THE CURIOUS CASES OF DIFFERENCES OF 6 METER Es RECEPTION FOR 2 STATIONS AT 10 KM SEPARATION RECEIVING FT8 FROM MULTIPLE TRANSMITTERS OVER 5 HOURS 7/30/22 N6MW

Introduction

N6MW, Bill and AA6DW, Alan, pointed antennas East-ish (not well calibrated) and listened with WSJT for several hours from 2200 30Jul2022 to 0335. The stations are about 10 km apart with AA6DW northeast of N6MW in Santa Barbara County CA in CM94. During this time there was a decent opening, generally to the east. Band Activity data were saved from both stations to files.

The plan is to compare reception of individual transmitting stations SNRs at the exactly the same times at our 2 relatively close stations. This is motivated by some past times in which AA6DW seemed to be hearing rather less well than N6MW.

Just for example, here is a data sample from DW:
013145 -3 0.1 1644 ~ N7BHC N4LR EM50
013215 0 0.1 1644 ~ N7BHC N4LR EM50
013245 -2 0.1 1644 ~ N7BHC N4LR EM50
013300 -13 0.0 1106 ~ NO7BS K3FM EM50
013330 -10 0.0 1107 ~ NO7BS K3FM R-01
013400 -10 0.0 1107 ~ NO7BS K3FM 73
013400 -6 0.1 1644 ~ AI9L N4LR EM50
013430 -4 0.1 1645 ~ AI9L N4LR R-11
This shows time, SNR, TX (TX=transmitting) station (second) and usually grid square, plus other information not used.

Ignoring the unneeded data elements, the two data sets were put into a single spreadsheet with the contributions from each station having a different background color (AA6DW yellow) to allow distinguishing them. This was then sorted first by TX call sign and secondly by time.

The result is that when any TX station is copied by both our stations at the same time, they are on adjacent lines in the sorted list. Then the difference in SNR (DW minus MW) for that pairing is calculated and the TX grid square is included on the same line as the SNR **difference**. For example

11815	-6	CQ	AB5CC	U.S.A.	EM14	cq hi	#	0	EM14
11815	-6	CQ	AB5CC	EM14	EM14	cq hi	#		
11845	-11	CQ	AB5CC	EM14	EM14	cq hi	#		
11915	-8	CQ	AB5CC	U.S.A.	U.S.A.	cq hi	#	-1	EM14
11915	-7	CQ	AB5CC	EM14	EM14	cq hi	#		
11945	1	CQ	AB5CC	U.S.A.	U.S.A.	cq hi	#	-8	EM14
11945	9	CQ	AB5CC	EM14	EM14	cq hi	#		
12015	-3	CQ	AB5CC	U.S.A.	U.S.A.	cq hi	#	1	EM14
12015	-4	CQ	AB5CC	EM14	EM14	cq hi	#		
12045	-13	CQ	AB5CC	U.S.A.	U.S.A.	cq hi	#	-11	EM14
12045	-2	CQ	AB5CC	EM14	EM14	cq hi	#		
12115	-12	CQ	AB5CC	U.S.A.	U.S.A.	cq hi	#	-8	EM14

Different stations are not necessarily shown in time order in the final spreadsheet but the time order for each station's receptions is retained.

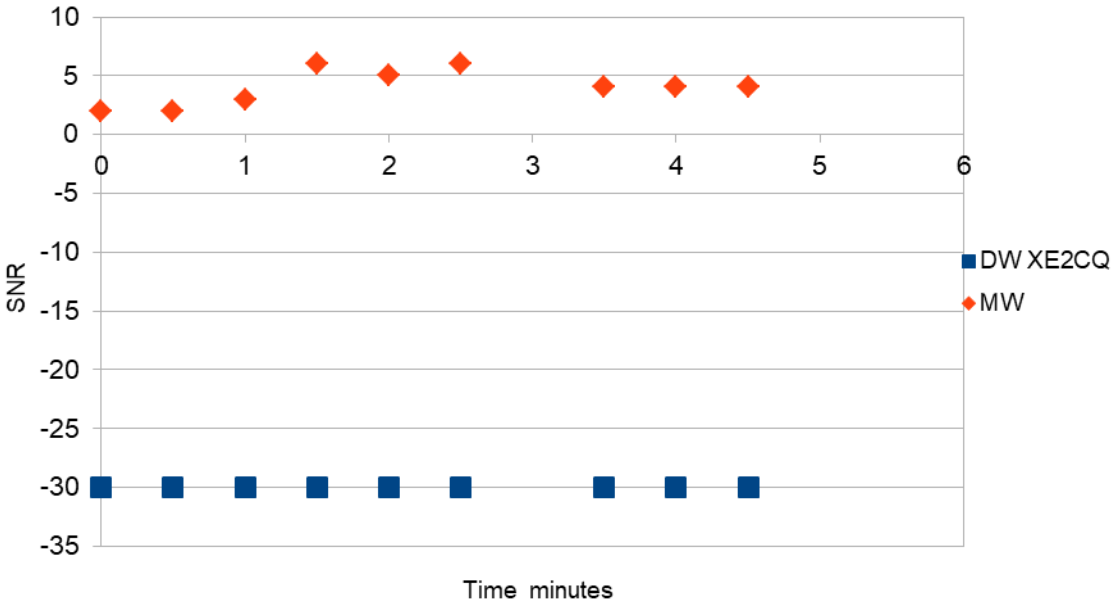
The AA6DW antenna is a Teledyne LPA at ~60' and the N6MW antenna is a 3 el Yagi at 25'. In the final spreadsheet Green highlights periods of interest, while Red highlighted times showing when only one of the two stations was copying the TX station. Focus was on stations at 1 or 2 hop range to the east. The "local" CA stations are probably not useful since the propagation was likely not by Sporadic E so those are not commented on here.

The bulk of the "East" stations received were at mid to longer 1 hop range (1500 to 2500 km), mostly Texas to Florida. The MS and FL stations were likely with 2 hops. Intermediate cases are uncertain, possibly being the result of two short-ish hops. (However, short hops require higher electron densities in Es clouds.)

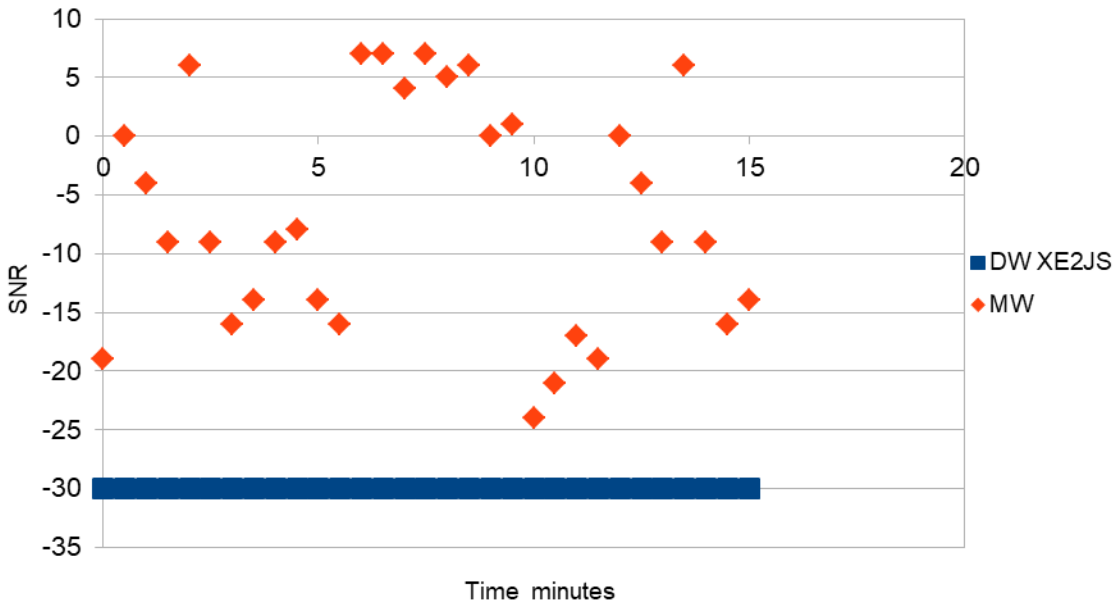
In the following we will show plots of the SNR (WSJT version) of concurrent receptions from individual TX stations at both receiving stations. In some cases transmissions from a given TX station was received only at one of our two RX stations. The plots are shown in order of the distance to the TX stations.

20 Examples of Differences at the 2 RX Stations

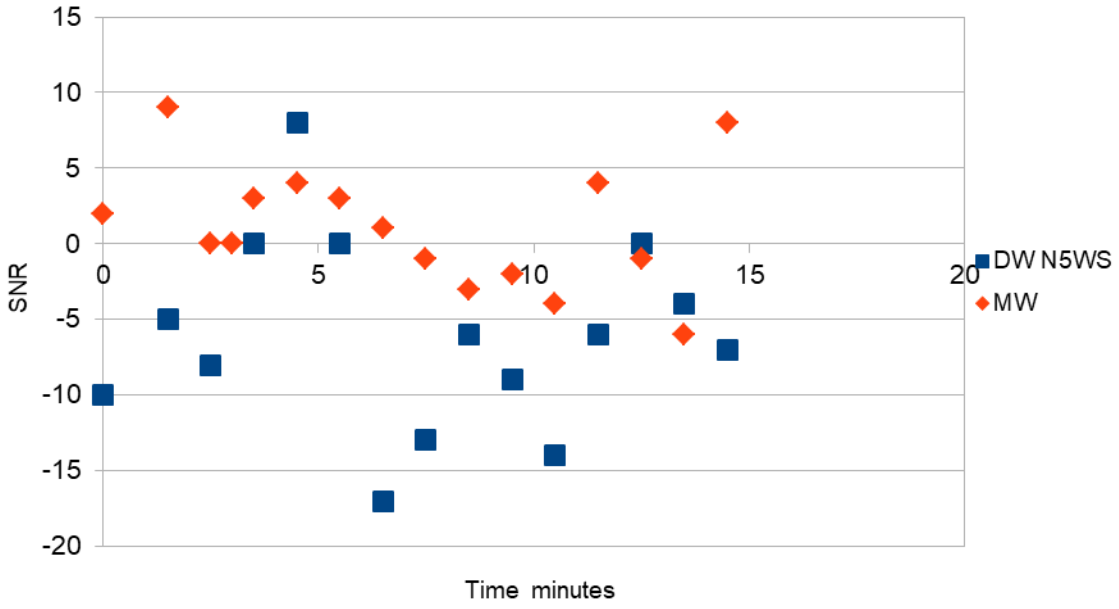
The TX station plots are given in order of the range to that station using the SNRs recorded by WSJT at the 2 RX stations. Time order from different TX station receptions is not displayed but that seems to have little if any effect. Each TX station case has the call, the grid square and the range in km displayed under the plot. Dark square symbols are for AA6DW and lighter color diamonds are for N6MW. For cases in which one of the 2 RX stations did not decode transmissions from a given TX station are indicated by fake small SNR value -30.



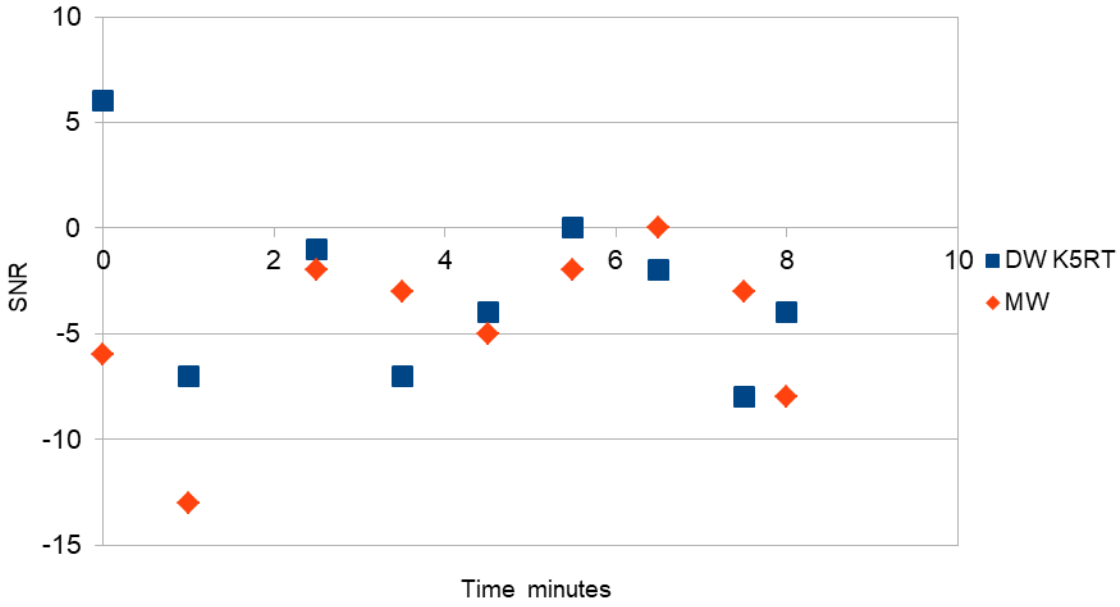
XE2CQ DM12 430km



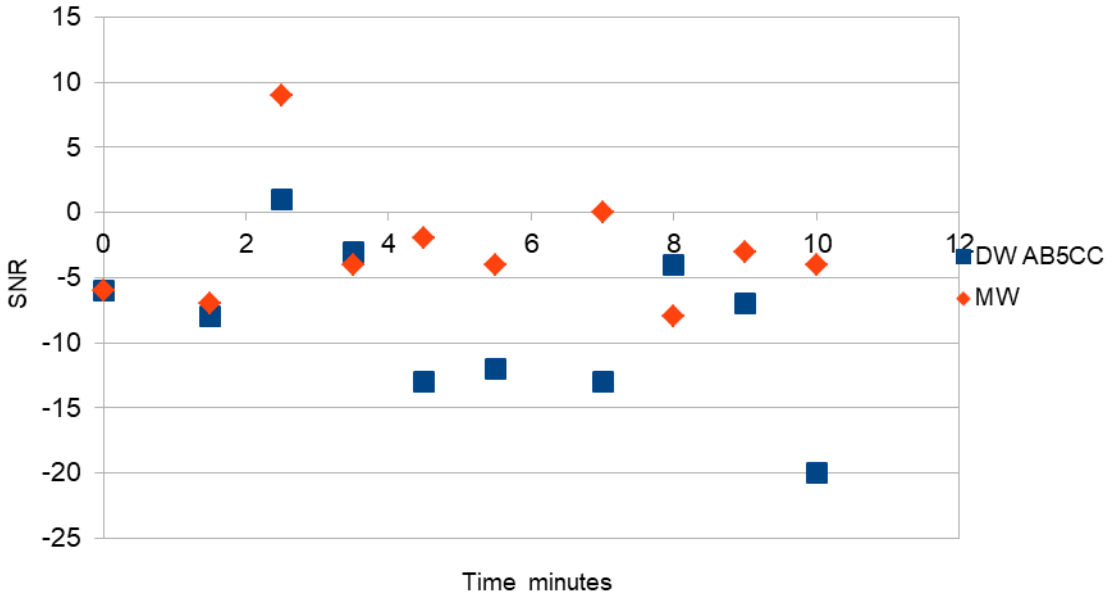
XE2JS DL68 1500



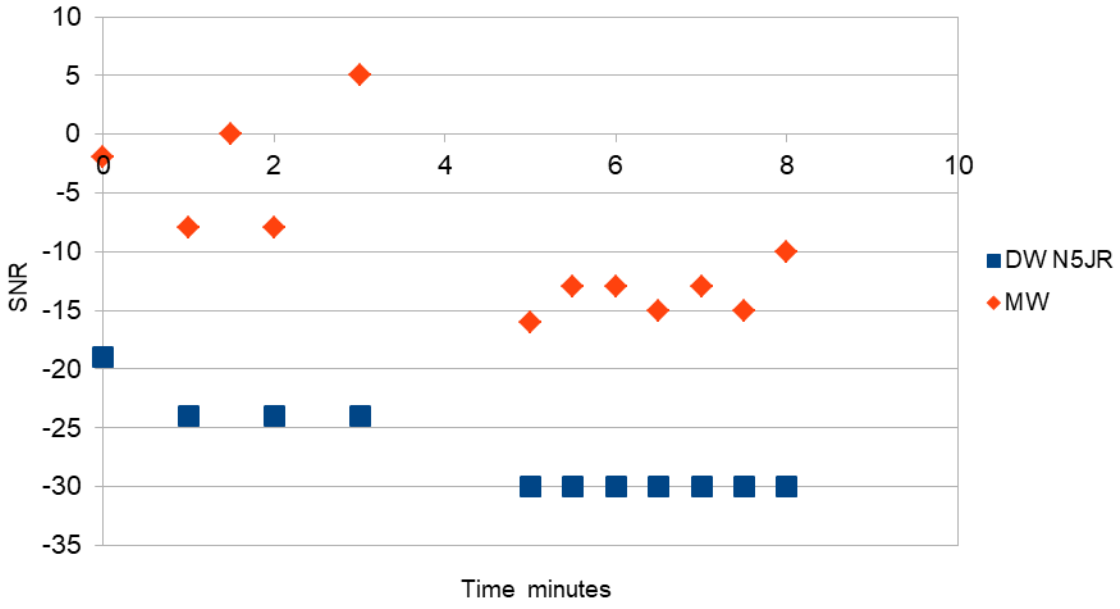
N5WS EL09 2150



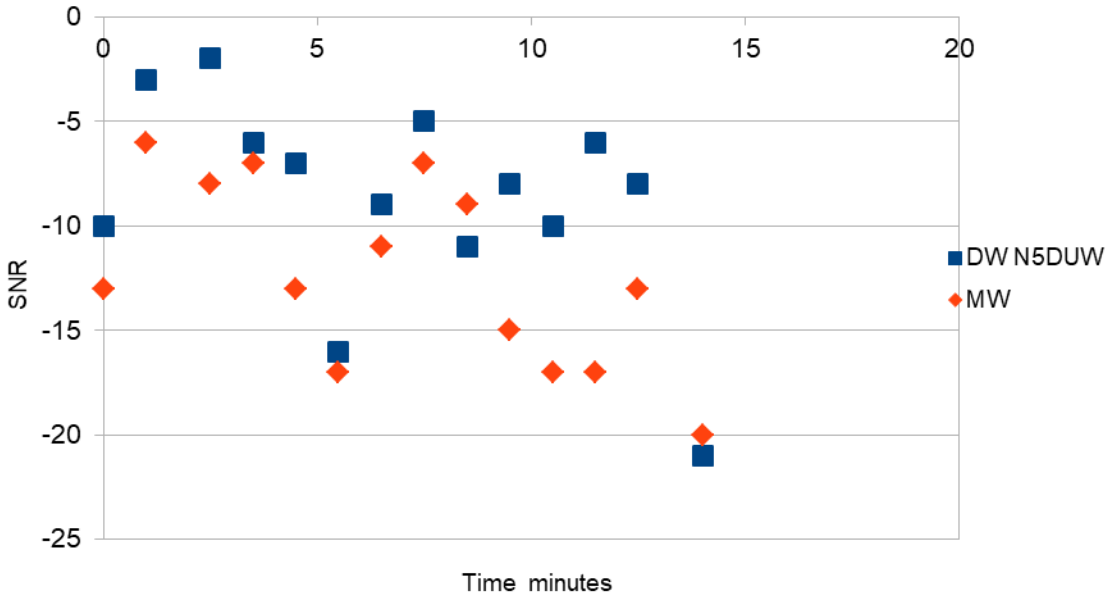
K5RT EM12 2200



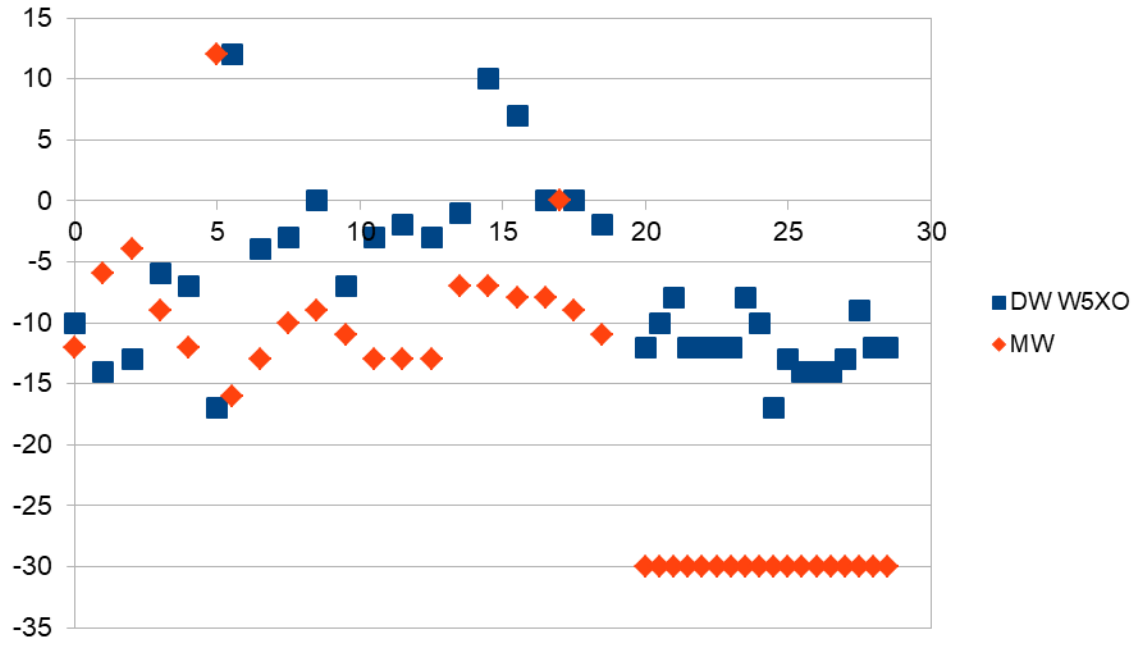
AB5CC EM14 2200



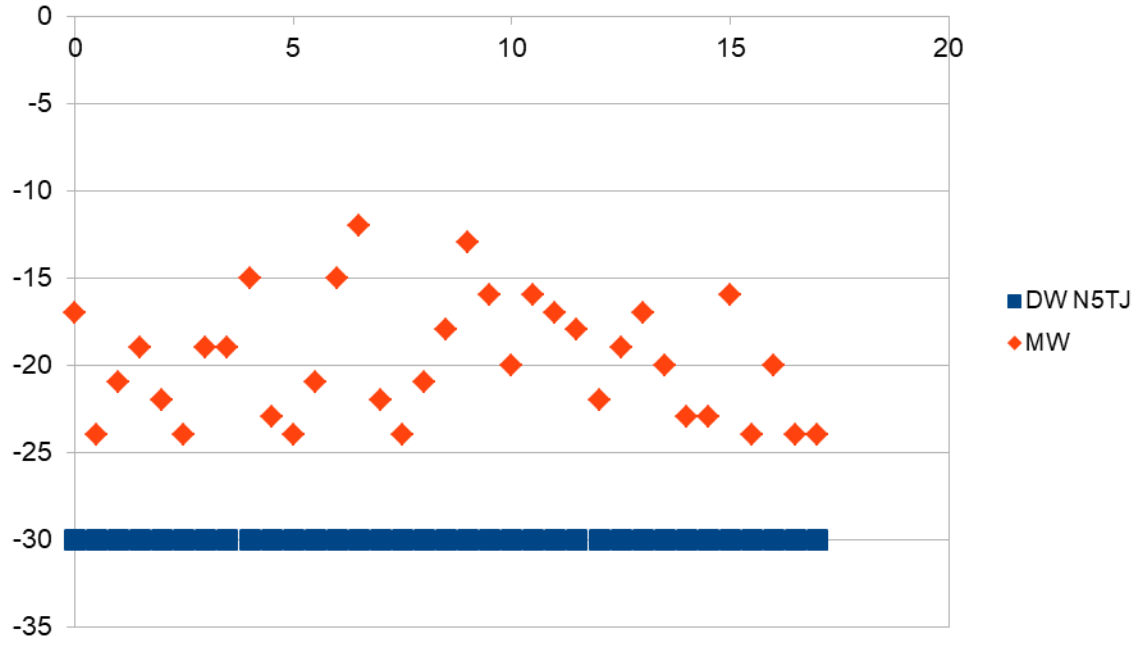
N5JR EM12 2200



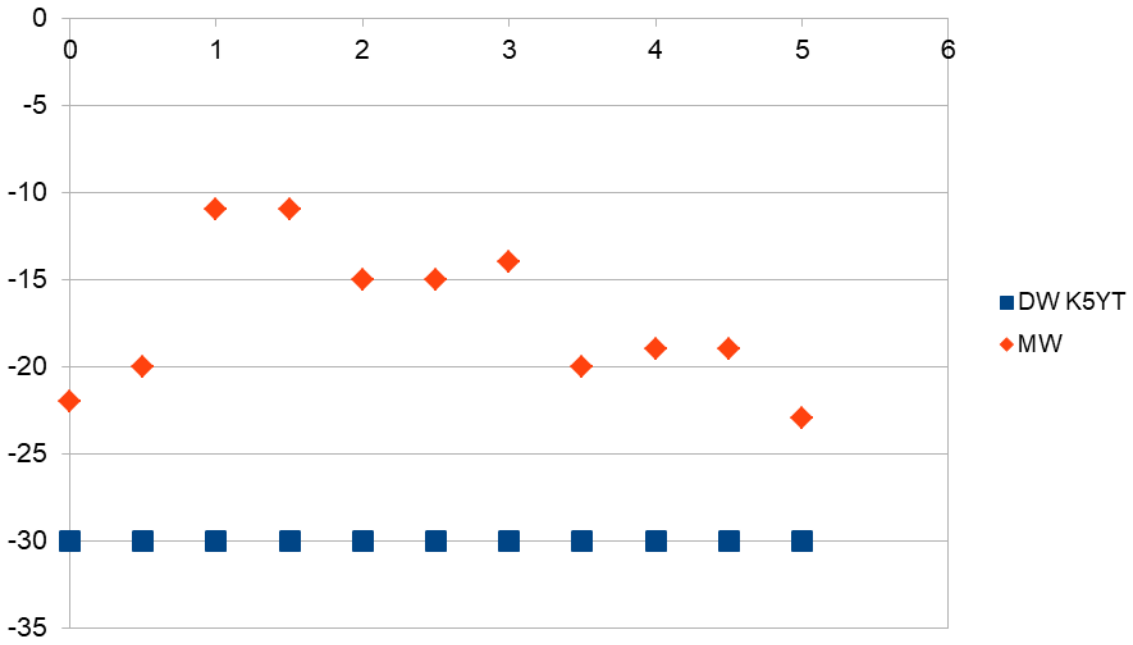
N5DUW EM11 2250



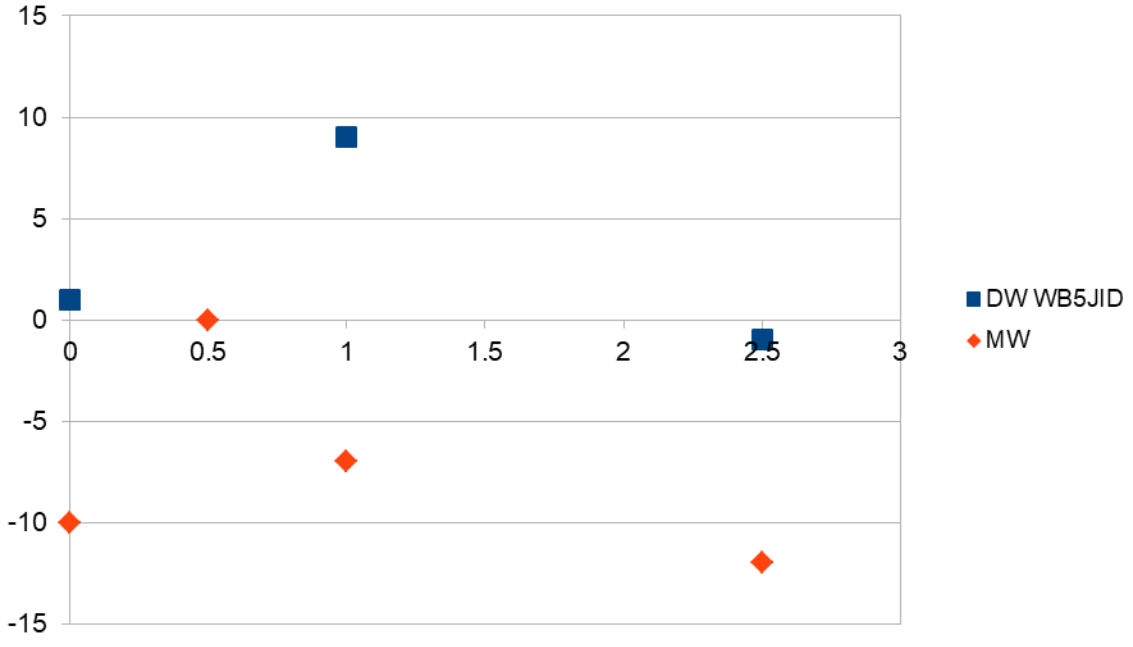
W5XO EM10 2300



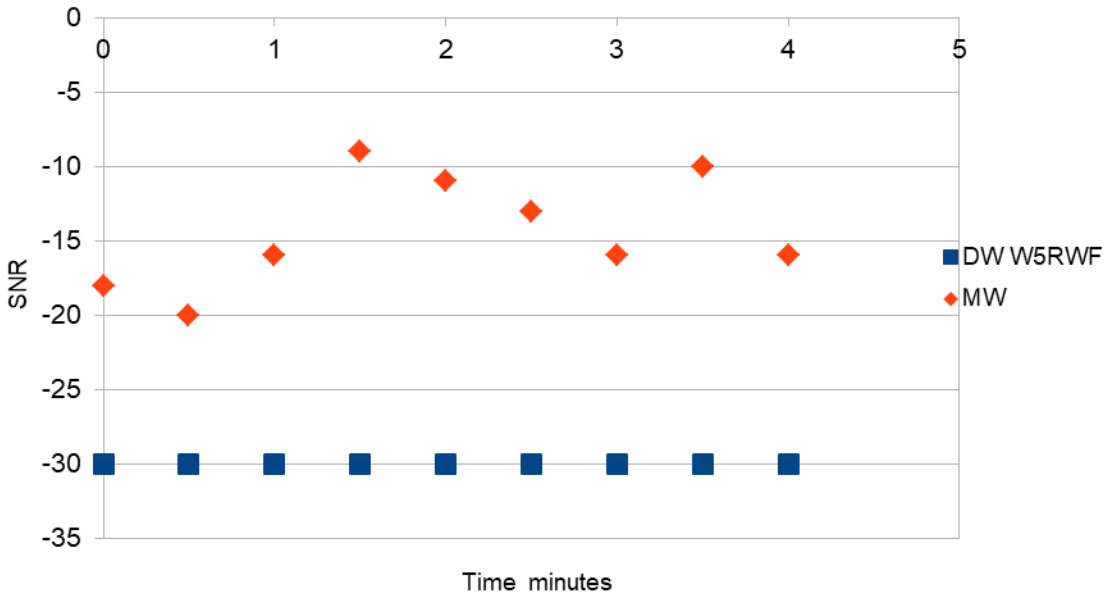
N5TJ EM10 2300



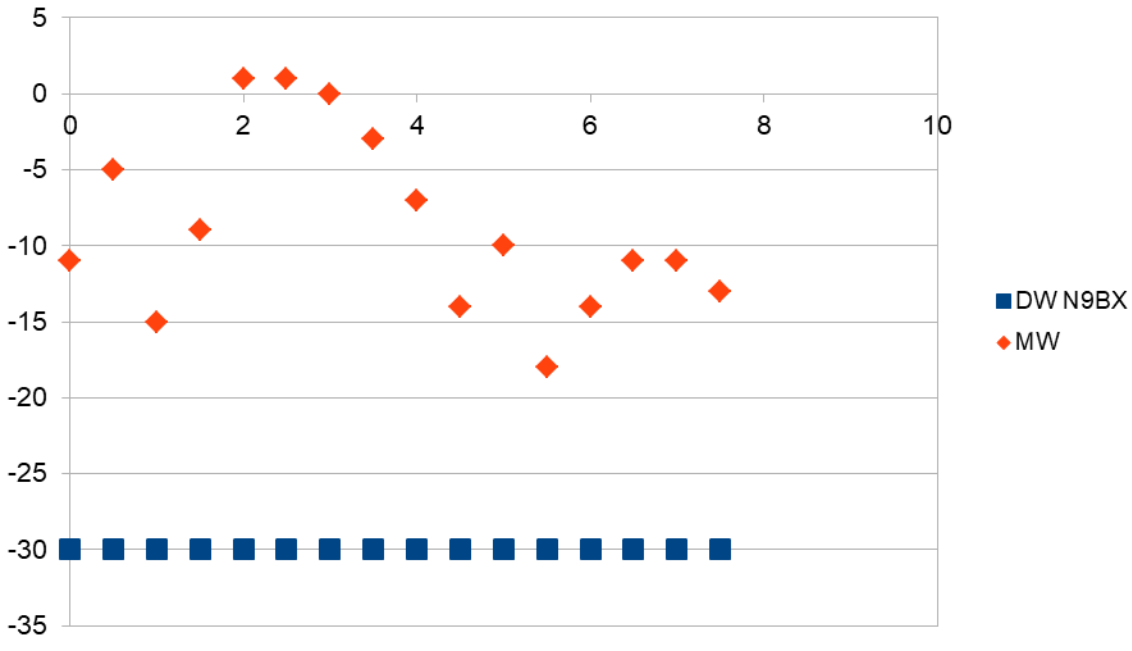
K5YT EM22 2400



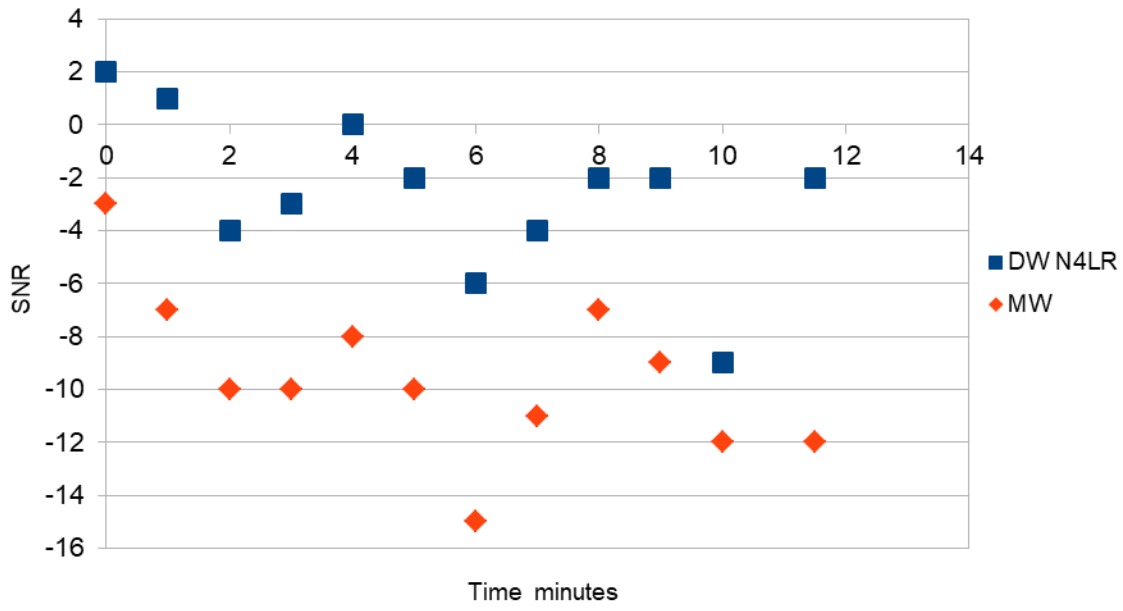
WB5JID DM12 2500



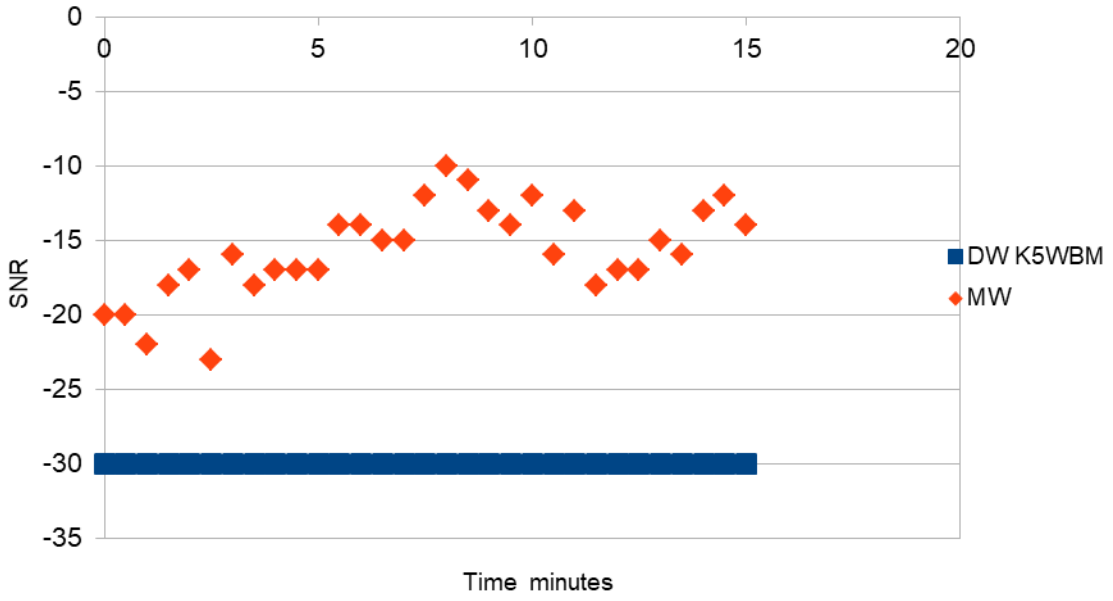
W5RWF EM50 3000



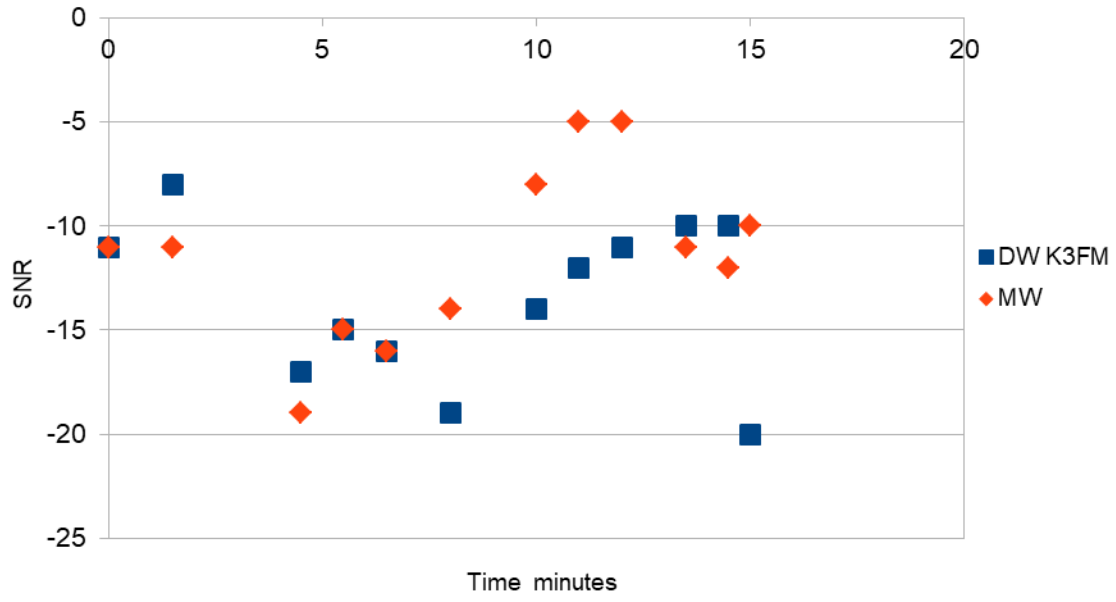
N9BX EM50 3000



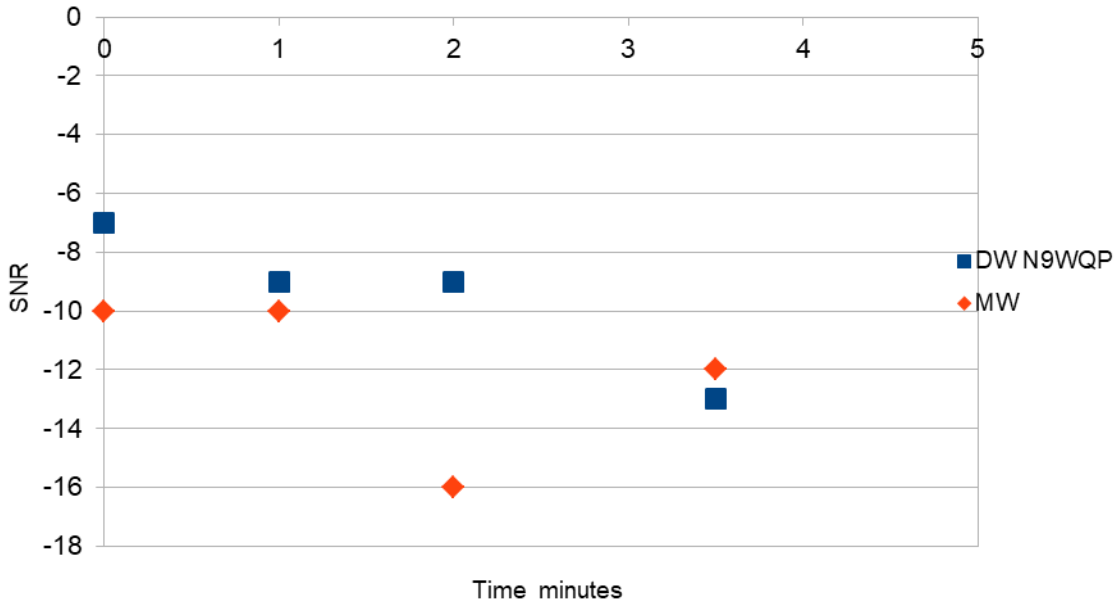
N4LR EM50 3000



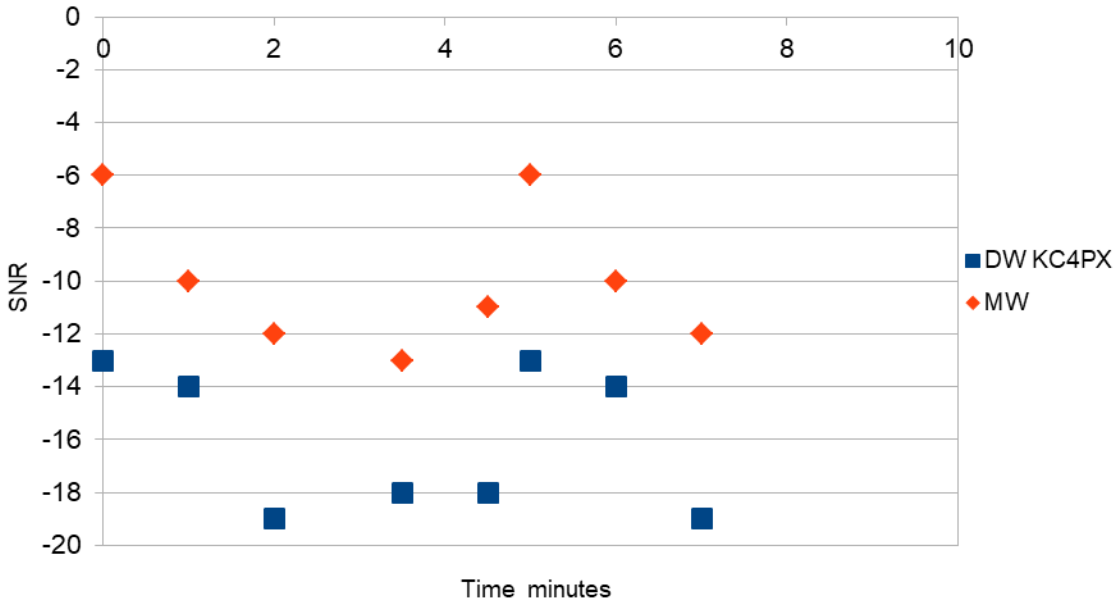
K5WBM EM50 3000



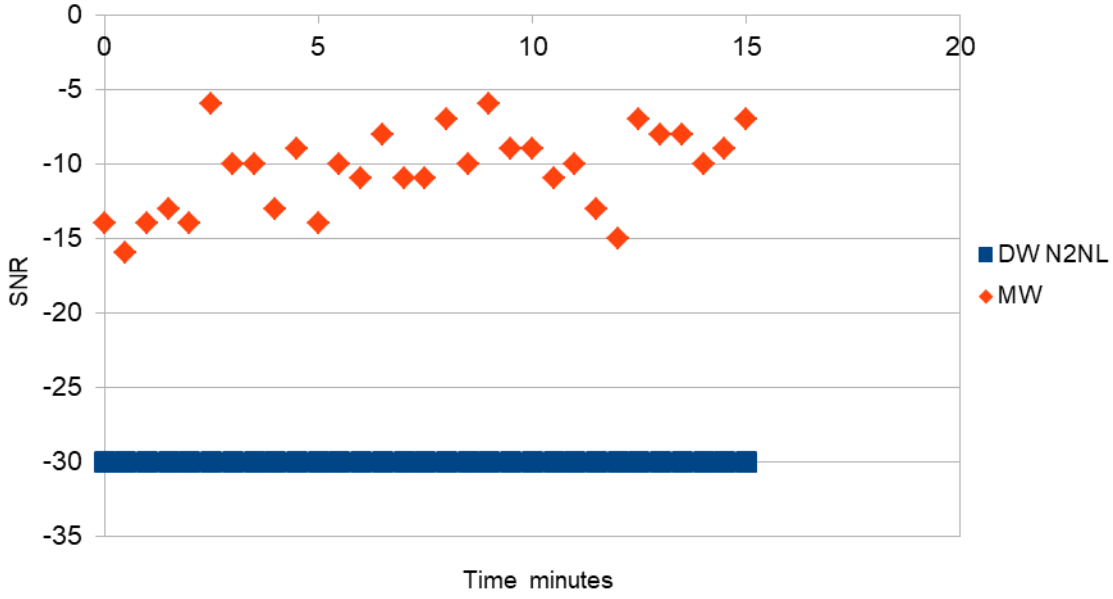
K3FM EM50 3000



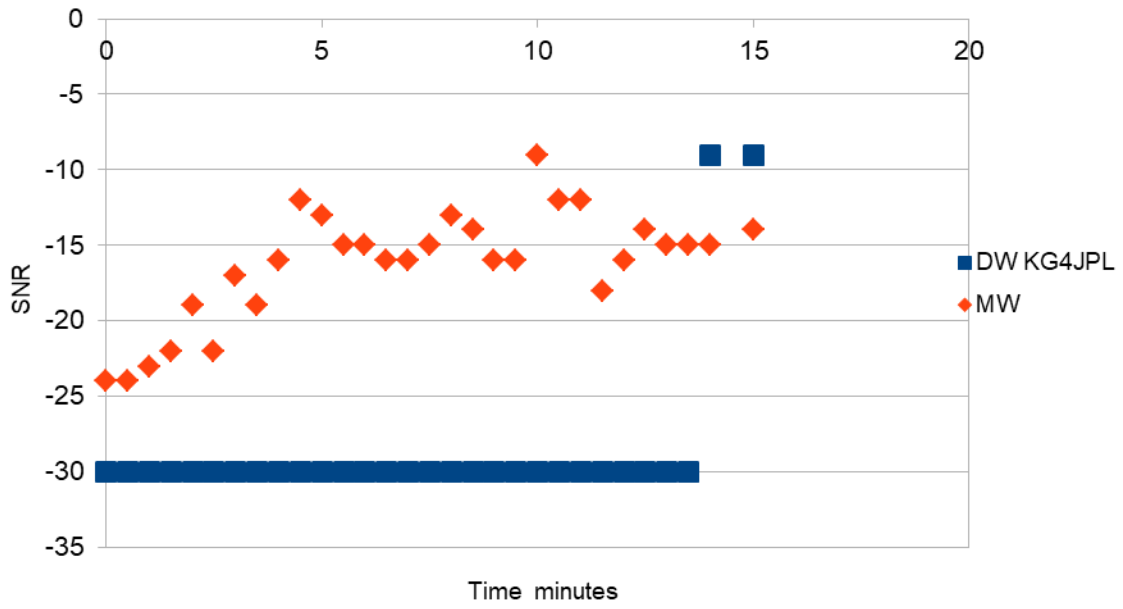
N9WQP EM69 3050



KC4PX EL98 3600



N2NL EL88 3650



KG4JPLEL88 3650

XE2CQ	Short range	MW SNR ~ +4 DW no decodes
XE2JS	1 hop range to SE	MW SNR ~ +5 to -20 DW no decodes
N5WS	East 1 hop	MW SNR ave ~ 0, DW ~ -5 large fluct tend to follow
K5RT	East 1 hop	MW & DW SNR ave ~ -4 mostly together
AB5CC	East 1 hop	MW SNR bit higher that DW
N5JR	East 1 hop	MW SNR ave ~ -5 , DW ave ~ -21 for 5 min, then MW ave ~15 , DW no decodes
N5DUW	East 1 hop	MW SNR bit **lower** that DW, large fluct.
W5XO	East 1 hop	MW SNR ave ~ -10 , **hjgher** DW ave ~ -5 for 20 min, **then MW no decodes** , DW averages -12
N5TJ	East 1 hop	MW SNR ~12 to -24 DW no decodes
K5YT	East 1 hop	MW SNR ~11 to -23 DW no decodes
WB5JID	East 1 hop	MW SNR ave ~ -5 , **DW ave ~+3**
W5RWF	> 1 hop	MW SNR -9 to -20 DW no decodes
N9BX	> 1 hop	MW SNR +1 to -18 DW no decodes
N4LR	> 1 hop	MW SNR -3 to -15 **lower** that DW +2 to -9
K5WBM	> 1 hop	MW SNR ave ~ -15 DW no decodes
K3FM	> 1 hop	MW SNR bit higher that DW but both vary together
N9WQP	> 1 hop IND	MW & DW SNR ave ~ -8 mostly together
KC4PX	> 1 hop	MW SNR ~ 7dB higher than DW but both vary together
N2NL	> 1 hop	MW SNR ave ~ -10, DW no decodes
KG4JPL	> 1 hop	MW SNR ~25 to -14 for 13 min, only then 2 DW decodes at -9

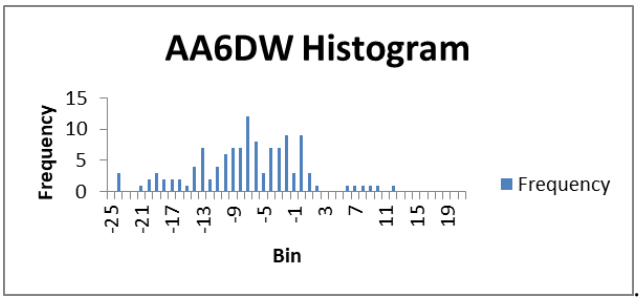
Short summary table of some plot features**.**

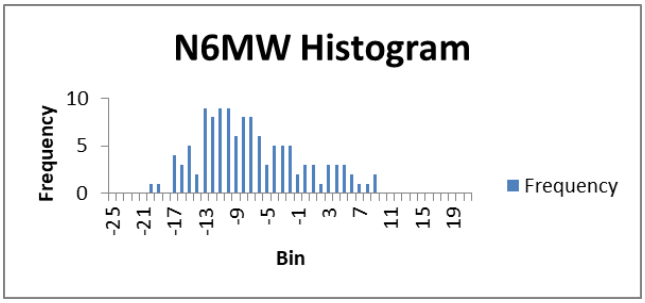
Meaningful statistical information is difficult to justify so these results are to be taken with a block of salt. Here we offer only the average SNR and standard deviation (sigma) for only cases for which both stations were successfully decoding. First the mean and sigma for the raw SNR values for each station and then those values for the signed differences (DW minus MW).

Source	**SNR average**	**+/- Sigma**
AA6DW	-7.1	7.0
N6MW	-7.0	6.6
AA6DW-N6MW	-0.02	8.7

SNR statistical variation seems to be of limited value.

Here are histograms for distribution of SNR values as found at the two RX stations for cases where both are decoding.





AA6DW vs N6MW

In spite of the fact that the average SNR values for the 2 stations decodes are very close, the distributions differ with DW having more low SNR decodes and MW having more higher SNR decodes.

Observations

No Decode Cases for DW
The most striking feature is the number of cases where DW alone fails to decode is substantially greater than those where MW alone fails to decode. In 9 of 20 cases DW does not get any decodes at all and there is just a single case where MW fails to decode about half of one of the transmissions (W5OX).

How can this be?

First we note that **most** those cases of no DW decodes, the MW decodes show a typical SNR of -15 +/- 5 dB. If the SNR available to DW was 5 to 10 dB lower for some unknown reason, in those cases this would be the effect.

The receiver at MW is an older Elecraft K3 which has an Elecraft add-on preamp for 6 meters which might make some difference but we have no current way to compare the receiver sensitivities.

Receiving capability can also differ due to differences in RF gain settings (AGC always off and manually set) as well as potential differences in the audio processing in the sound cards that could affect the dynamic range.

There is also the potential of noise level and quality differences in the environments of the two RX stations.

In the Appendix there is mention of the effects of ideal models of antenna height difference effects but the data do not appear to show this to be a cause.

Both Decoded Cases
For cases where both RXs did decode, the results are irregular. For different TX stations often one or the other of us (DW, MW) showed fairly consistent notably better SNR, sometimes at differences of upward of 10 dB. Usually the better station was the consistent over the full range of times for a given TX station. However, there was variation as to which RX was

better. It happened relatively infrequently that our two stations copied a TX at about the same SNR over a period of time.. Still the average SNR for the two stations when both copied was nearly the same. Still for a number of cases, the two RX stations SNR variations with time followed similar patterns.

Are some effects due to the separation of the 2 RX stations?

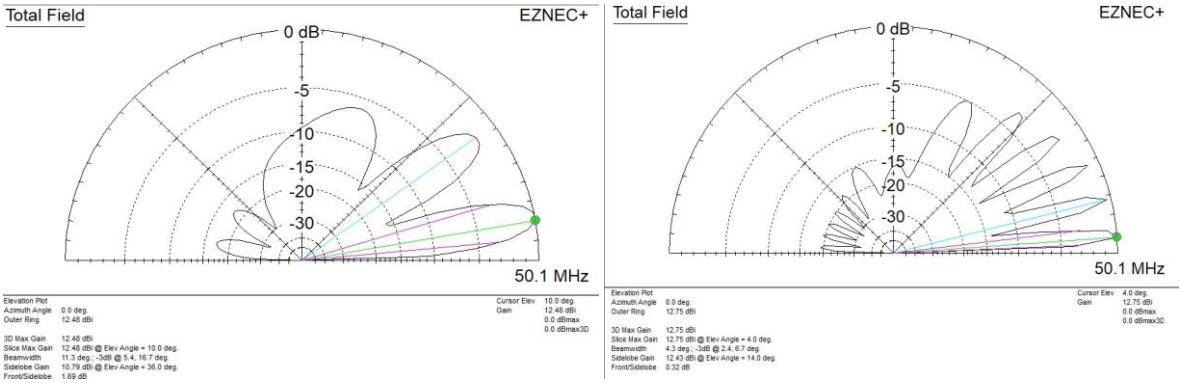
There are a number of factors that may cause differences in reception between the 2 RX stations. We initially thought that the separation of the stations of 10 km would cause only little effect since the usually claimed sizes of Es clouds are generally larger than that. The results may call that into question. However, there are certainly substantial differences of uncertain causes. Some possibilities are these.

1 This is reality and the variation of SNR over a smallish region really is indeed substantial so separation is a cause. It is hard to see why that could be unless there are small scale features of Es cloud structure that come into play.

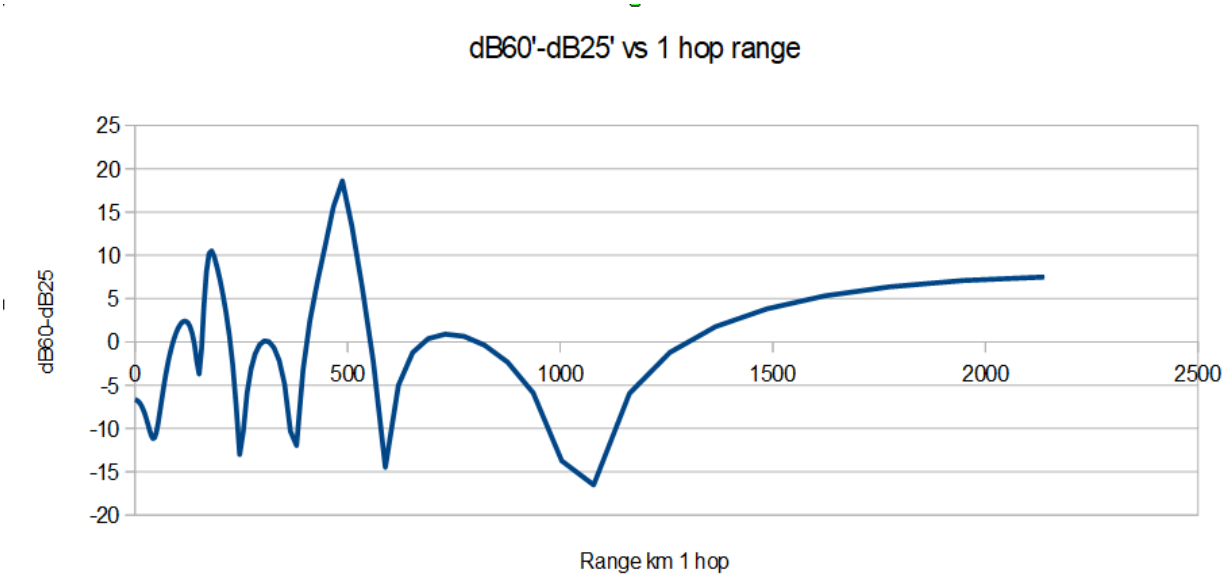
2 If there are electron density ripples on the bottom of clouds, or perhaps edge effects of thin clouds, that are encountered by the signals that are different this could matter. Note that the reflection first "Fresnel Zone" for a horizontal flat reflecting object such as an Es cloud is approximately 2 km across by 20 km long in the antenna-to-antenna dimension for 1 hop at 6 meters. Differences in the Es cloud structure between the paths from the TX to the two RX stations which are expressed over the Fresnel zone dimensions can produce different signal structure. Details of Es clouds are unclear in general.
3 Antenna pointing could be off and/or azimuthal pattern distorted by local effects. However, the forward beamwidth of these antennas are pretty broad so this seems unlikely to matter. The case to case variation does not seem consistent with this for fixed antennas.
3 The antennas, of similar gain, are at significantly different heights this could generally have an effect (see the Appendix). However the data do not seem to support this cause.
4 It's not called the Magic Band for nothing.

Appendix

A factor we could not control is the difference in the heights of the 2 antennas. This causes evident differences in the elevation patterns for them. For example here are the elevation patterns for 3 el yagis (LPA is not much different) at 25' and 60' above electrically average (and level) ground. The nulls in the patterns are at different elevations. This provides an advantage to the higher antenna for low elevation angles but it can be a disadvantage at higher elevations.



The effects of the difference in relative signal levels from different ranges for this factor alone can be found by noting that for 1 hop and an Es cloud at, say, 110 km height there is a particular elevation angle that corresponds to a given range. When these facts are combined a nominal signal level differences from elevation patterns alone at different ranges can be found in the following plot.



Nominal signal difference vs range for 60’ vs 25’ high 3 el yagis.

However, this is idealized and may be significantly affected by terrain features. Still it appears that the differences can vary sharply with TX range although it is very TBD if 10 km range differences could matter much for the current case based on the plot. In any case, the examples in the text **do not** have obvious variations with range as this figure might suggest possible although the variation in ranges in the examples is not the most interesting.