EDGES MEMO #403

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December 13, 2022

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To: EDGES Group
From: Alan E.E. Rogers
Subject: Preliminary analysis of the first EDGES-3 data from the MRO

EDGES-3 was deployed on the new 48x48m welded mesh ground plane in late November 2022. The data analyzed in this memo covers days 319 to 332 prior to the intermittent failure of the antenna connection on day 333.

Figure 1 shows the temperature measured by the FET temperature sensor in the pr59 thermal controller in the inner box which contains the Nuvo computer, ADC and the last amplifier and filters of the signal chain. The air circulation is described in memo 401 and because it is summer the outside air ranges from about 22C at 5 am to 38C at 3 pm local time. The figure shows that the inner box ranges from 30C to 50C. It was hoped that the 80m closed loop air path of PVC buried pipe would have resulted in a much smaller diurnal temperature due to the geothermal stabilization of the temperature but the soil thermal conductivity may be as low as 0.1w/m/K compared with 1w/m/K assumed in memo 33 of the deuterium array. Figure 2 shows the temperature of the “ambient” load which ideally should have remained more constant but may be good enough if the pr59 set-point is changed with season.

Figure 3 shows the unfiltered spectra on day 320. The RFI rails at 16 UT (0 MRO time) was from a VNA in the hut scheduled to make a daily test of an EDGES-2 system, which was no longer running, and was turned off. The VNA was turned off and this source of RFI is no longer present in the data. Most of the remaining RFI is from the micrometeor reflections in the FM band and is occasionally very strong most likely due to enhanced refraction as suggested in memos 58 and 141, scattering from aircraft as in memo 47 or from the presence of sporadic E.

Figure 4 shows the calibrated and RFI filtered data for days 319 to 330. Day 319 has a resonance at 100 MHz which was most likely because the cover plate on the baseplate under the antenna had not yet been screwed down and conductive copper tape put on the seams. There is considerable variability in the spectra below 65 MHz. One of the sources of this variability is due to lightning bursts. For example one such burst, which occurs on day 327 at 2022:327:01:10 is shown in Figure 6. A nearby lighting burst will be strong enough to result in ADC saturation (as discussed in memo 325) and be filtered out but more distant lightning will only effect the spectrum at the low end of the band. Figure 7 shows that dropping the peak power threshold from the value of 10% used in figure 5 helps reduce the variations of the spectrum below 65 MHz especially for day 327.

Unfortunately owing to the limited amount of data, the RFI and the possibility of resonances the maximum range over which residuals under about 160 mk can be obtained is only 60 to 99 MHz. Over this range the grid search results have some ambiguity in the absorption profiles even with a fixed tau = 7. Figures 8 and 9 marginal verification of the 21-cm absorption in the 2018 paper using 5-physical and 5-loglog polynomial foreground terms respectively. Simulations show that the limited range of 60-99 MHz makes is difficult to get a very solid unique fit to the absorption owing to the low rms residuals expected for a 5-term fit. Figure 10 shows the low rms of only 45 mK for lowband limited to this range for comparison with 48 mK rms in the residuals prior to fitting a profile in Figure 8.

Given the increased solar activity, sporadic E and the power line noise at many sites detection and verification of the global 21-cm absorption is getting more difficult. The EDGES-3 system can be improved in the following ways:

1] Better temperature control for more accurate calibration.
2] lower antenna reflection coefficient at the low end of the band. EDGES-3 has an S11 at 55 MHz of -9 dB compared with lowband at -14 dB.
3] Design improvements to make is easier to assemble without the need for any adjustments of antenna.

Some concerns based on the limited data which need further study:

1] Figures 5 and 7 show a narrow bump at 58 MHz. The is seen intermittently in figures 5 and 7 and with much greater strength in figures 8 and 9 of the Devon data in memo 397. I don't see it in EDGES-2 but it could be a resonance or from a bump in the ground plane. It is essential to understand and eliminate this bump to allow a feature search with a frequency range that goes below 60 MHz. The sensitivity to S11 error and noise is highest at the low end of the band and more integration will help analyze the effects below 60 MHz.

2] There is broad bump in the spectrum at about 75 MHz which is evident in Figures 5 and 7. It looks like it varies its strength varies from day to day so more data in also needed for further study.

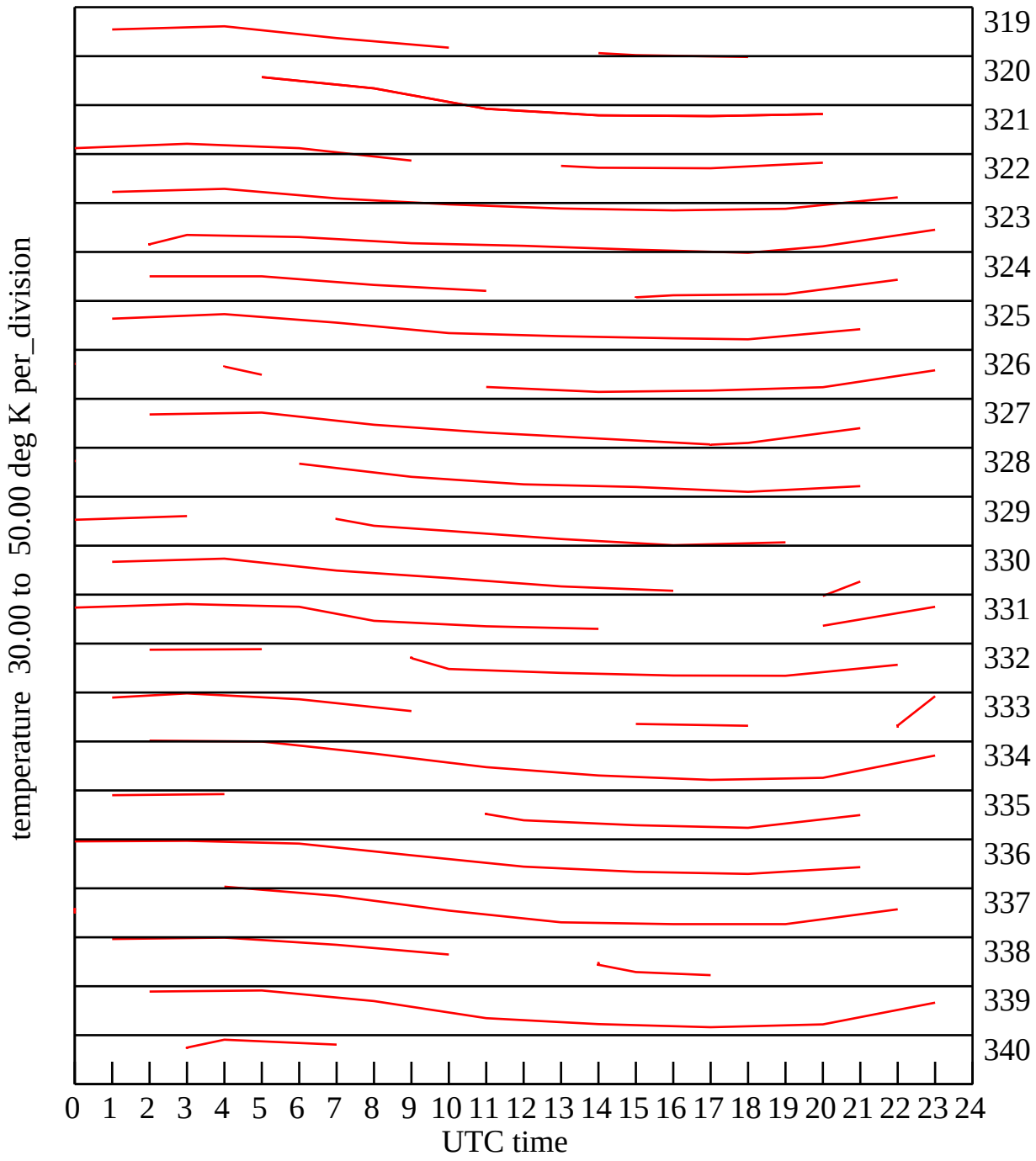

Figure 1. Temperature from sensor in “inner box” with Nuvo computer

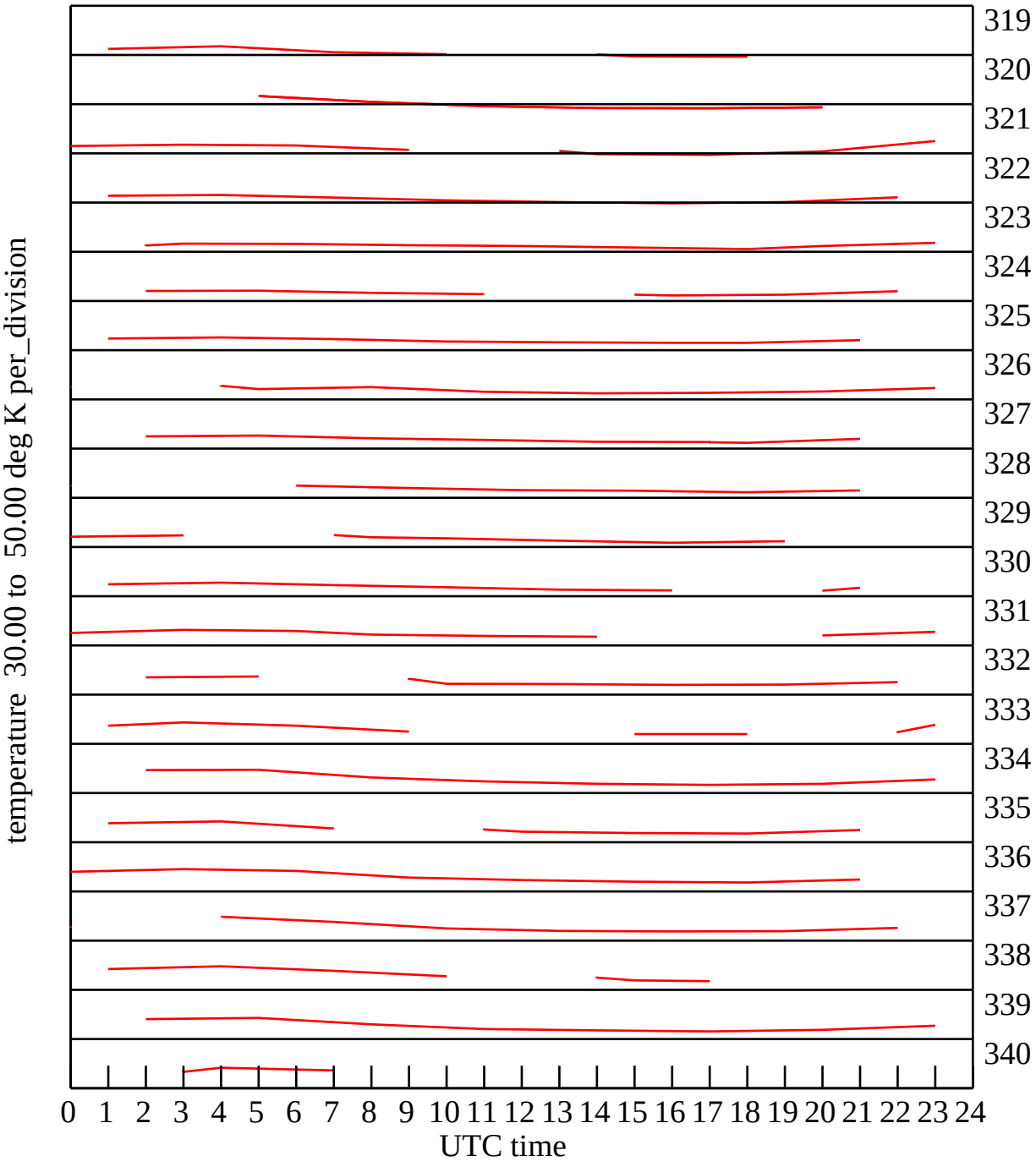

Figure 2. Temperature of ambient load in box with EDGES-3 frontend.

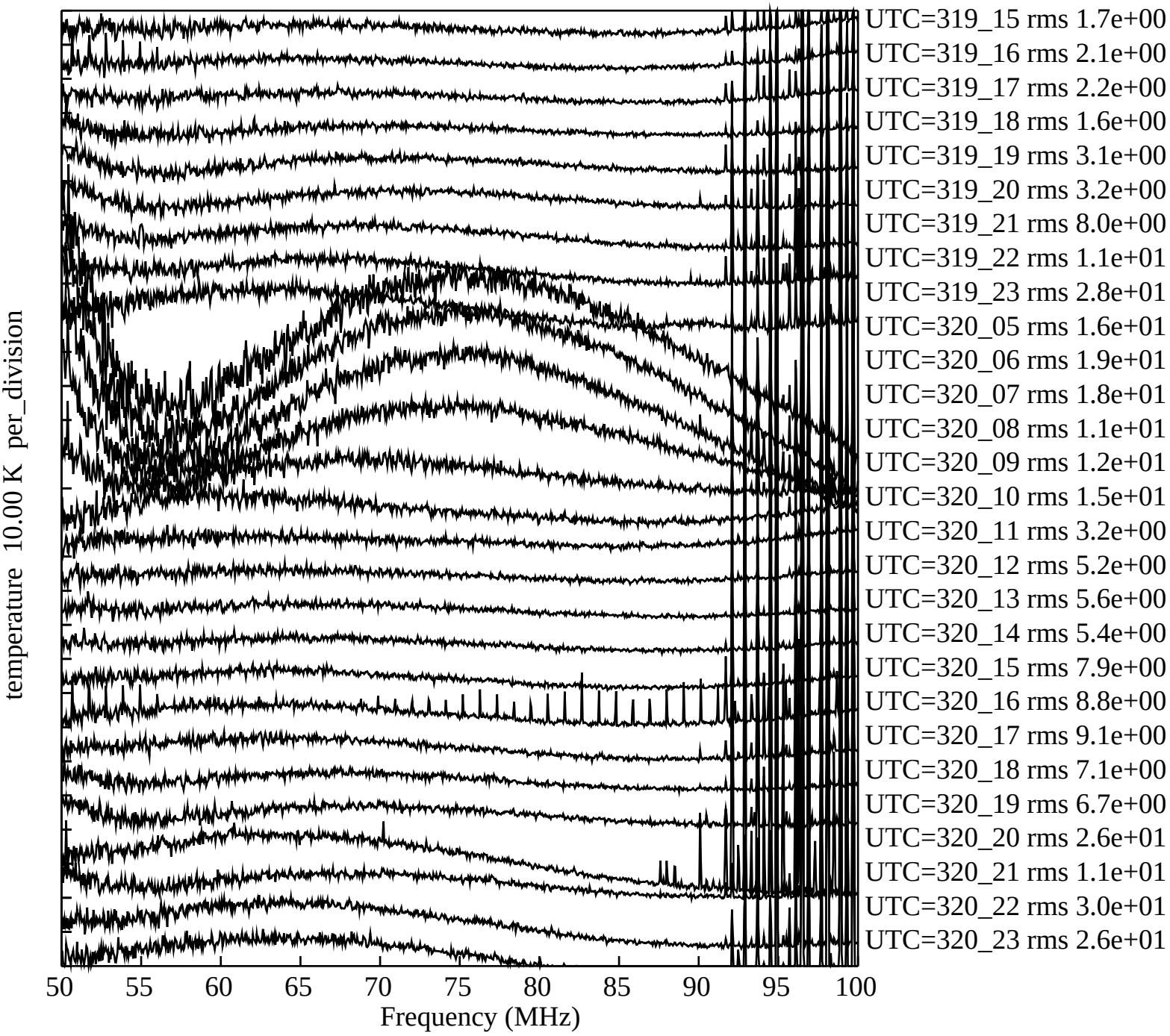

Figure 3. Spectra without RFI excision with 5-terms removed.

Figure 4. Spectra from days 319 to 330 in 1 hour blocks of GHA with beam correction and 5-physical terms removed.

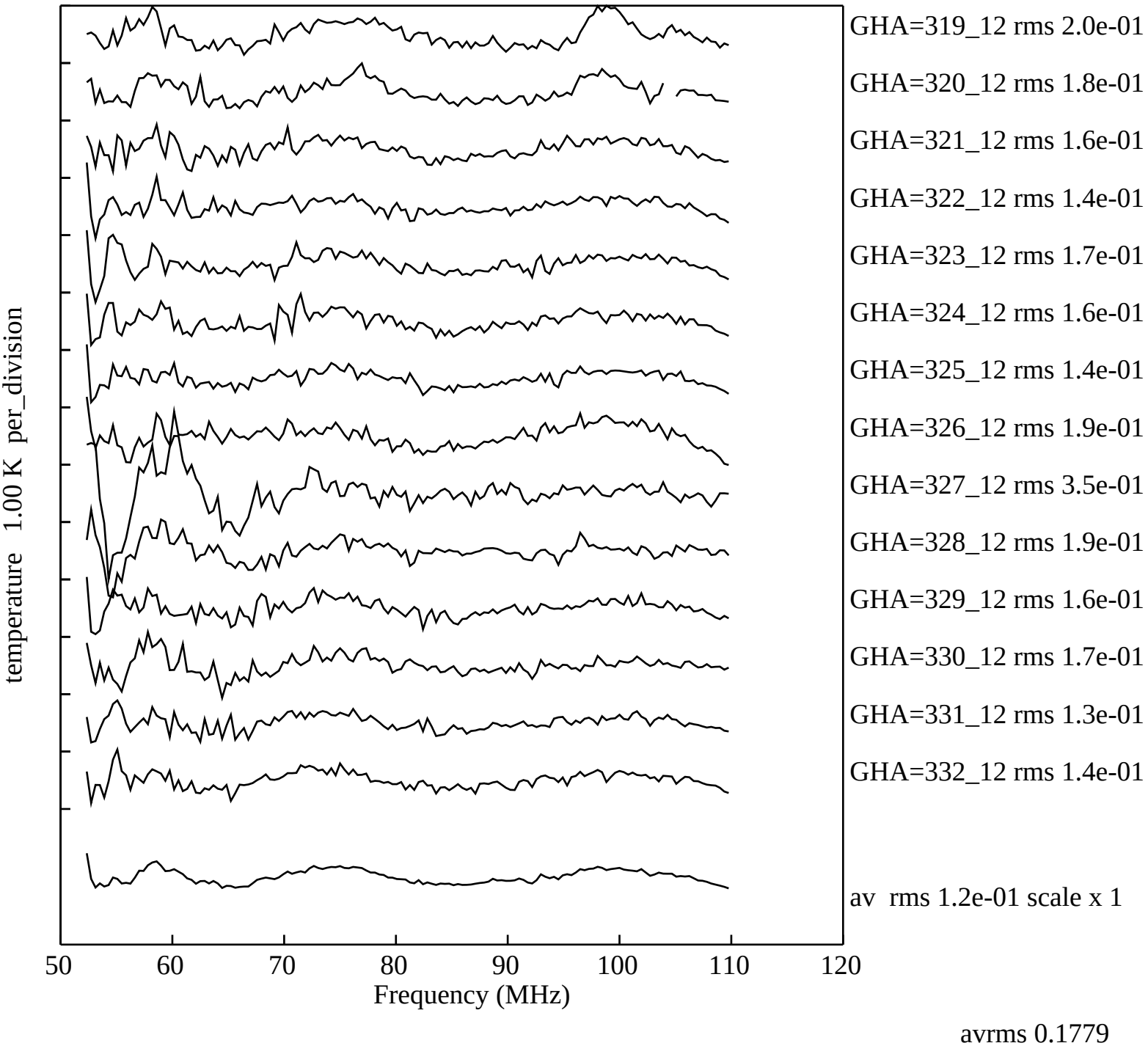

Figure 5. Spectra from days 319 to 330 in 8 hour blocks centered at 12 hours GHA with beam correction and 5-physical terms removed.

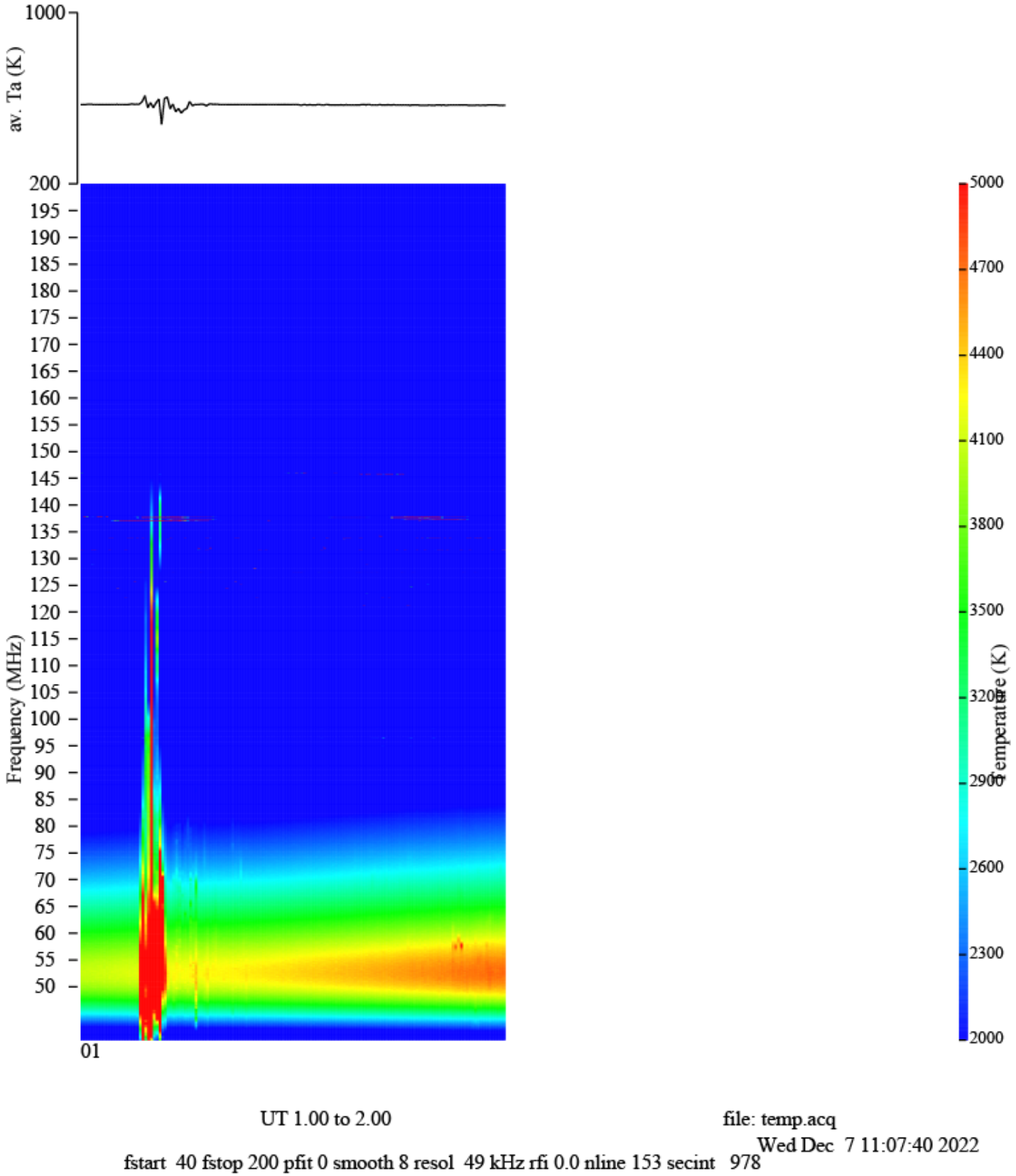

Figure 6. Waterfall plot of a burst of noise which is most likely from lightning.

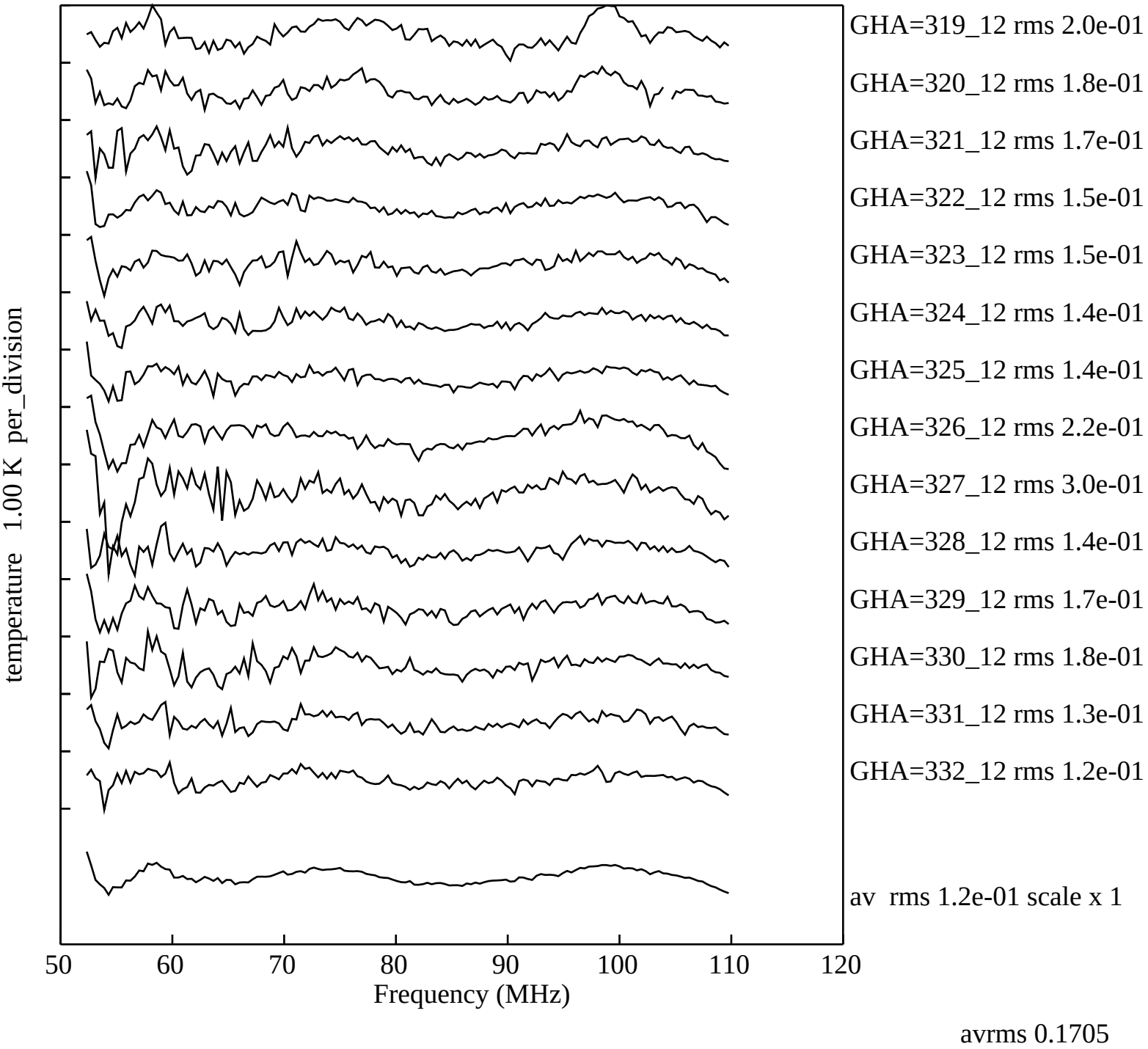

Figure 7. Repeat of spectra shown in figure 5 with lower peak power threshold.

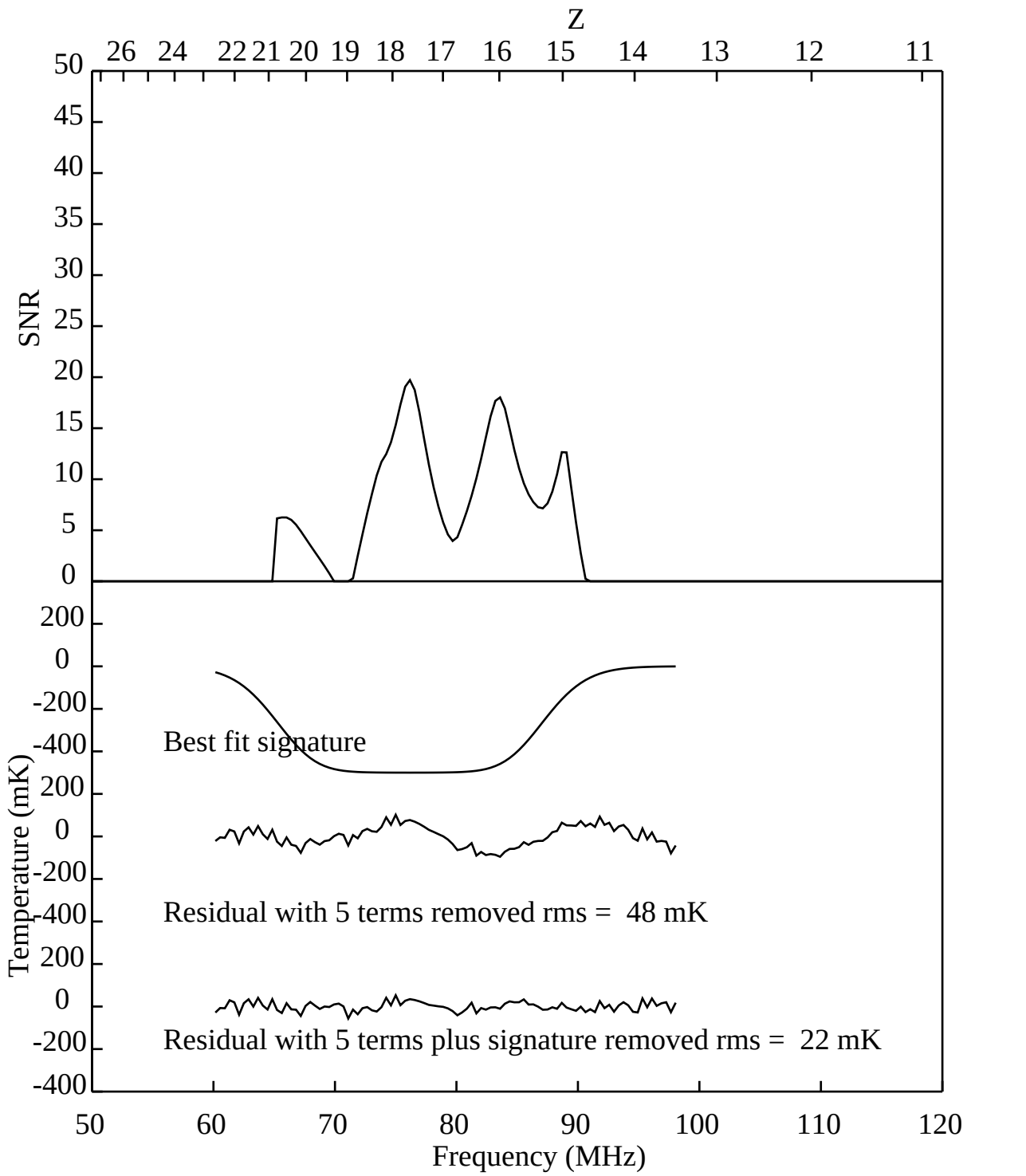

Figure 8. Grid search for absorption using data from days 319 to 332 using 5-physical terms.

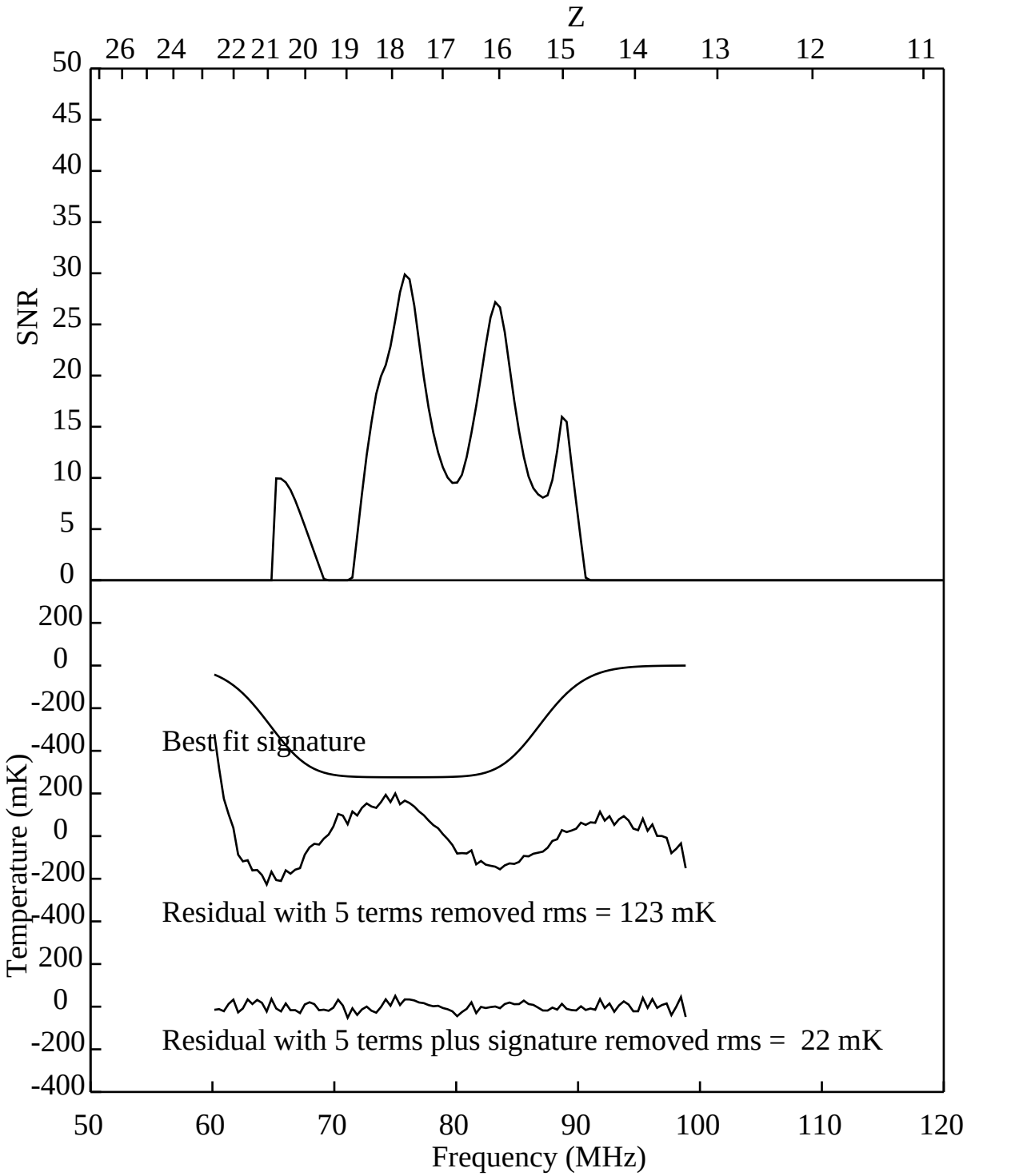

Figure 9. Grid search as in figure 8 using 5 loglog poly terms

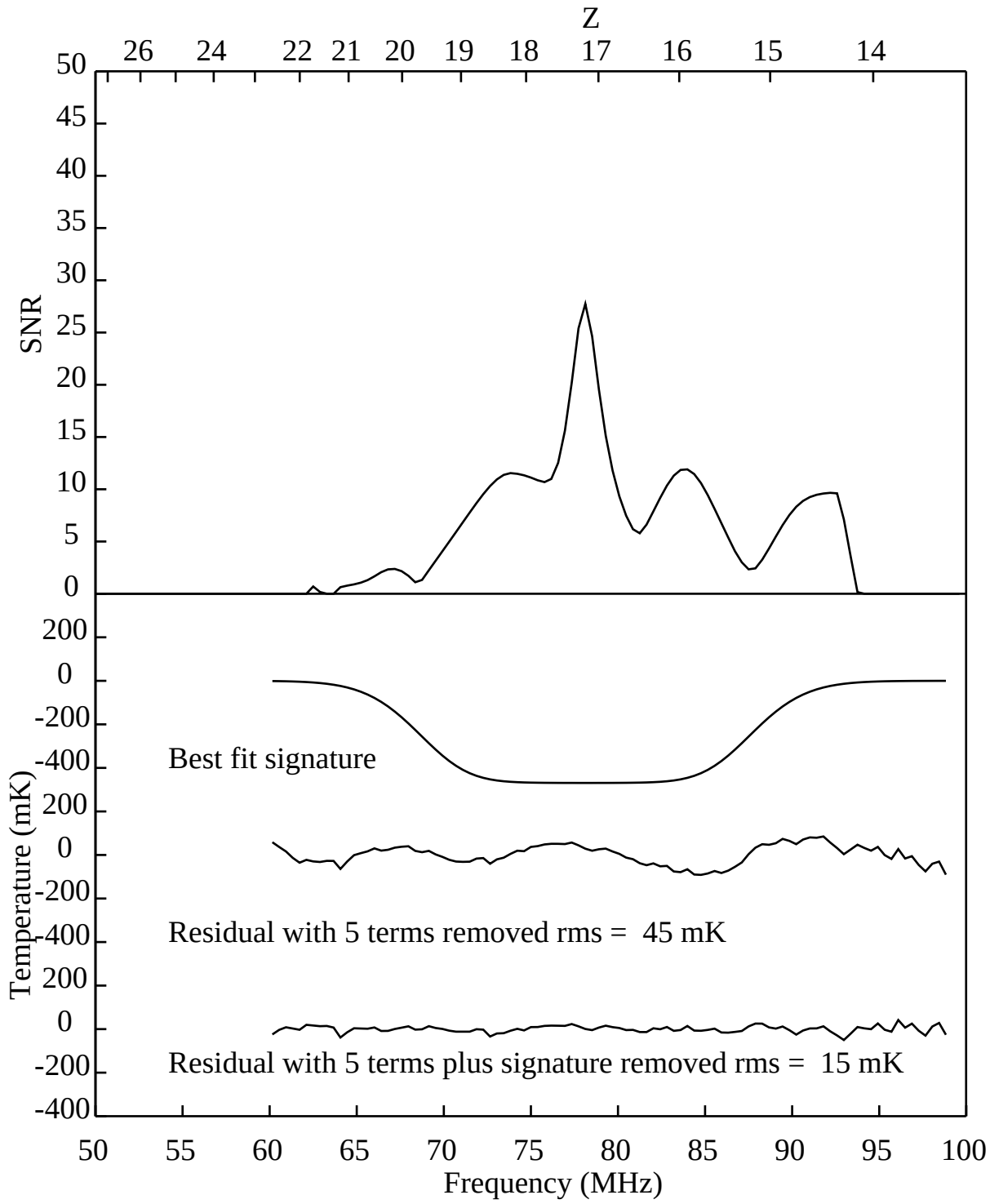

Figure 10. Grid search of the lowband data release in Nature 2018 paper using the limited range of 60-99 MHz for comparison with Figure 8.