EDGES MEMO #484

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To: EDGES group

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Subject: Tests of RFI filtering using 2025 EDGES-3 data from WA

The effects of the processing parameters needed to remove RFI and the effects of solar emission have been studied in memos 211, 244, 402, 417, 418, 419, 420, 437, 445 and 479. There are several key questions which have been studied and may need more study given the high level of solar activity for example:

1] Should all analysis be limited to when the sun is more than 30 degrees below the horizon ?
2] Should the analysis be limited to when the moon is below the horizon to avoid FM reflections?
3] What is the optimum block integration time on which to set an rms threshold on data acceptance?
4] What is the best fine scale bandwidth and thresholds needed to remove fine scale RFI and smooth over channels?

The answer to question #1 is yes at least for 2024 and 2025 owing to the high level of solar activity because the solar emissions are broadband and of significant duration that they cannot be filtered unless the data blocks are short enough to get data with an rms residual with 4 or 5 terms removed of less than about 0.3 K

The answer to question #2 is no because the moon reflections of FM signals are relatively narrow band and are very weak and can be filtered using low levels the -rfi using the values as listed in table 2 of memo 468 whereas strong reflections from aircraft and can be filtered with the -maxrmsf 50 -maxfm 2000 filters. These filters which will just remove particular frequency channels in the first stage of processing which will then be “smoothed over” with -nrfi 2 without having gaps in the smoothed spectrum. Tests like those done in memo 468 should be done to be sure moon reflections are not effecting the results but in general times when the moon is above the horizon can be included without having a significant effect. Memo 468 also shows that the -rfi limit of 2.1 removes both the weak and strong RFI.

The answer to question #3 is that one hour is a good choice to avoid having short bursts of RFI not filtered out go undetected due to the long averaging time. Shorter blocks may be needed for some data which have broadband signals that are too weak to be filtered in the first stage of processing and require some integration to be detected by a rms that is expected from the noise. Blocks of about an hour are needed so that the rms limit can be used in the second stage of processing. While even shorter blocks can make further improvements in the removal of RFI the processing time needed for many days of data in blocks of 30 minutes or less becomes very significant so initial tests of a few days are needed.

The answer to question #4 is that typically a good choice for the limit on one hour blocks is -lim 0.25 which sets an rms residual limit of 250 mK on the spectrum with 4 or 5 physical or polynomial terms removed. A simple test using the data from 2025 days 1, 2 and 3 gives the following results in Table 1

show that as long as an rms limit of 250 mK is set and used on 1 hour blocks the results are acceptable and using FM filtering makes only small difference. For one day blocks all 3 days have a rms residual over 2 K and no acceptable data for a 21-cm feature is obtained. The choice of frequency spacing is discussed in memo 244 and 49 kHz and 391 kHz are chosen for the first and second stage processing respectively. These are factors of 8 and 64 times the 6.1035 kHz frequency spacing obtained from the 400 MHz sample rate and 65536 point Fourier transform.

The following parameters normally for data filtering:

first stage frequency spacing 49 kHz
second stage frequency spacing 391 kHz
-maxrmsf 50 -maxfm 2000
-rfi 2.1 -nrfi 2
-smooth 8 in acqplot and -smooth -8 in edges3
-lim 0.25 in longav

These parameters may need some adjustment to get the best results for a particular set of data. The results of the tests on 2025 EDGES-3 data from the WA are shown in Table 1 and selected test results are plotted in the figures. The residuals rms1 and rms2 are prior to and following the grid search respectively.

The first tests were made using only 3 days of data and show that with one hour data blocks reasonable results can be obtained by only accepting data blocks with rms residuals with 4 or 5 terms removed less than about 250 mK.

freq MHz	SNR	amp K	width	rms1 mK	rms2 mK	sun elev limit	FM filter	data range
78.1	11	0.54	20.9	118	85	0	yes	2025 days 1,2,3
77.7	11	0.55	20.9	121	87	-30	yes	“
77.7	13	0.55	20.9	112	73	-30	no	“
77.3	12	0.52	20.9	113	78	-20	yes	“
78.9	12	0.52	20.9	104	72	all day&night	no	“
78.1	11	0.54	20.9	118	85	all day&night	yes	“
79.3	16	0.57	20.9	98	56	all day&night	no	1 -161 10d steps fig. 1,2,3
79.3	13	0.51	20.9	97	64	-30	yes	“
79.3	15	0.54	20.4	99	59	-30	no	“
79.3	27	0.48	21.2	74	28	-30	no	2025 days 1 – 163 fig. 4
79.3	25	0.44	20.9	68	28	-30	yes	“

Table 1. 21-cm absorption search using 4 physical terms on 1 hour blocks 57 – 106 MHz

Figure 1 shows the residuals for all hour blocks of 2025 day 1 and Figure 2 shows the UT times with residuals less than 0.25 K. For day 1 only 14, 16, 17 and 18 UT blocks are under 0.25 K and reach 7.9 K at 08 UT with solar electron cyclotron maser activity centered at about 62 MHz. Figures 3 and 4 show the global 21-cm feature extraction using data from every tenth day and every day in 2025 up to day 163. The results in Table 1 also show that when as rms limit of 0.25 K is applied to 1 hour blocks the -maxrmsf 50 -maxfm 2000 limits make a small increase in rms2 because a little less data is used in the grid search.

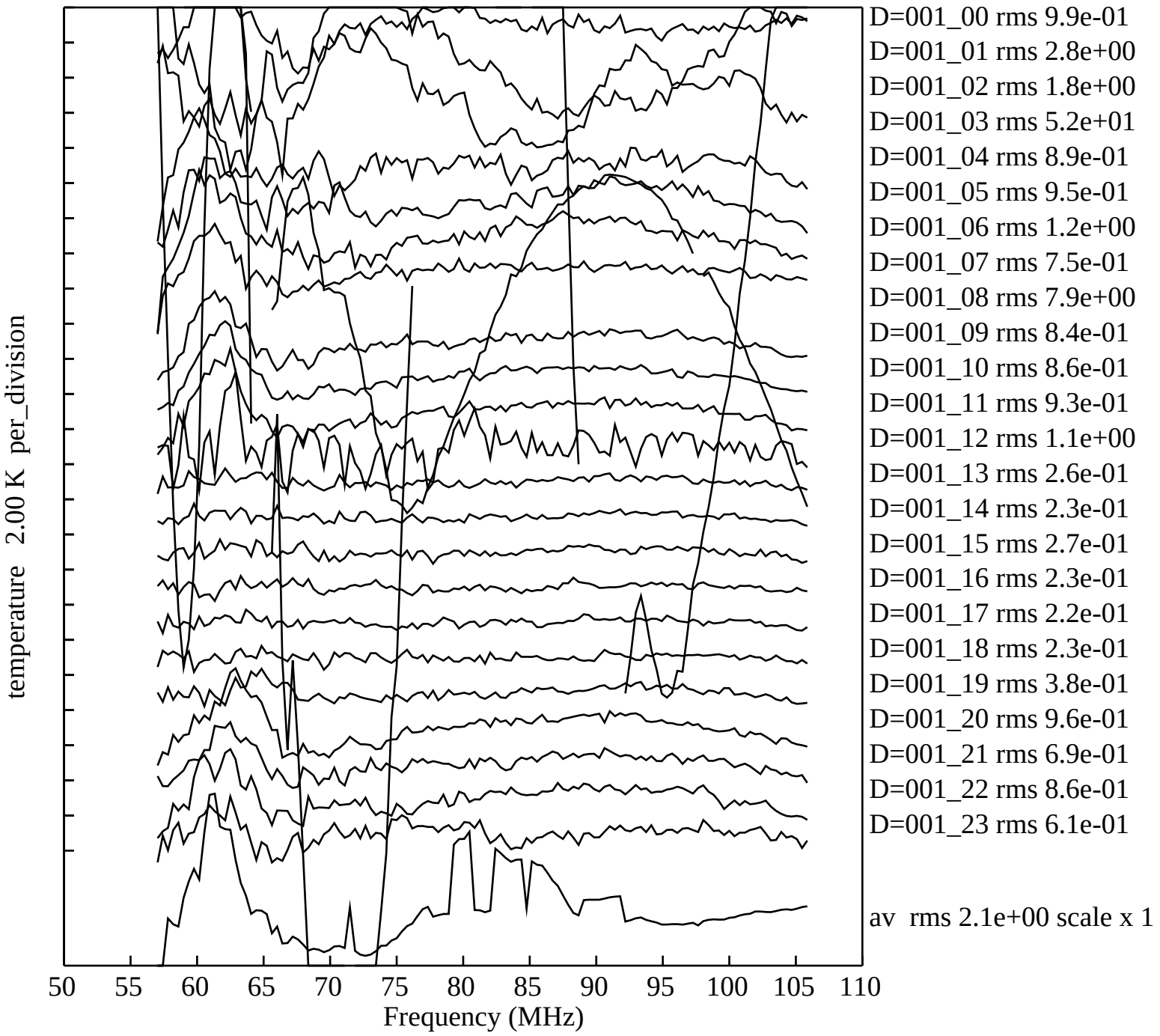


Figure 1. Residuals with 4 terms removed 1 hour blocks from 2025 day 1 without filters or rms limit

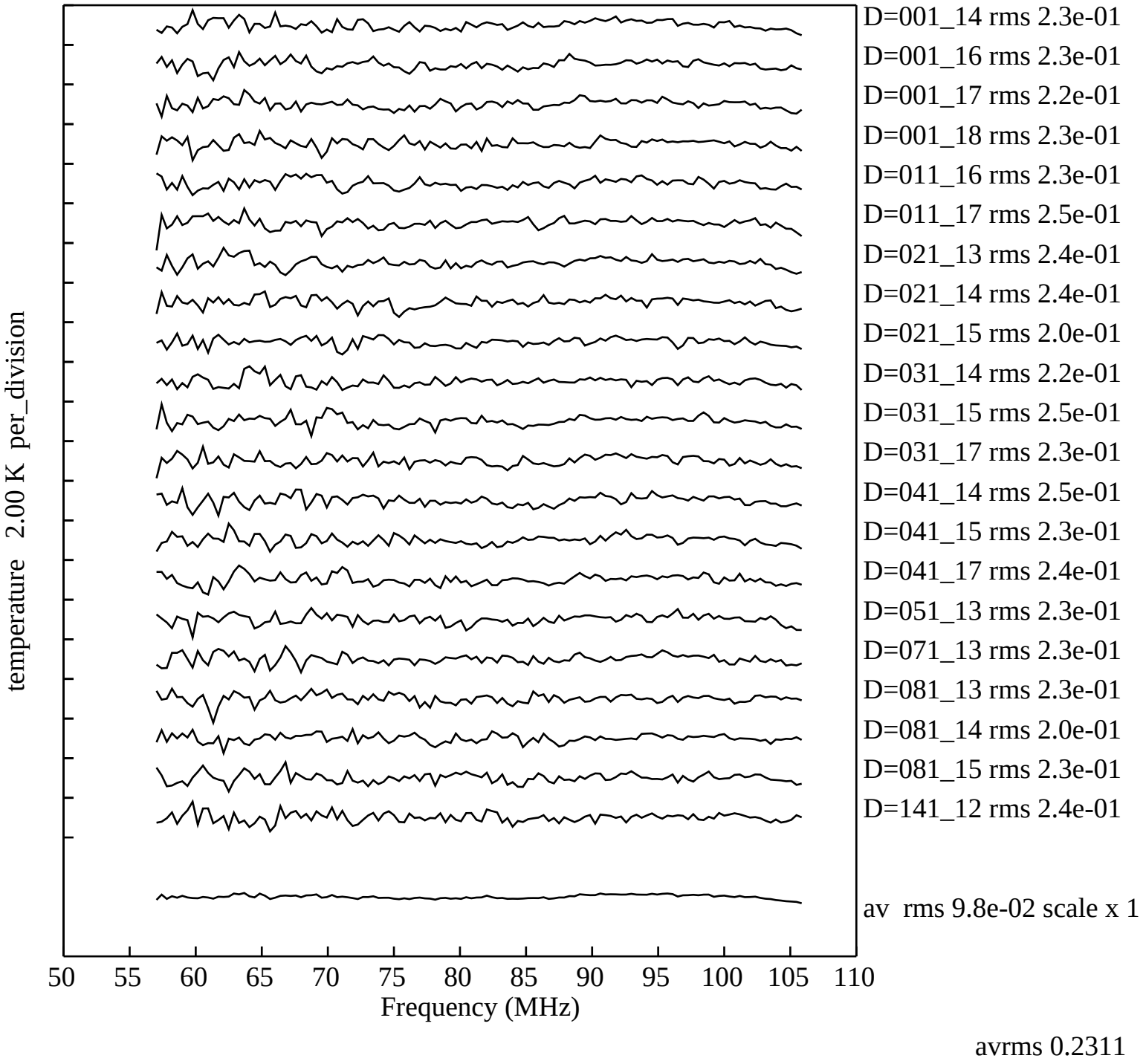


Figure 2. Residuals with 4 terms removed 1 hour blocks from 2025 every 10 days 001 - 161

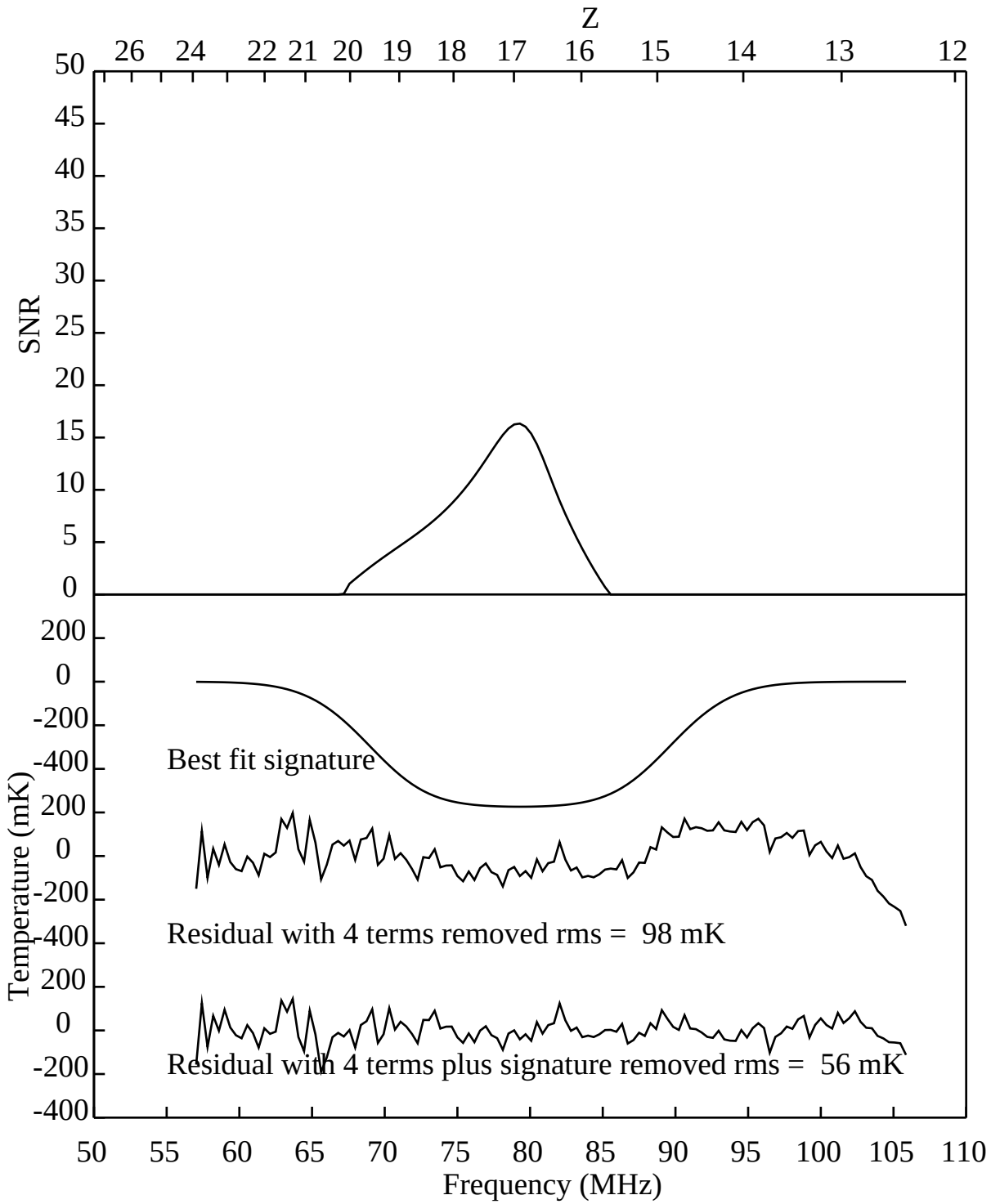
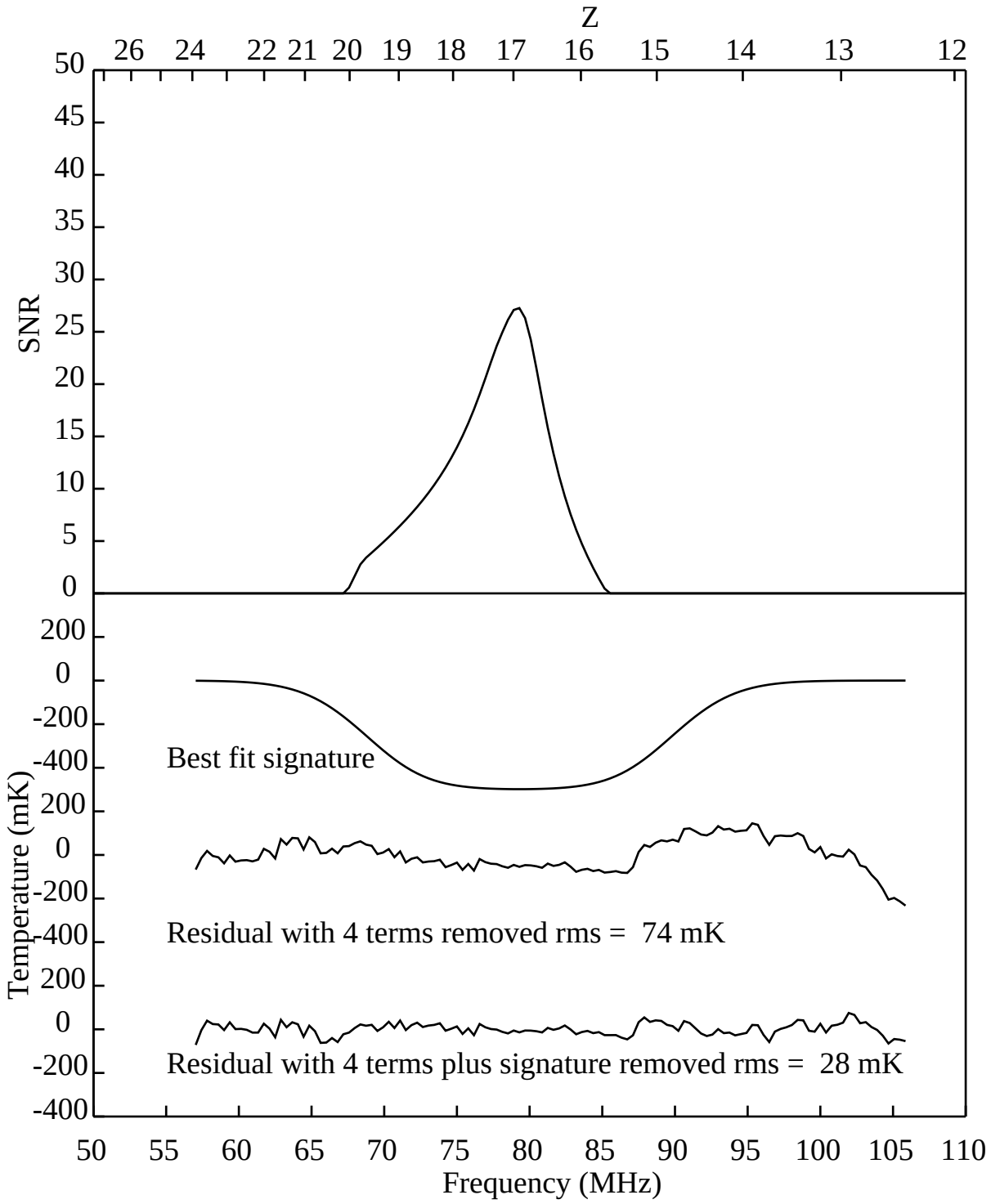


Figure 3. Grid search using rms limit 0.25 K and tau 4 for 1 hour blocks shown in figure 2



freq 79.3 snr 27.3 sig 0.50 wid 21.20 tau 4 rmsin 0.0737 rms 0.0281 57 - 106

Figure 4. Grid search using rms limit 0.25 K and tau 4 2025 for 1 hour blocks days 001 - 163