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To: EDGES group

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Subject: Analysis of EDGES-3 vs Galactic Hour Angle (GHA)

The results from EDGES-3 summarized in memo 437 are consistent with the 2018 result (Bowman et al. 2018). Now that we have a year of EDGES-3 data from the WA it is possible to obtain a 21-cm absorption result over a range of Galactic Hour Angle (GHA) as was done in 4 and 6 hour bins of the Extended Data Table 2 in (Bowman et al. 2028 *Nature*, 555(7694), pp.67-70).

Obtaining a result over GHA is more difficult now for the following reasons:

- 1] Solar activity has increased substantially since 2018
- 2] RFI from the reflections from satellites has increased – see memo 424
- 3] RFI from quasar scintillations and effects of the ionosphere have increased – see memos 428 and 438
- 4] While the 48x48m ground plane results in a lower overall beam chromaticity there maybe some resonances as discussed in memo 429

As a result of the above an analysis over 4 and 6 hour bins has been made by only using data when the Sun is more than 20 degrees below the horizon. The key parameters being used are

key acqplot7amoon parameters: -maxrmsf 200 -maxfm 2000 -sunlim -20 -rfi 2.1 -nrfi 2

key edges3 parameters: -antaz 269 -aloss 0.01 -bfit -12

key longav parameters: 5 loglog polynomial terms and -tau 4

The beam chromaticity correction which minimized the residuals to the 5-term fits for the best fit absorption with fixed flattening parameter of $\tau = 4$ was found for the FEKO beam using a soil conductivity of $2e-3$ S/m. Simulations of the beam chromaticity over 20 minute blocks over all GHA gave the following average chromaticity for different soil conductivity. All cases were run with a soil of dielectric 3.5 and the ground plane on the soil except the last case for which the ground plane was elevated by 5 cm to produce gaps at the edges which increase the reflections from the edges as discussed in memo 317.

Soil conductivity S/m	rms residual mK	Gap at edges
PEC	41	0
$2e-3$	65	0
$1e-2$	59	0
$2e-2$	59	0
$2e-2$	69	5 cm

Table 1. average beam chromaticity 5 - terms removed

One hour blocks for EDGES-3 data from 2023 day 54 to 2024 day 40 are processed using 1 hour blocks of data from each day which are then combined into 4 and 6 hour bins of GHA. The results of the grid search for each 4 and 6 hours bins are given in table 2 and plotted in Figures 1 and 2. In each case a fixed value of tau = 4 was used.

These plots were made with the beam file: azelq_box_fulsiz_perf48x48_2e-3.txt

The selection of calibration and antenna S11 vs day used was that listed in memo 437. The Haslam map scaled with a spectral index of 2.5 was used for beam correction. The selection of the threshold of acceptance for the rms for best SNR. A value of tau = 4 was chosen for more consistent results vs GHA and lower residuals than were obtained with tau = 7. The frequency coverage of 58 to 102 MHz was the widest that resulted in enough data within the RFI thresholds needed to get enough data at GHA = 0 and in this regard the loglog polynomial was found to result in lower residuals than other polynomials with only 5-terms.

The choices made on filtering at each GHA were made to get an acceptable fraction of data with low residuals with no more than 5 polynomial terms. Tests were made on the sensitivity to the choice of soil conductivity and antenna azimuth and were found to have minimal effect on the absorption depth, center frequency and width when using data from all GHA. The most poorly determined parameter is the flattening which could have a value of tau between 3 and 7. The absorption results for the plots in Figures 1 and 2 which are also printed in the plots are listed in Table 2 below:

GHA	center frequency MHz	SNR	amplitude K	width MHz
00	79.7	9	0.59	20.9
04	78.1	13	0.52	20.9
08	78.5	27	0.48	20.9
12	79.3	27	0.44	18.9
16	80.1	27	0.55	17.4
20	79.7	22	0.56	17.0
all	78.9	34	0.57	20.7
00	78.5	9	0.59	20.9
06	78.5	11	0.39	20.9
12	78.5	32	0.64	20.9
18	78.5	13	0.62	17.0
all	78.9	33	0.49	20.6

Table 2. Absorption search results for 4 and 6 hour bins of GHA

These results used a FEKO beam model which used a soil conductivity of 2e-3 S/m. The results using a soil conductivity of 1e-2 S/m with all the other processing parameters exactly the same as for Figure 1 are shown in Figure 3. While the change in the absorption over all GHA is very small there are significant changes vs GHA. The largest changes are a drop in absorption amplitude at GHA 4 and 8 from 0.52 and 0.48 to 0.34 and 0.26 respectively. The absorption results for GHA=all which were obtained using the processed data from the 4 and 6 hour GHA bins are very close but are not identical owing to the different effects of the rms thresholds used for the rejection of RFI in each case.

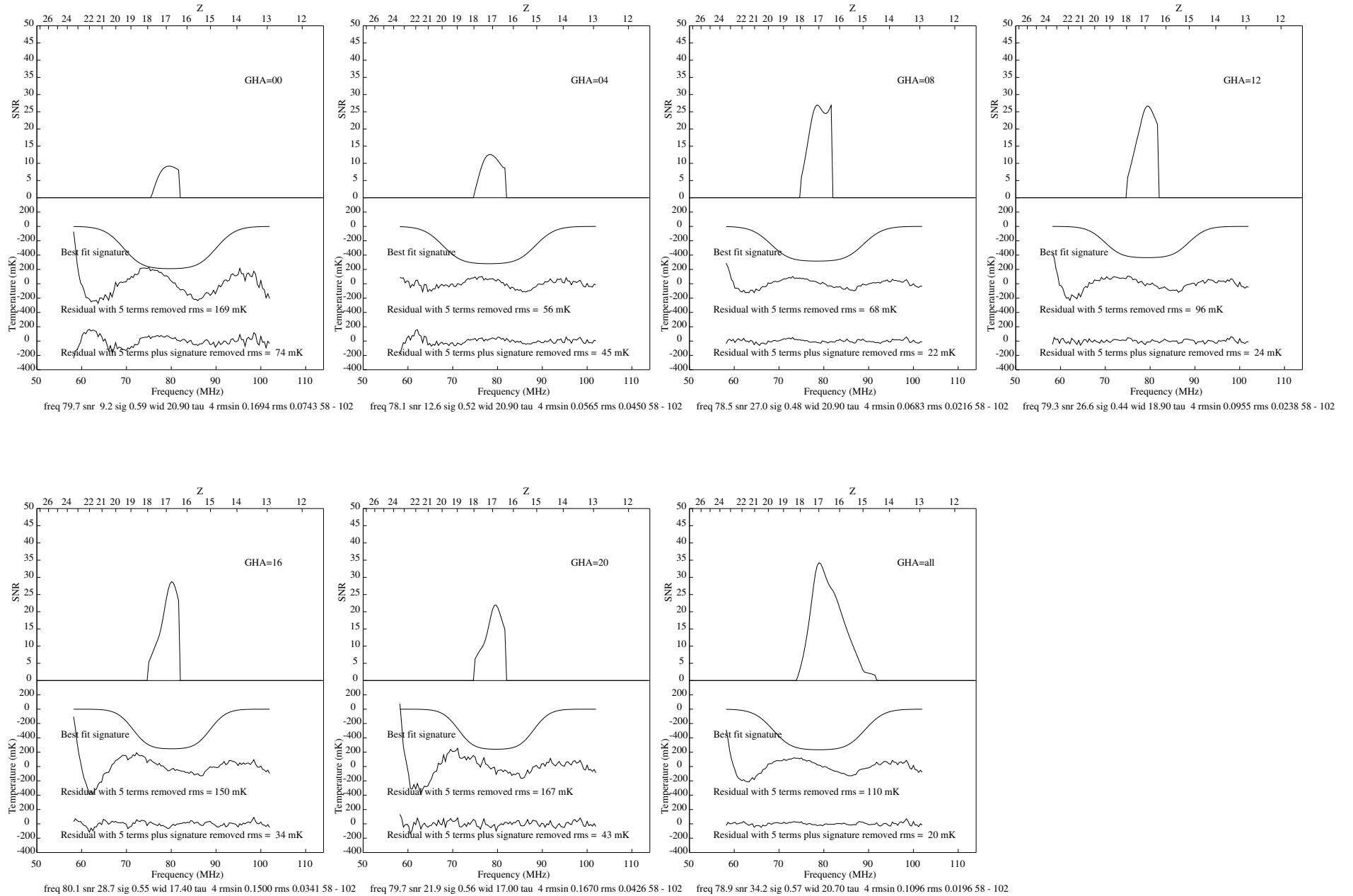


Figure 1. Absorption search plots for 4 hour bins centered at 0 4 8 12 hours GHA on the top row and 16 and 20 hours GHA followed by a search for all hours on the bottom row.

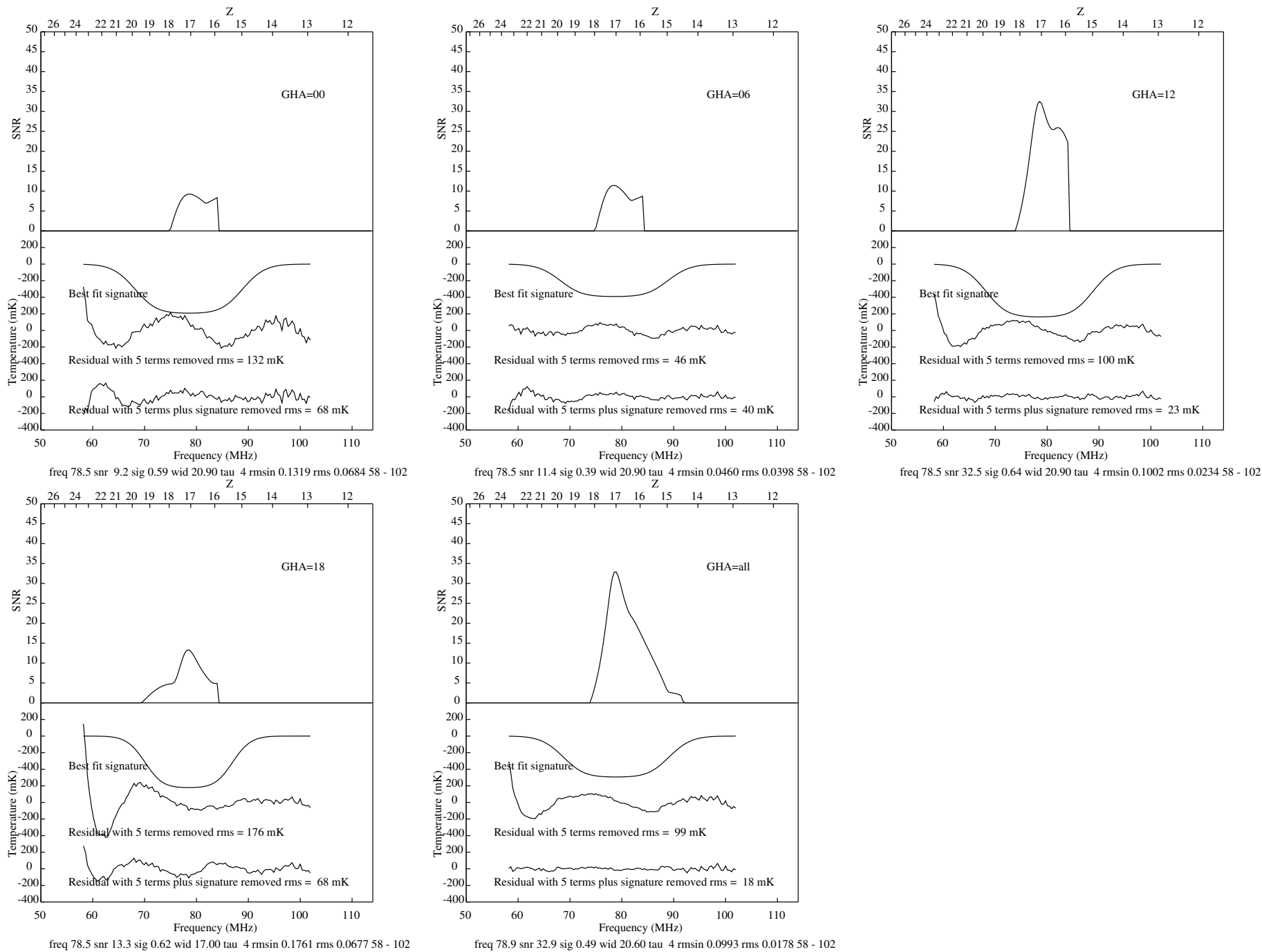


Figure 2. Absorption search plots 6 hour bins centered at 0 6 12 hours GHA on the top row and 18 hours GHA followed by a search for all hours and on the bottom row.

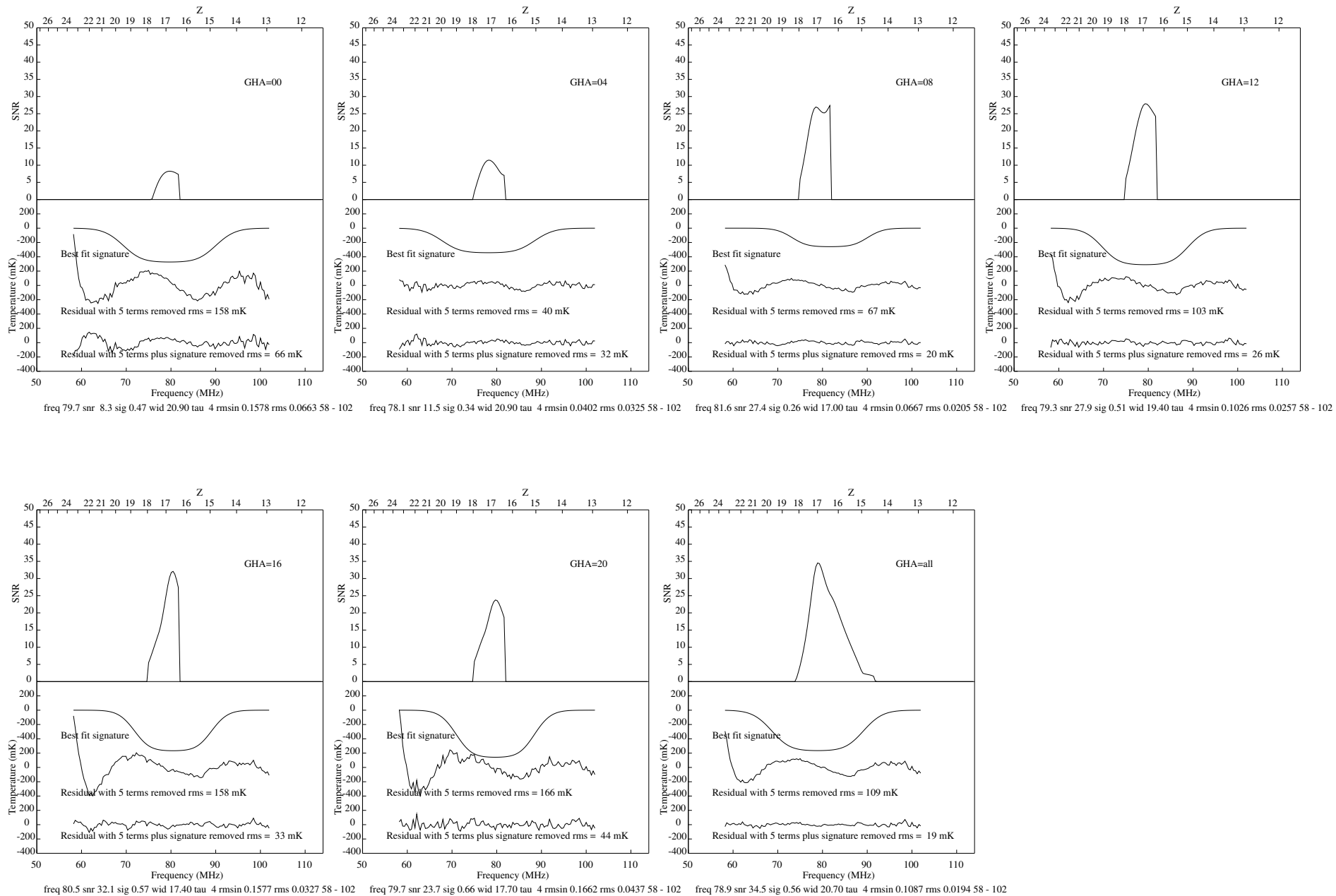


Figure 3. Absorption search plots for 4 hour bins using FEKO beam with soil conductivity of $1e-2$ S/m.