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To: EDGES Group

From: Alan E.E. Rogers, John Barrett, Ken Wilson

Subject: EDGES-3 test deployment at Skull Creek, Oregon

The EDGES-3 was deployed at the Roaring Springs Ranch near the Skull Creek Reservoir from September 12 to September 17, 2019. The antenna which is shown in Figure 1 was placed on a 30×16m wire grid ground plane using a meandering 18 awg wire with 6.25 cm spacing for the inner wires and 12.5 cm spacing for the outer wires. This "mixed wire spacing" is studied in memo 308 and the layout of the wire and pegs are shown in Figure 2. The antenna and ground plane wire were oriented N-S within 1 degree at a location relative to the cattle branding area (shown in Figure 3 of memo 296) is shown in Figure 3. FEKO simulations were run to show that the wire fencing around the cattle branding area and along the farm road has a negligible effect on the beam at a distance of more than 70m.

In this test deployment it was only possible to operate the system while observing the sky for a period of about 3.5 hours on a single charge of the 4 batteries inside the "receiver box" compartment of the antenna. The RFI generated by the gasoline generator and the DC/DC inverter in the charger was extremely strong and even saturates the ADC so that only an internal calibration with the spectrometer connected to the internal ambient and hot loads along with the open and shorted cable could be run during charging. In a deployment to obtain more data the batteries could be continuously charged if the DC power for charging could be supplied form a solar panel with large battery storage and DC/DC converters in shielded boxes placed 100m from the antenna.

The area for the ground plane was cleared with a weed wacker and the wire grid ground plane was constructed on 11 September and the antenna set-up and data taken on 12 September (day 255). For charging the batteries a cable was run from the generators to the antenna. When taking Sky data the cable and generator were put back in the SUV and we drove back to the ranch HQ. In some cases for short tests we parked the vehicle about 150m from the antenna.

UT Day	Directory	File UT hours	Comments
255	oregon	18, 19, 21	No cover on receiver box
256	quick test	15	Quick test
256	or256	16.17,18	Sky data
256	generator test	20	Test of generator RFI
257	or 257	15,16,17	Sky data
258	or257cal	1,2,3	Internal calibration
258	or258	15,16,17	Sky data
258	or258_shrot_int	22,23	¼ samples per accum
259	or258_short_int	0	¼ samples per accum
259	or259	14,15,16	Sky data
260	or260	15,16,17	Sky data
260	or260_no_ground	21,22	Sky data with no ground plane

Table 1. List of data

A list of the acquired data is given in Table 1. Whenever we took spectra or S11 data we made sure the frontend box was maintained at 30 degrees C by the PR59 temperature controller.

RFI results:

Figure 4 shows the calibrated spectrum using thin lines from day 256 sky data without any RFI excision and Figure 5 shows that the RFI is mainly from the reflected FM and TV transmitters for which there is a line of sight from the transmitter to the micrometeorite and from the meteor to the EDGES-3 antenna. As discussed in memo #54 this can include a range of transmitters up to a range of almost 2000 km from the antenna only limited by the elevation of local horizon at the EDGES and transmitting antennas. The frequency of occurrence and strength in the Oregon data is much higher than that seen at the MRO shown in Figure 6 for comparison.

Reasons for the larger contribution of micrometeorite reflections from the Oregon site are:

1. There are far more FM stations with 2000 km of Oregon compared from those with 2000 km of the MRO.
2. The local time (UT -7 for Oregon) may be times and seasons with more micrometeors for Oregon than for the MRO – see Janches_et_al_2006

The effects of these micrometeorite "bursts" with the 8 second integration time used in the spectra files is that in the case of the Oregon data only about 10% of the 3 position cycles are not effected by the RFI.

It may be possible to increase the fraction of data not effected by the RFI generated by meteor scatter by reducing the integration time. Figure 7 shows the "bursts" obtained using a 2 second integration time obtained from a test made on day 258. In this case the fraction of data unaffected by RFI increased to 20%. The stronger bursts may last several seconds as it appears that some bursts in Figure 7 are picked up in adjacent 3-position cycles which are 6 seconds apart. Estimates of scattering from the moon, the space station and satellites in low Earth orbit are about, 50 mK, 100K and 0.06 mK respectively using the radar equation calculation given in memo 244. Aircraft are another potential source of the scattering of FM and TV signals but are expected to be less frequent than the scatter from micrometeorites. Comparison with the data form the EDGES systems at the MRO are approximately consistent with a factor 50 more FM power reaching the micrometeors from the ground. Also it appears that this added power results in a factor of 10 times more meteors are detected by EDGES in Oregon. Presumably this is because there is a tenfold increase in population of meteors which produce scattering which is detected in Oregon as a result of the increased power reaching the ionized region excited by the population of meteors, which are probably smaller particles. It is also apparent from the data that these particles has a flux which is more constant with the time of day and season. What EDGES observes is consistent with the Forward Scattering of Meteors in Yrjola and Jenniskens 1998.

RFI excision:

Figure 8 shows the spectra from days 256, 257, 258, 259 and 260 along with average using the same parameters and frequency range of 60-98 MHz as used in case 4 of memo 250. These parameters which included excising and 3-position cycles with average FM band signal over 800 K were found to give the lowest rms while still providing a few data points in the FM band in the average of all days. The total integration is only one tenth of the available data owing to the need to excise 90% of the data due to strong signals from the micrometeors. The final rms of 300 mK is probably too large for a significant verification of the hydrogen absorption signature obtained from the data taken with EDGES-2 at the MRO but improvements in the rfi excision algorithms is under study.

Other tests:

The spectra in Figure 8 were calibrated using the internal calibration performed on day 258 shown in Figure 9. Table 2 shows that using lab calibration, instead of internal calibration in the field along with not using beam and loss corrections made little difference to the rms with 4-terms removed from 60-98

MHz but given the high noise level due to the limited integration due to RFI these tests are not very definitive.

Internal calibration	Beam correction	Antenna S11	Loss corr.	Rms mK
Day 257	Yes	15 UT	Yes	305
Lab 30C	Yes	15 UT	Yes	331
Day 257	No	15 UT	Yes	314
Day 257	Yes	15 UT	No	319
Day 257	Yes	16 UT	Yes	310

Table 2 calibration tests

The ground plane was removed on day 260 and Figures 10 and 11 show the antenna S11 with and without a ground plane. Figure 12 shows the calibrated spectrum without beam correction of ground loss correction. The same RFI excision as in figure 8 was used and only 3% of the 40 minutes remained after removing RFI well enough to obtain any spectral points above 90 MHz. Four poly terms were removed in the fit.

The S11 of the antenna on the ground without the ground plane wires shows no more structure in the residuals to the 12 term polynomial fit than for the S11 with the antenna on the ground plane wires which is consistent with the absence of rock a few feet below the soil given the relatively low soil conductivity of 3e-3 S/m that we measured with the soil using a Hanna H198331 conductivity meter at the site. This low conductivity is also consistent with the soil conductivity made from the ground wave AM radio propagation maps of the USA. The ranch manager estimated that the bedrock in the area we placed the antenna is probably about 20 feet below the surface.

Wideband tests:

Figure 13 shows the calibrated spectrum from 50-200 MHz using the data on day 260 from 15:48 to 18:25 UT. The 2-term fit gives the spectral index of -2.478 and temperature of 319 K at 150 MHz.

Figure 14 show the residuals to a 5-term polynomial fit to calibrated spectra from 60 to 130 MHz using RFI excision in the manner similar to that used from 60-98 MHz shown in Figure 8 with some algorithm improvements.

Conclusions:

The site at Skull Creek in Oregon is limited by the FM and TV signals scattered by micrometeors but given the lack of many constant RFI signals it is better than the site 1 at the Gund Ranch in Nevada based on the data taken in 2014 shown in Figure 12 of memo #144 which shows more constant RFI signals in addition to the signals from micrometeors.

References:

Janches, Diego, Craig J. Heinselman, Jorge L. Chau, Amal Chandran, and Ronald Woodman (2006). Modeling the global micrometeor input function in the upper atmosphere observed by high power and large aperture radars. *Journal of Geophysical Research: Space Physics* 111, no. A7.

Yrjola, I., and P. Jenniskens (1998). Meteor stream activity. VI=. A survey of annual meteor activity by means of forward meteor scattering. *Astronomy and Astrophysics* 330: 739-752.

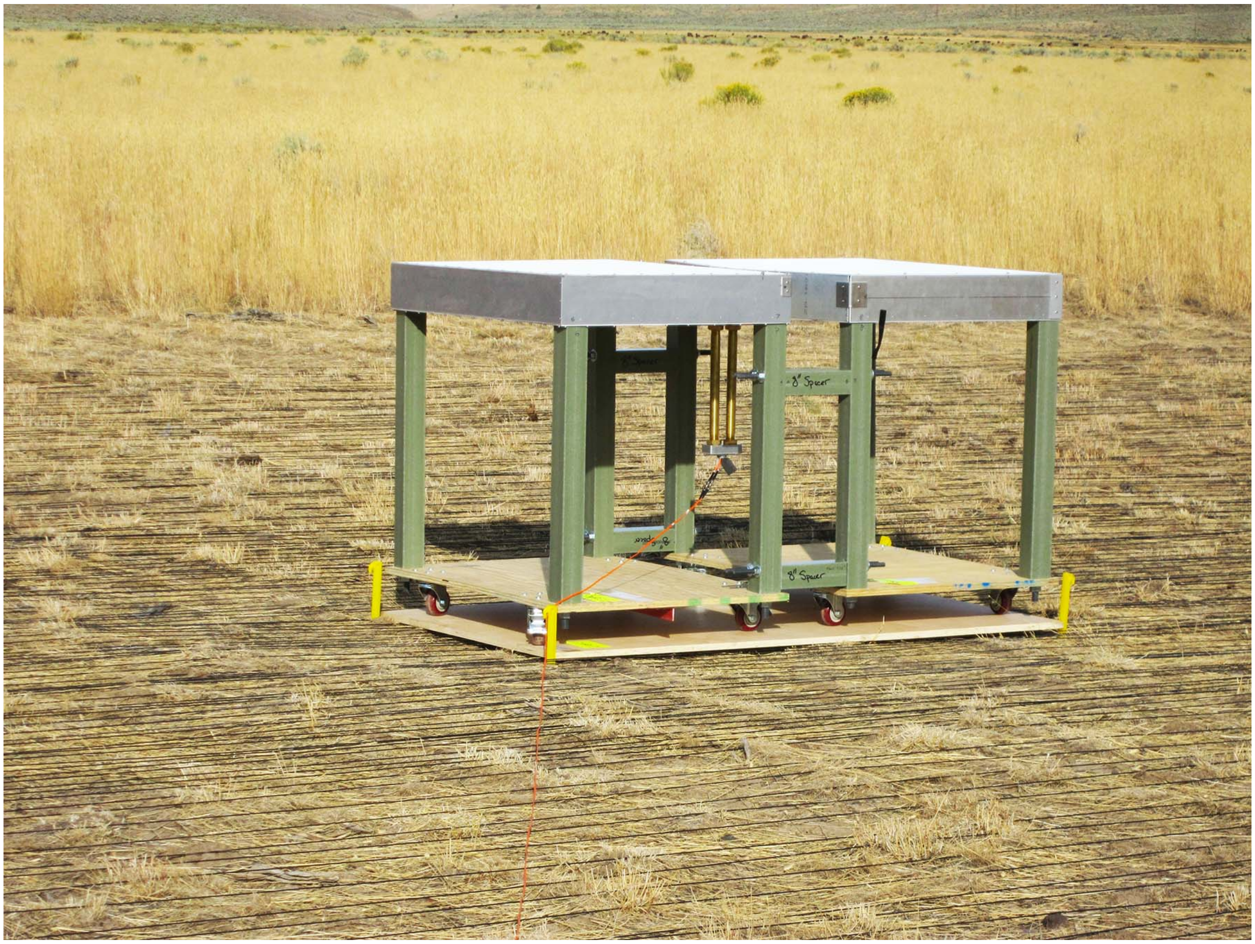
Figure 1. Test deployment of EDGES-3 at Roaring Springs Ranch.

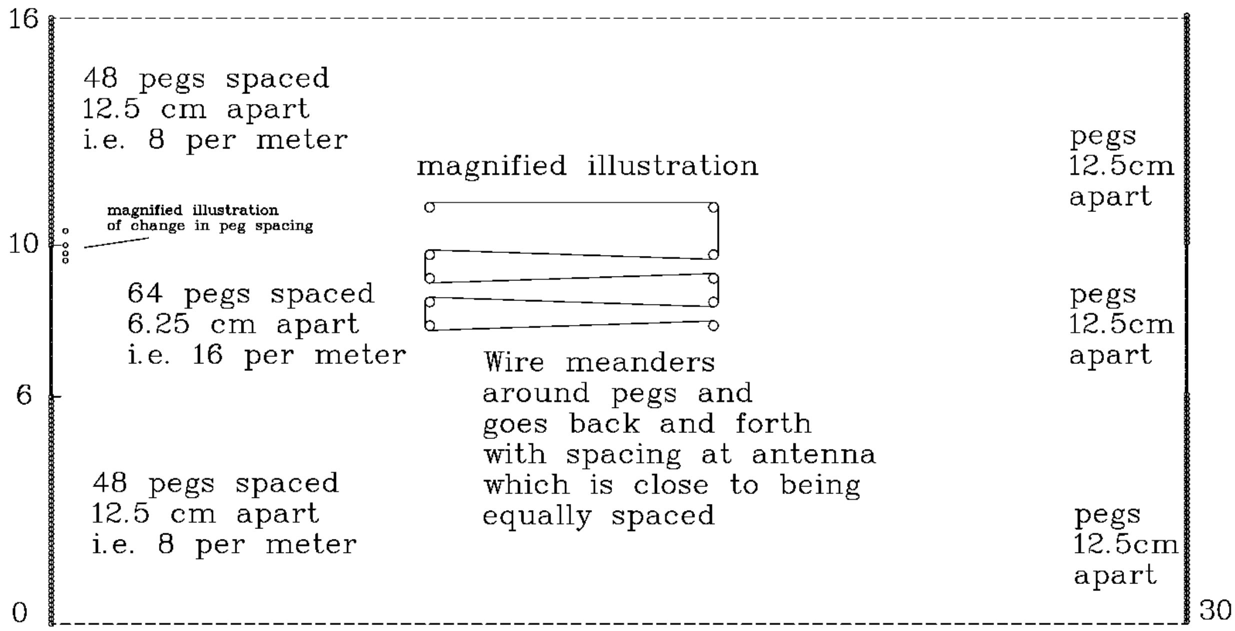

Figure 2. Layout of pegs and wire.

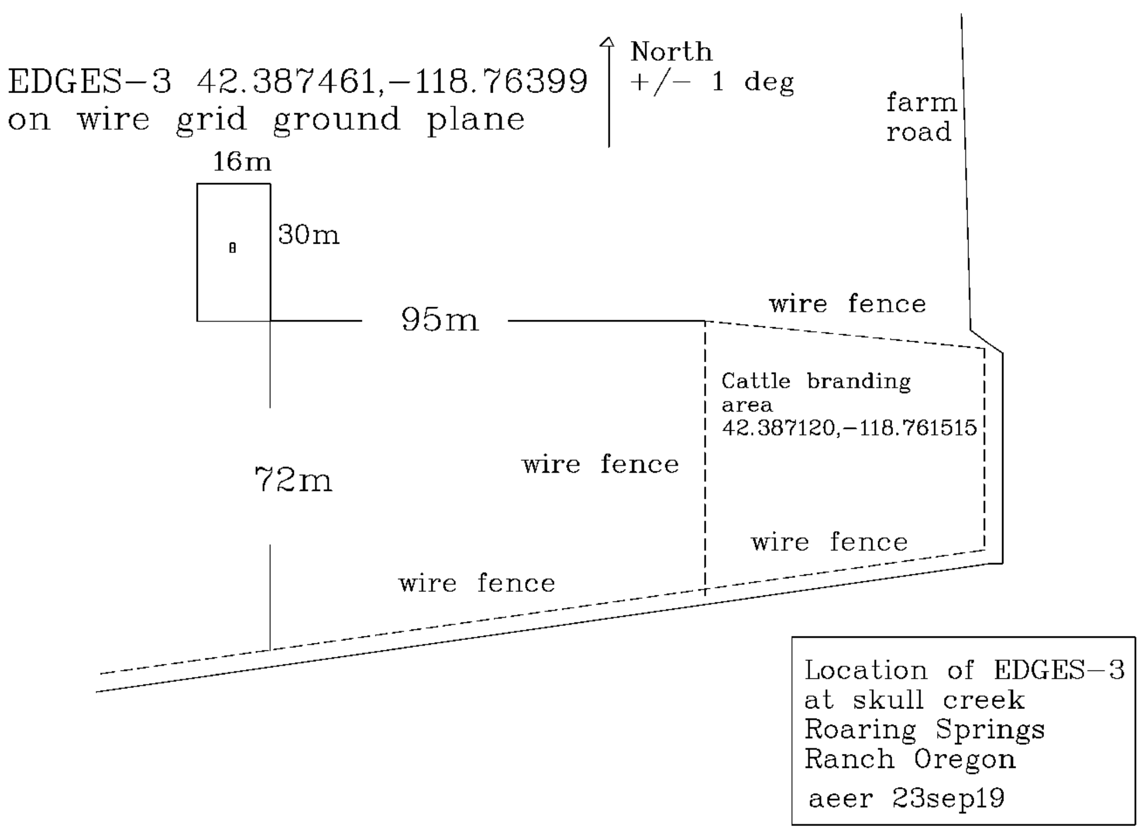

Figure 3. Location of the antenna relative to the cattle branding area.

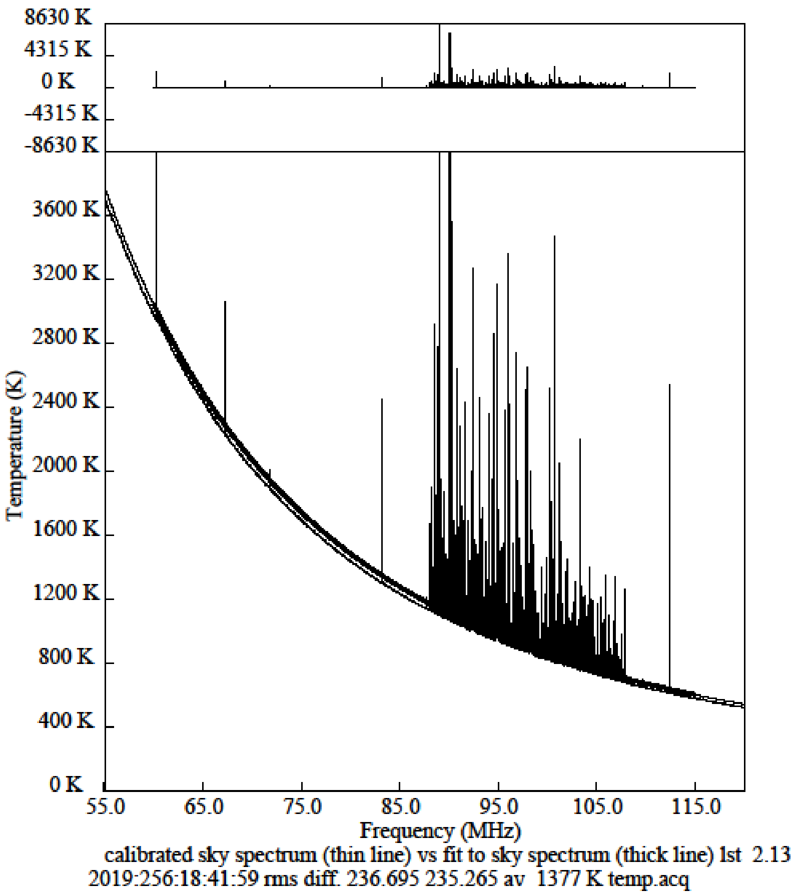

Figure 4. Calibrated spectrum from day 256 16:30 to 19:01 hr.

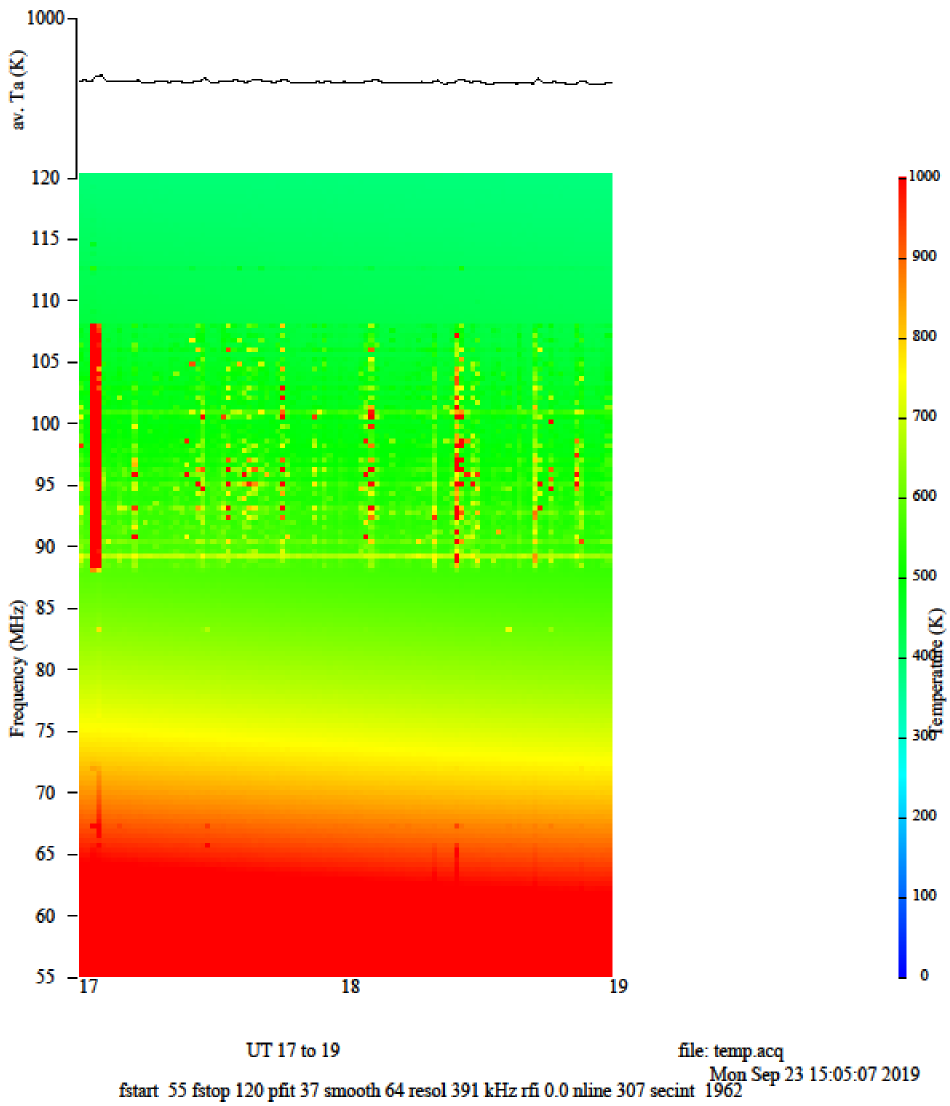

Figure 5. Waterfall plot for day 256.

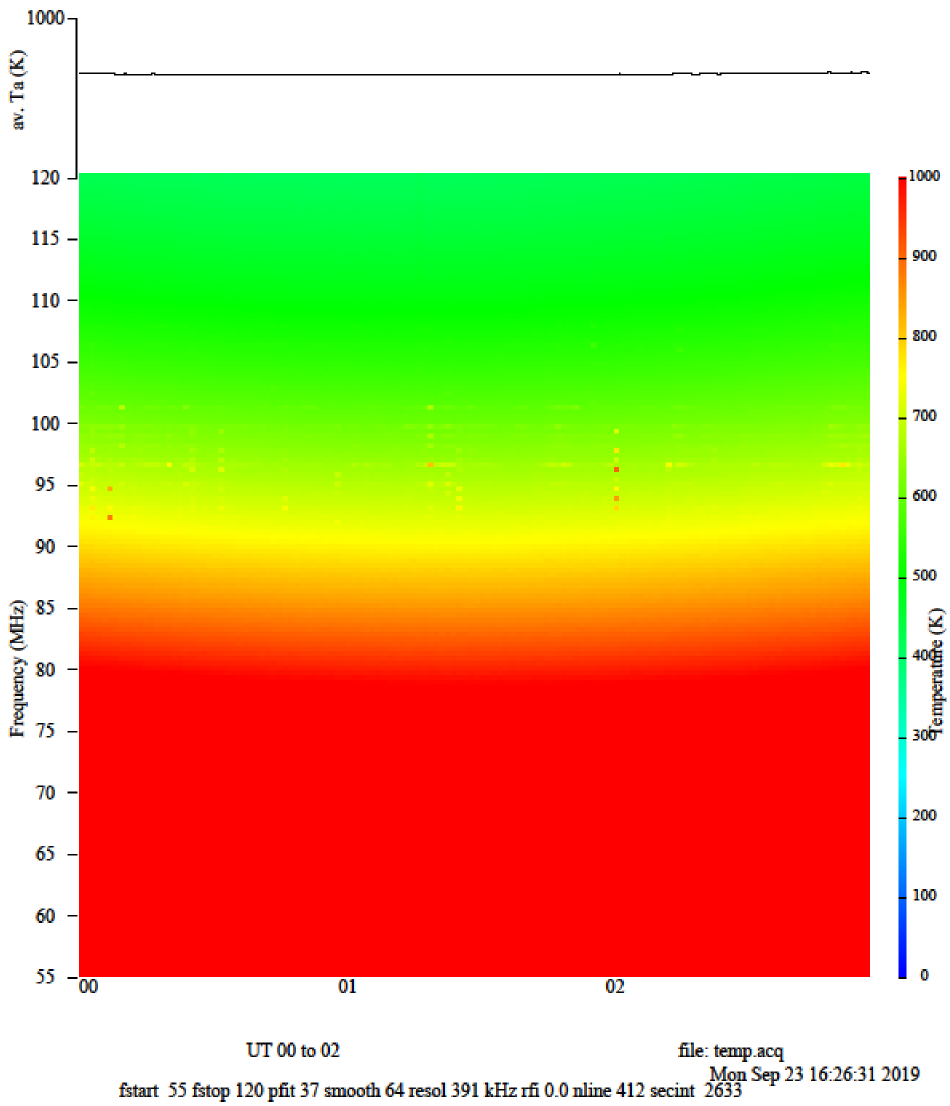

Figure 6. Waterfall plot for data from 2018_159_00.

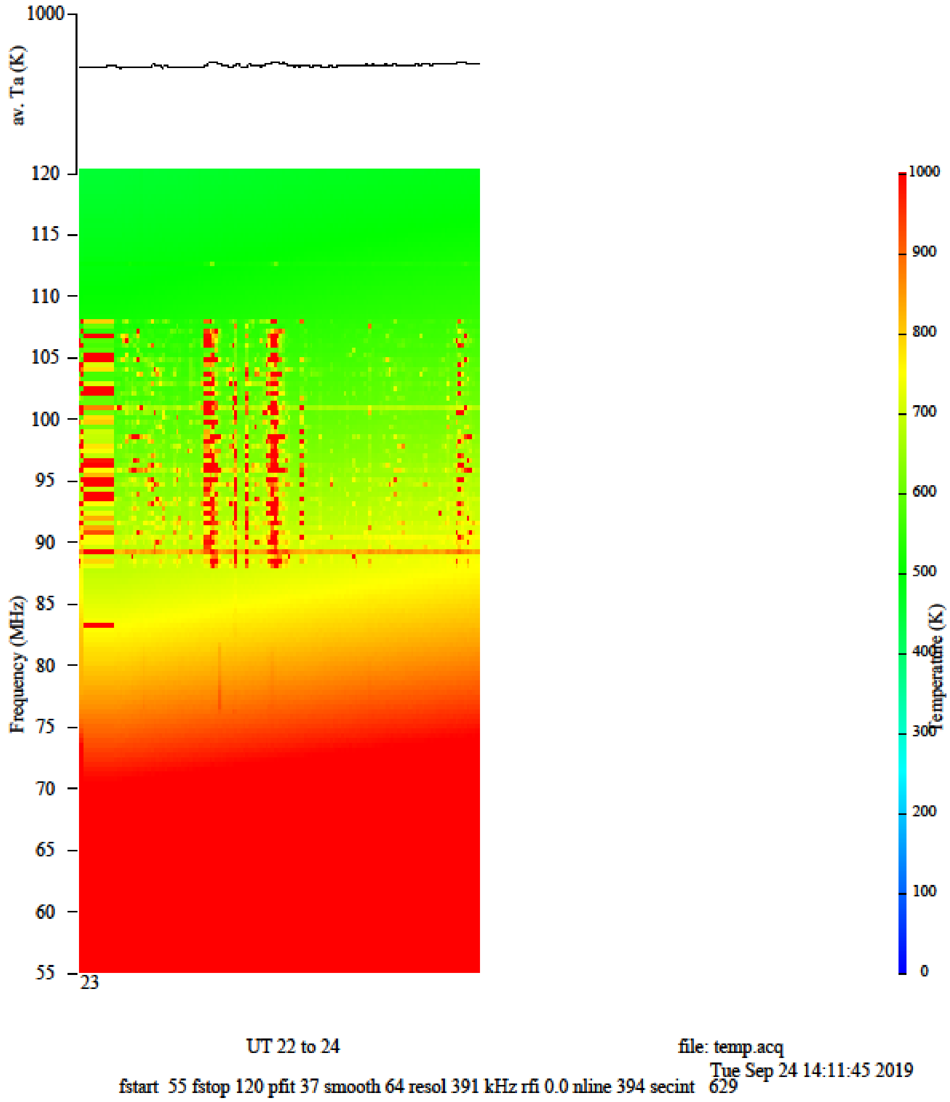

Figure 7. Data from day 258 with 2 seconds integration. The duration of the plot is 1 hour 20 min.

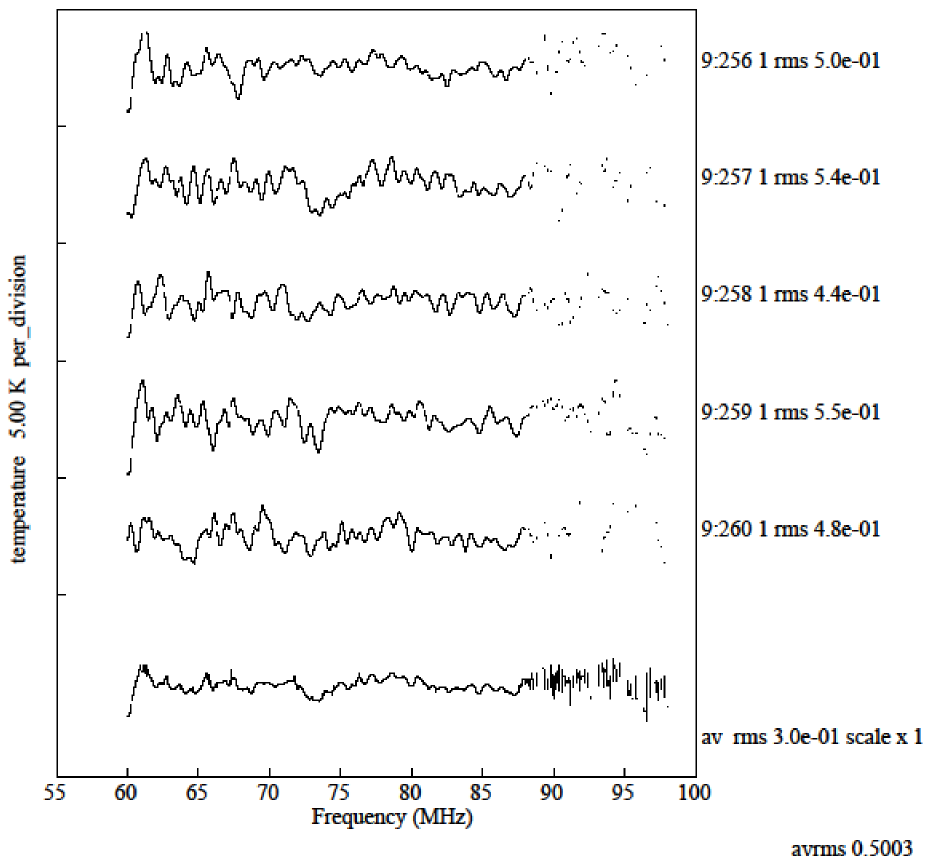

Figure 8. RFI filtered spectra with 4 poly terms removed.

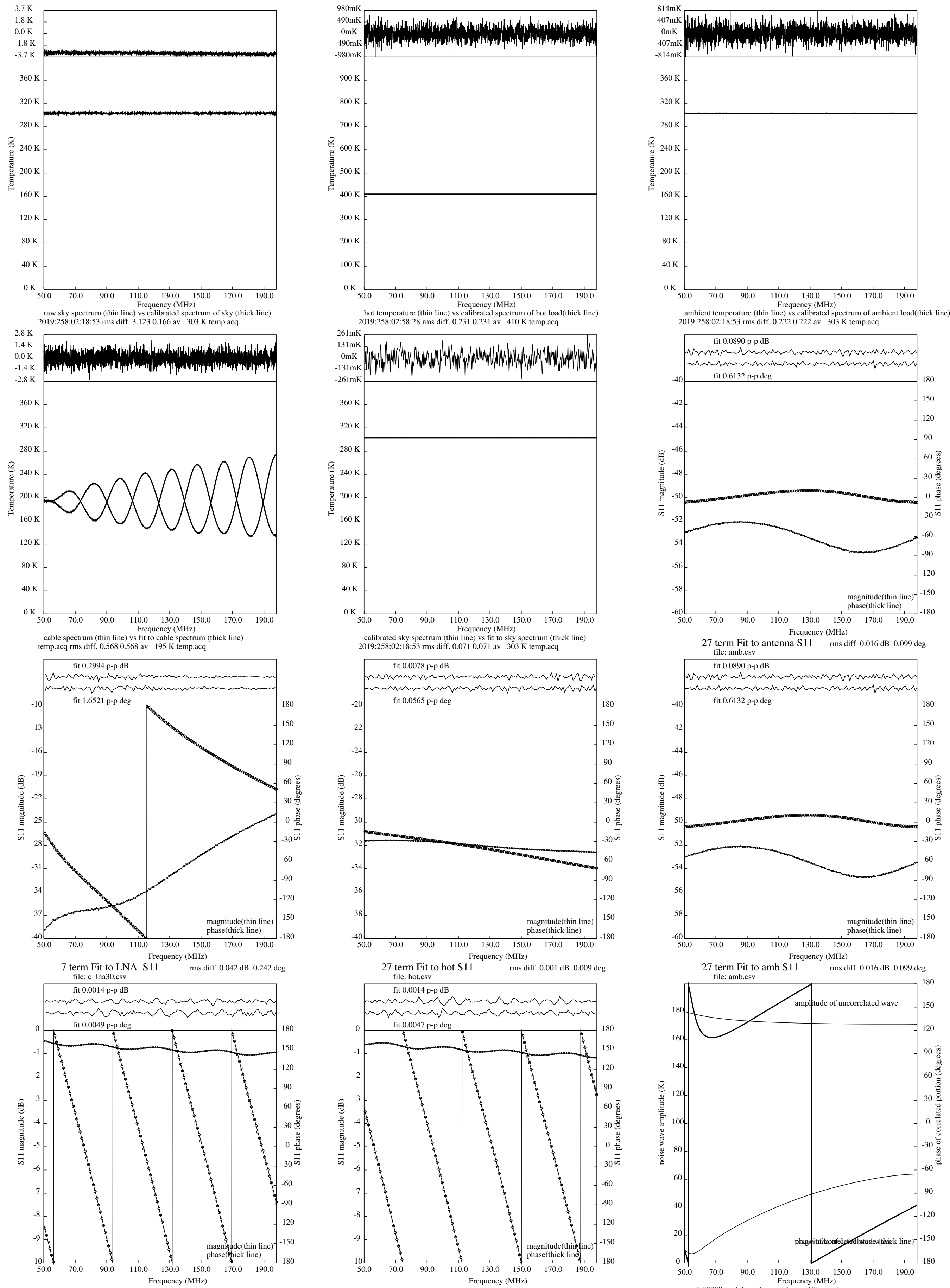

Figure 9. EDGES-3 internal calibration from day 257.

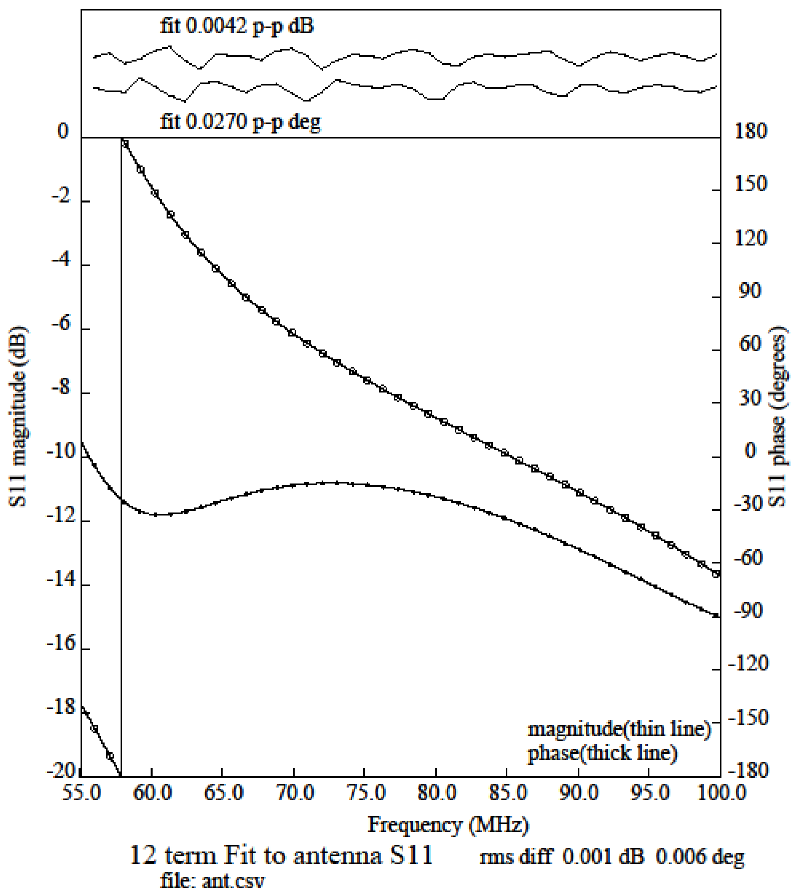

Figure 10. Antenna S11 on wire grid ground plane.

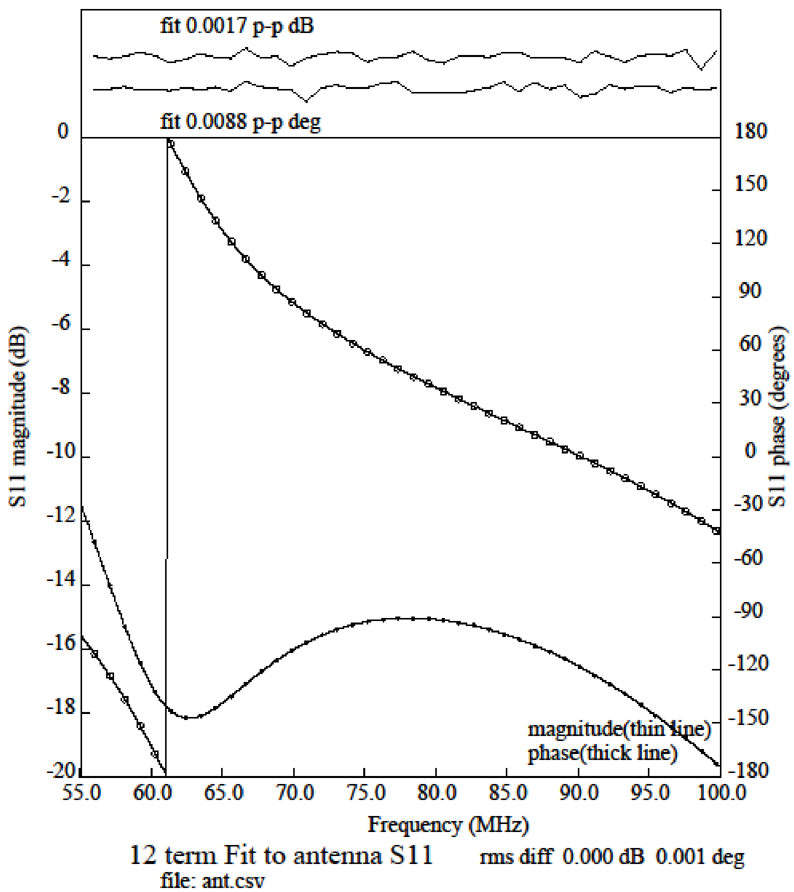

Figure 11. Antenna S11 on ground.

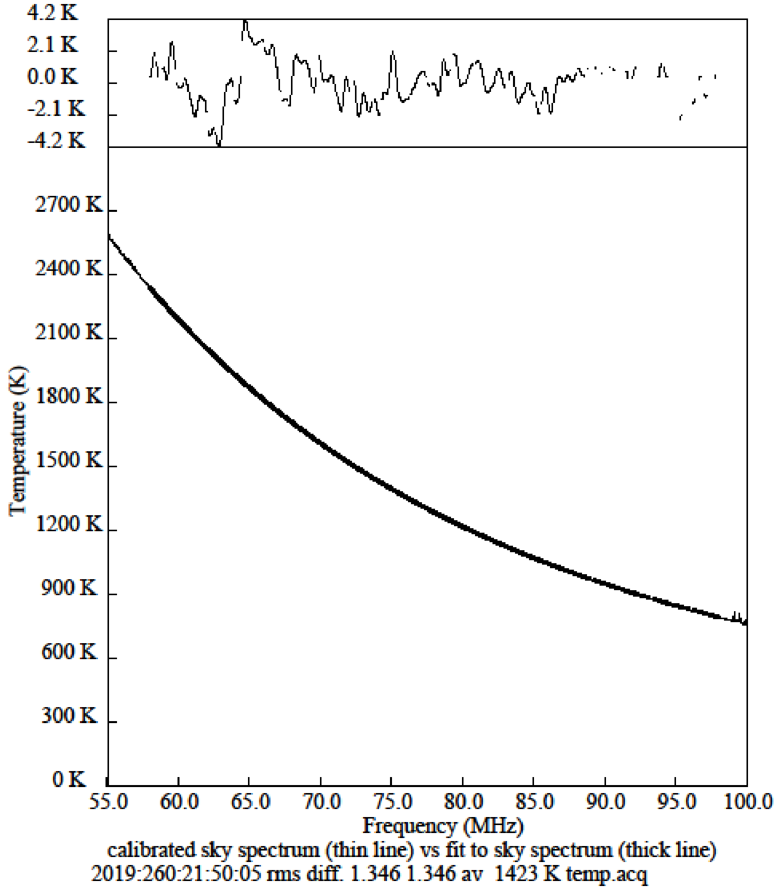

Figure 12. Calibrated and RFI filtered spectrum from antenna on ground without ground plane.

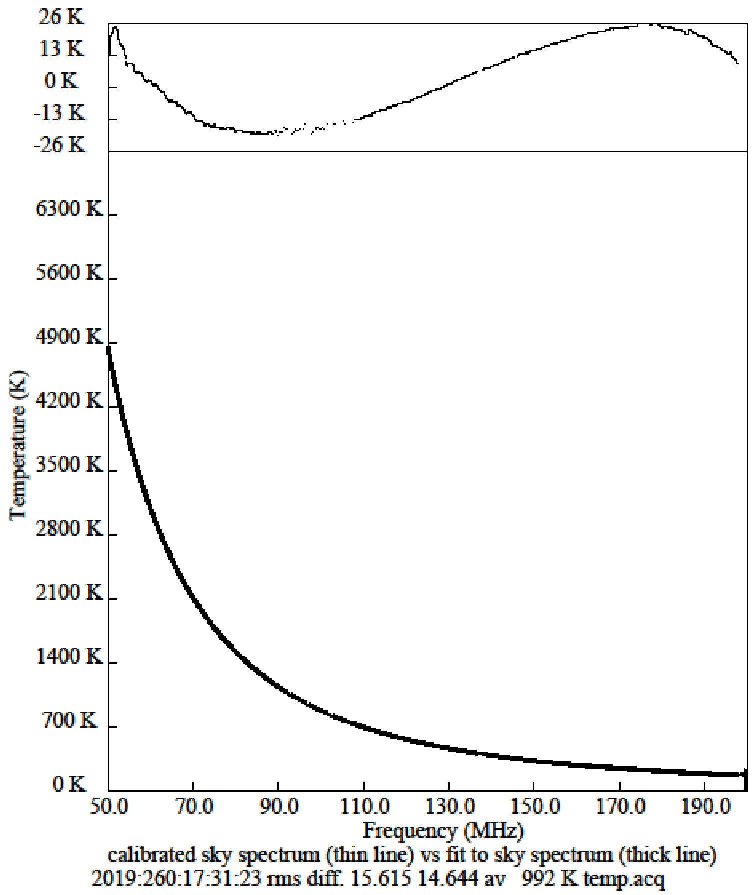

Figure 13. Full spectrum from 50-200 MHz.

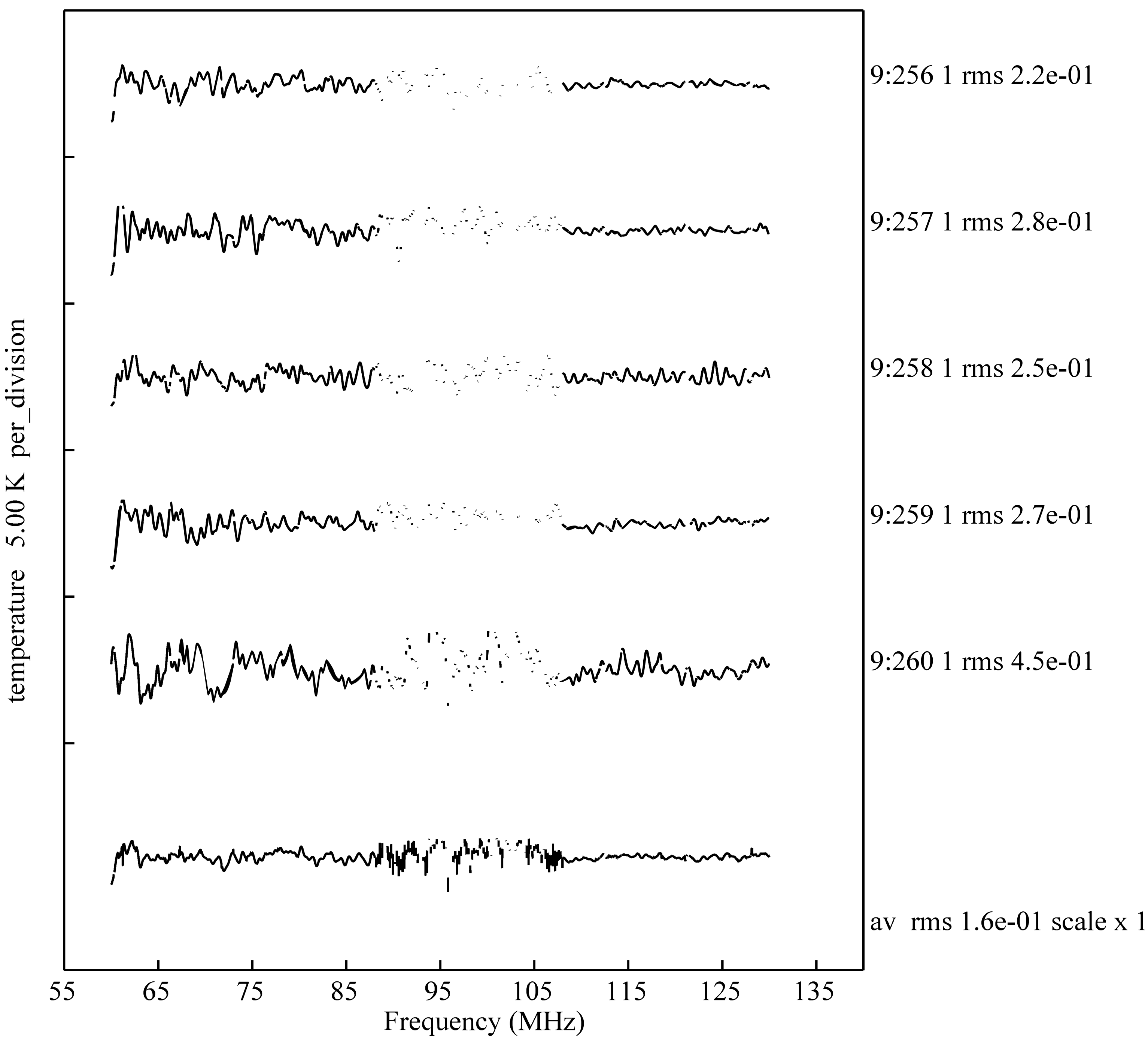

Figure 14. 5-term polynomial fit from 60 to 130 MHz.