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July 22, 2024

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To: EDGES group

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Subject: Fine time scale processing of solar bursts

The solar burst shown in figure 1 of memo 451 is over 1000 K but is only about 100 K when shown in figure 2 of memo 451. Figure 1 shows that in the case of this burst it is only present in one 30 second 3-position cycle and it could in fact be much stronger if it is only present in a fraction of the 30 second integration. Figure 2 shows a solar burst that has a peak which starts at 90 MHz drops in each 3-position switch cycle to 60 MHz as in a type 2 solar burst as discussed in memo 452. Figure 3 shows another solar burst, which like the one on day 175 in figure 1 is mostly in only one 30 second integration of EDGES-3. This one appears to be relatively broad band but could be a fast scan in frequency. This type could be studied with EDGES-3 if a mode which triggers the saving the individual data samples upon receiving a strong signal is implemented. These strong bursts of thousands of deg K, which are only seen by EDGES-3 when the sun is well above the horizon must be coming directly from the sun and are not detected at a high signal level when coming from a low elevation because the EDGES antenna gain drops to less than -20 dBi near the horizon. The plots in figures 1,2 and 3 are without a polynomial fit and have only a constant subtracted.

Figure 4 shows the variation of strength and frequency with local time. It is averaged in one hour blocks over 100 days of data to get low enough noise to see the fine structure. Figures 5 and 6 show the dependence of the feature on the sun elevation at sunrise and sunset respectively. These plots show that it is a little stronger at sunrise than at sunset and shifts down about 2 MHz between sunrise and sunset. The sunset plot shows that it is still be present in the sunset data that covers 21 to 22 degrees below the horizon.

Figure 7 shows the fine time scale processing of the solar event shown in figure 3 of memo 448 on a fine time scale with only a constant removed to show that the feature at 65 MHz is right on the bend in the spectrum due to attenuation of the ionosphere. As discussed in memo 448 the waterfall plot shows a surprisingly large increase in the reflections from the FM radio stations which starts at about 17 UT. While these FM signals are normally filtered out the FM filter has been turned off in the plots in figure 7 to emphasize that the feature at 65 MHz which is especially strong at 21.741 UT and is accompanied by more 65 MHz bumps in the spectra at 21.748 and 21.755 as well some at other switch cycles like that at 21.644 UT. This case of the presence of the feature, when the sun is very low on the horizon, suggests that the 65 MHz may be coming from the sun via reflections from the plasma in the ionosphere.

Based on the relatively constant amplitude of the feature with local time the "feature" must be coming from high in the sky and not directly from the Sun as in figures 1,2 and 3. A possibility is that it is coming from the sun via plasma in the ionosphere in a manner similar to the reflections from the FM radio stations which are enhanced as seen in figure 3 of memo 448.

Figure 8 shows the how the 40 K feature at 65 MHz in figure 7 averages down to about 4 K in one hour integration block from 05 – 06 LT (21 – 22 UT). The feature on day 198 of 2024 is shown for comparison. Data from the "Solar Maximum Mission" satellite recorded as many as 20 solar events per day averaged over a month at solar maximum compared with one per day at solar minimum which might explain the increase in the occurrence of the feature at 65 MHz from 2023 to 2024.

In only one case so far the feature, seen when the sun is only about 3 degrees above the horizon, is strong enough to be clearly seen at a level of about 40 K on a time scale of the 30 second switch cycle. This suggests that the feature at 65 MHz seen by EDGES when the elevation of the sun is between -20 to +3 degrees is not coming directly from the sun because gain of EDGES is more than a factor of 200 lower at 3 degrees than at 45 degrees.

A study of the details of the "feature at 65 MHz" made so far can be summarized as follows:

a) The feature is absent when the sun is more than about 20 degrees below the horizon – memo 452
b) There is a drop in frequency of the peak by about 2 MHz from when it is first seen before sunrise to sunrise as shown in memo 452
c) There are variations on time scales as short as 30 seconds as well as on time scale of hours and days
d) The feature was first seen around day 240 of 2023 and has risen in occurrence by around day 130 of 2024 as shown in memo 450
e) The apparent increase in amplitude shown in figure 1 of memo 450 is largely due to an increase in occurrence of the feature in a single 30 second 3-position switch cycle
f) There is a possibility that the feature at 65 MHz comes from the sun directed to the earth by "ionospheric bending" and not from the plasma above earth. I cannot find measurements of the plasma spectra from above the earth during this time of high solar activity which cover 65 MHz at the sensitivity of EDGES and are made from an area as radio quiet as the WA or are made from space. Measurements made at Greenbank reported by Stephen White are limited by a TV signal from 60 – 65 MHz and the RPW instrument only goes to 16 MHz.

References:
White, S.M., 2024. Solar radio bursts and space weather. *arXiv preprint arXiv:2405.00959*.
Maksimovic, M., Bale, S.D., Chust, T., Khotyaintsev, Y., Krasnoselskikh, V., Kretzschmar, M., Plettemeier, D., Rucker, H.O., Souček, J., Steller, M. and Štverák, Š., 2020. The solar orbiter radio and plasma waves (RPW) instrument. *Astronomy & Astrophysics*, *642*, p.A12.

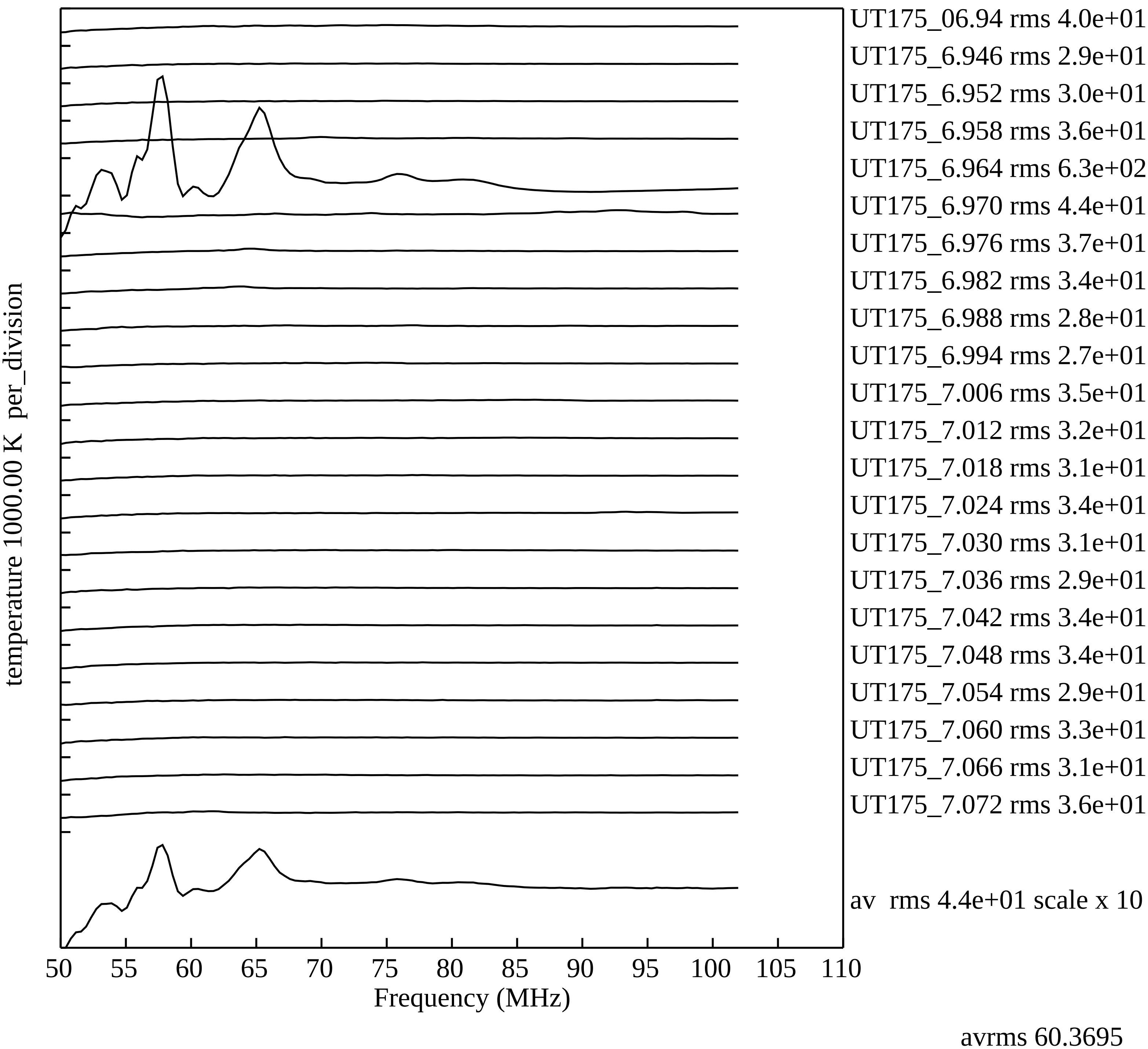

Figure 1. Solar burst on 2024 day 175 spectra for each 3-position switch cycle 6.940-7.072 hours UT

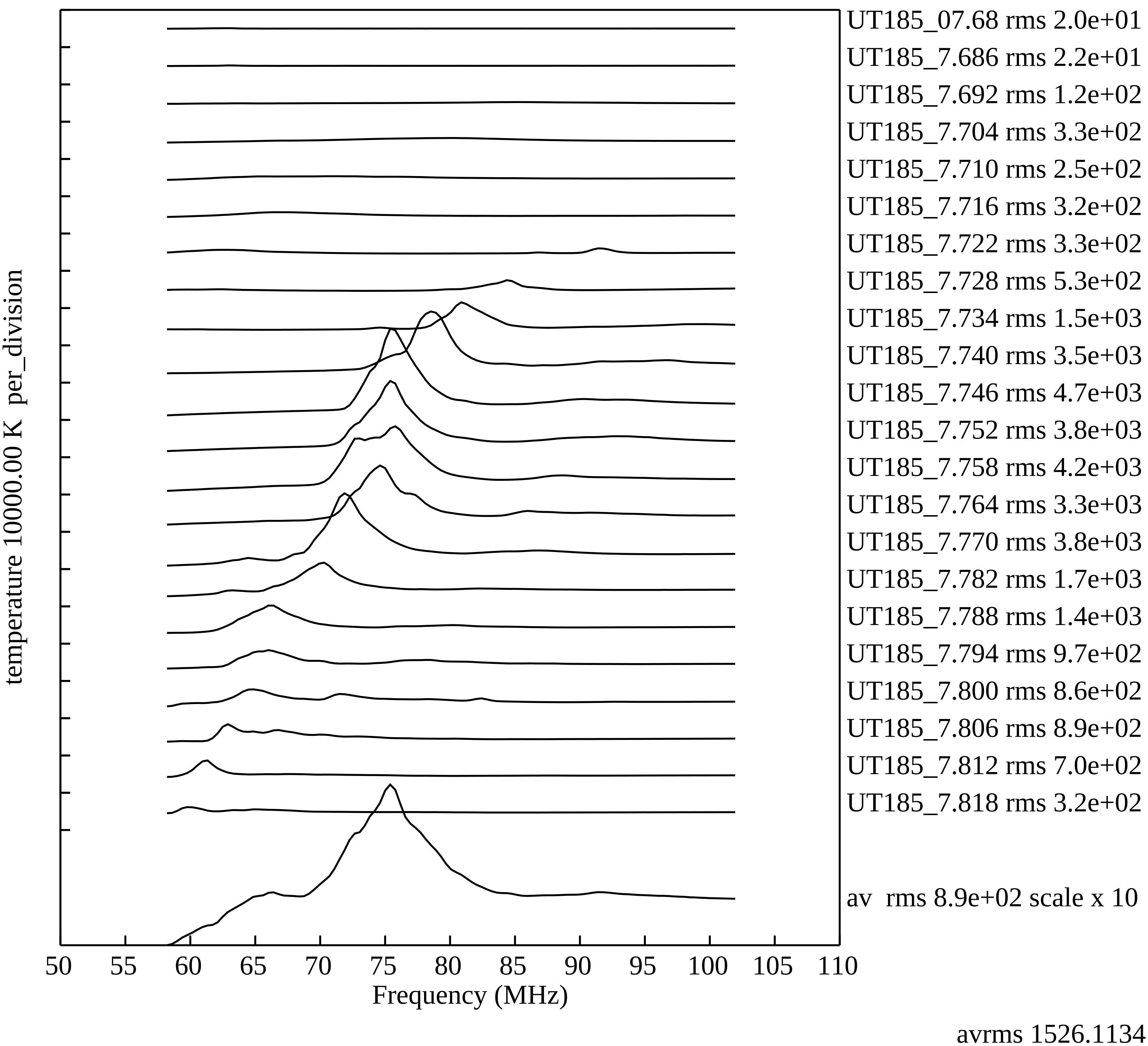

Figure 2. Solar burst on 2024 day 185 spectra for each 3-position switch cycle 7.680-7.818 hours UT

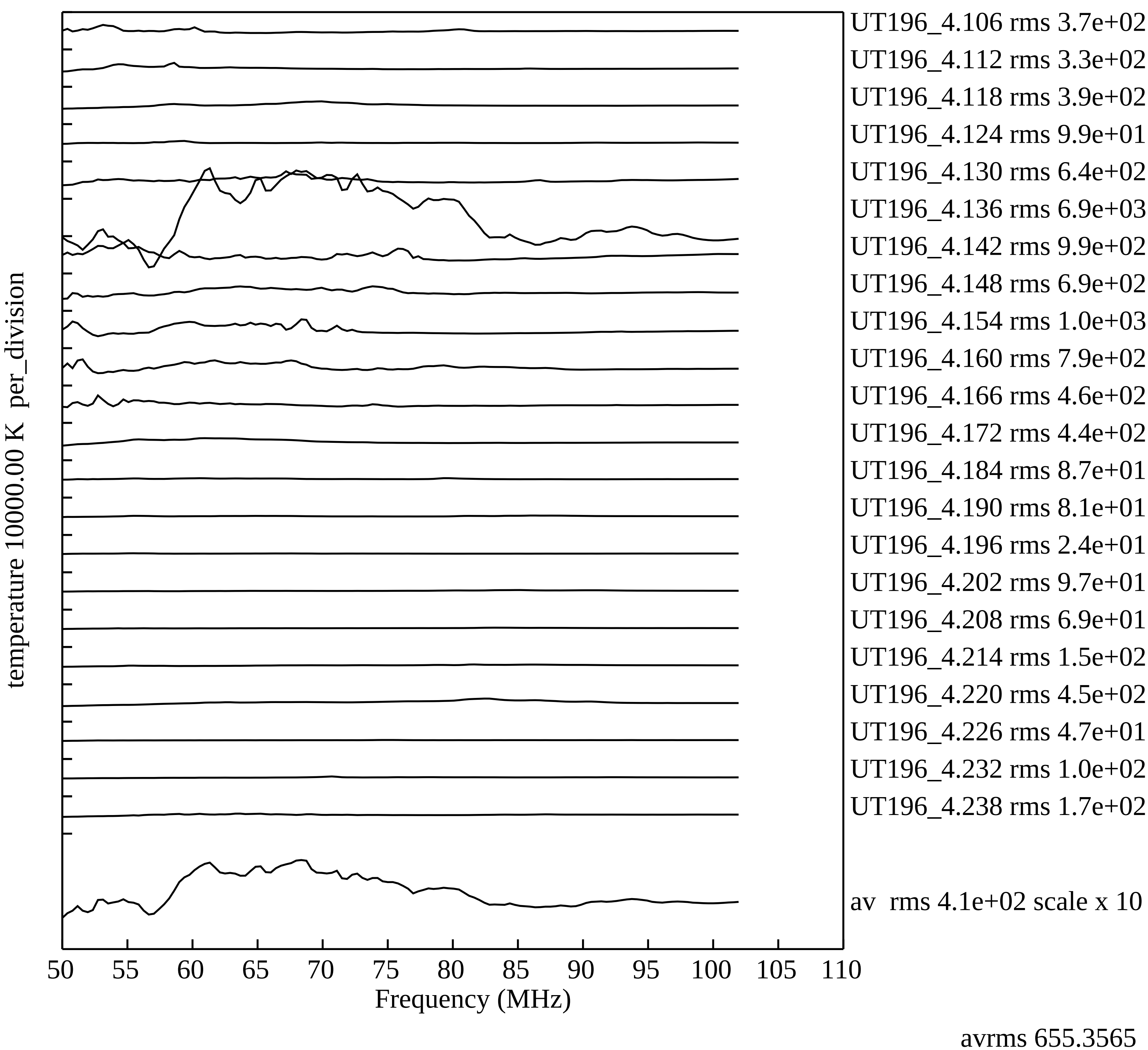

Figure 3. Solar burst on 2024 day 196 spectra for each 3-position switch cycle 4.106-4.238 hours UT

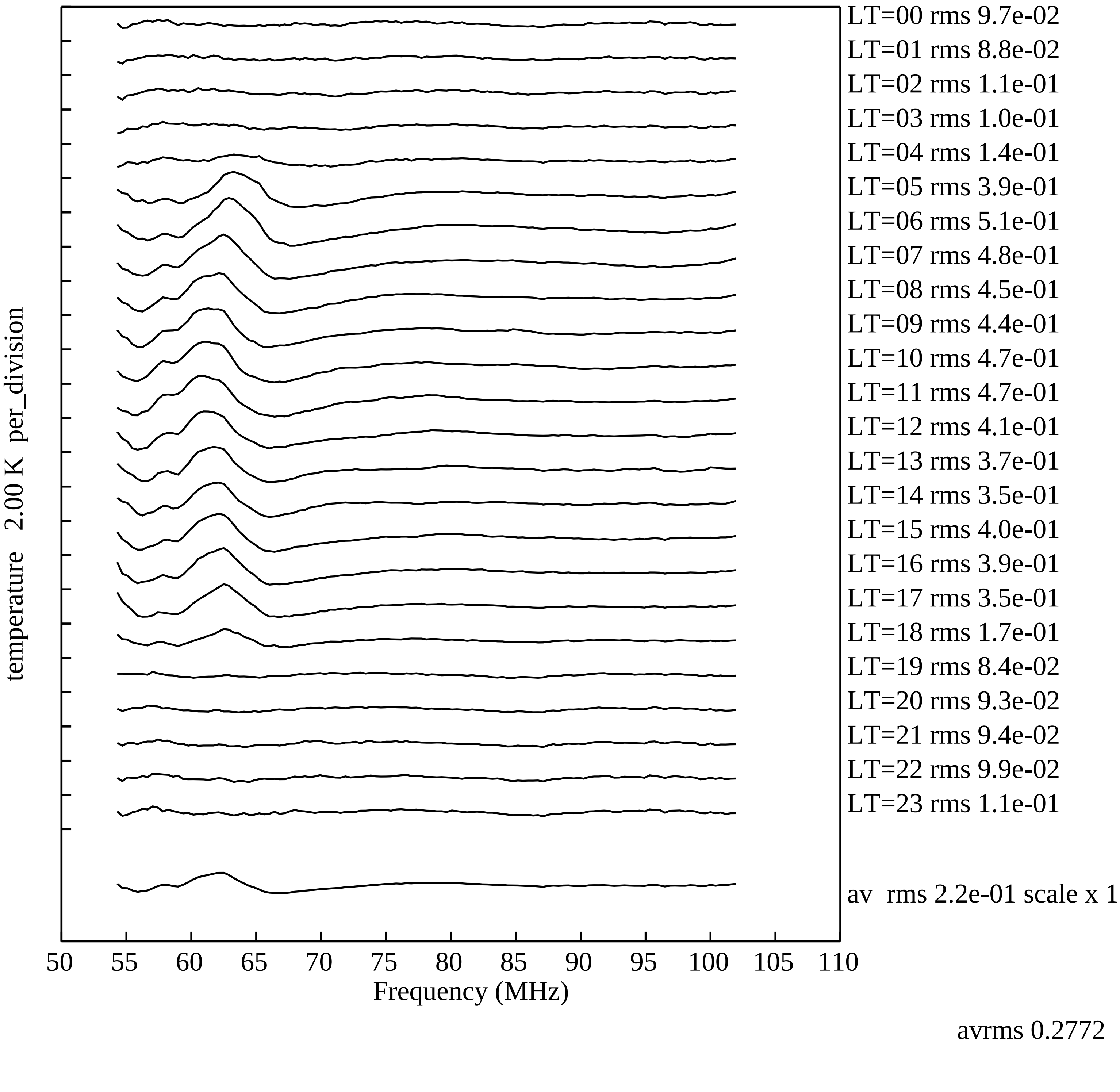

Figure 4. Average of 2024 days 96 to 196 spectra vs LT with 5-terms removed

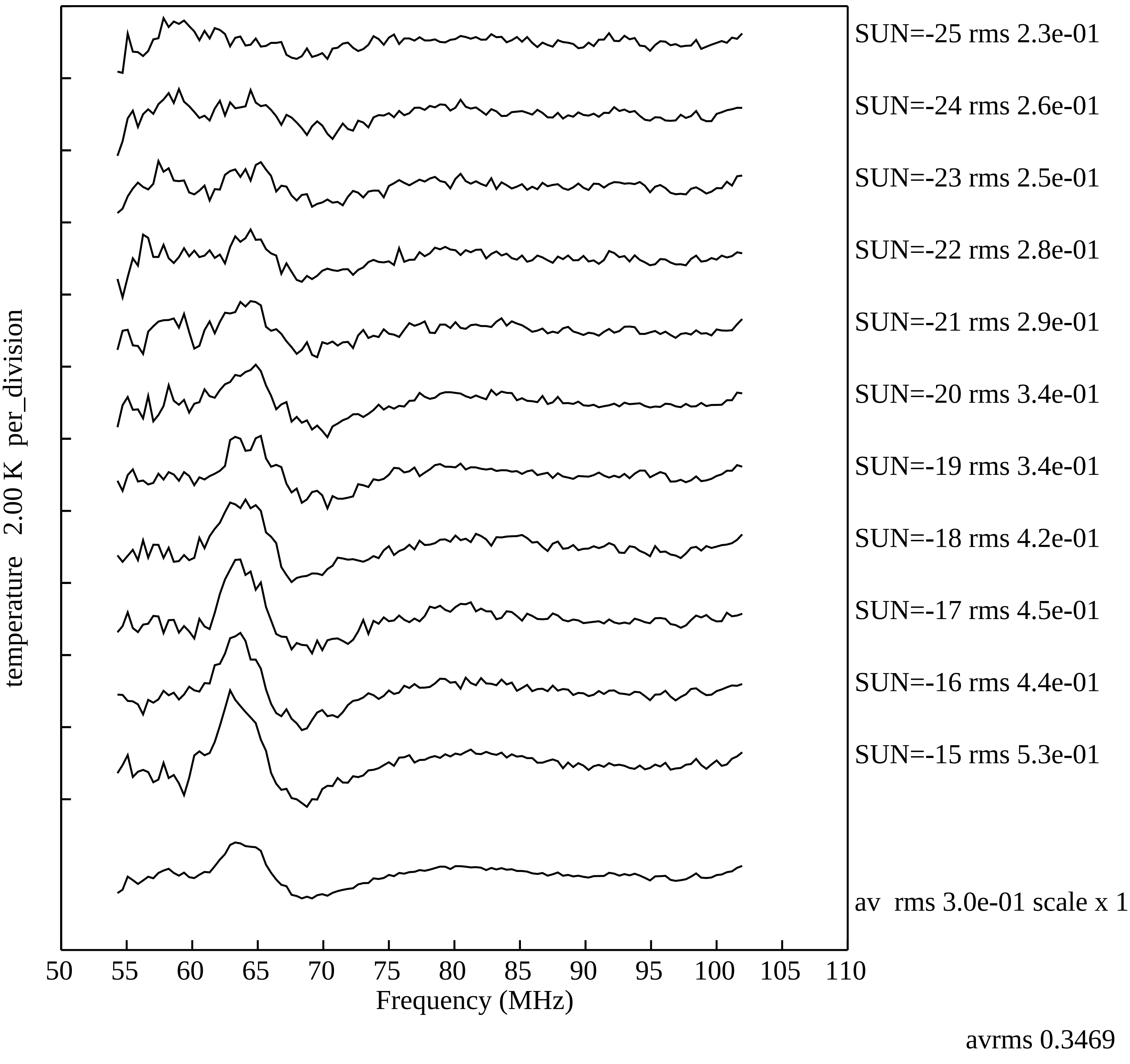

Figure 5. Average of sunrise spectra residuals 2024 day 135 to 197 5-terms removed vs limits of the sun's elevation from -25 to -24 at top to -15 to -14 degrees at bottom

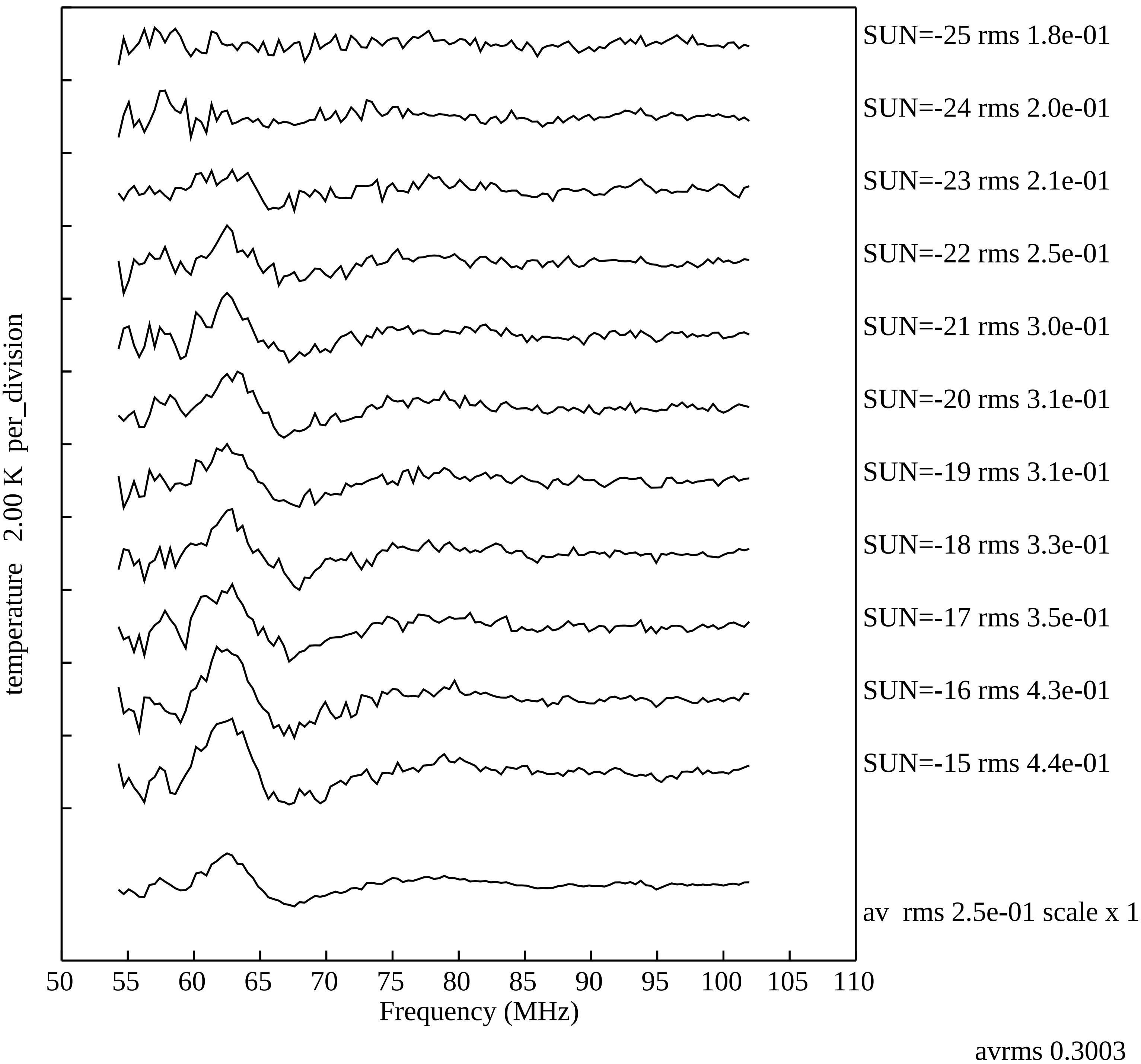

Figure 6. Average of sunset spectra residuals 2024 day 135 to 197 5-terms removed vs limits of the sun's elevation from -25 to -24 at top to -15 to -14 degrees at bottom

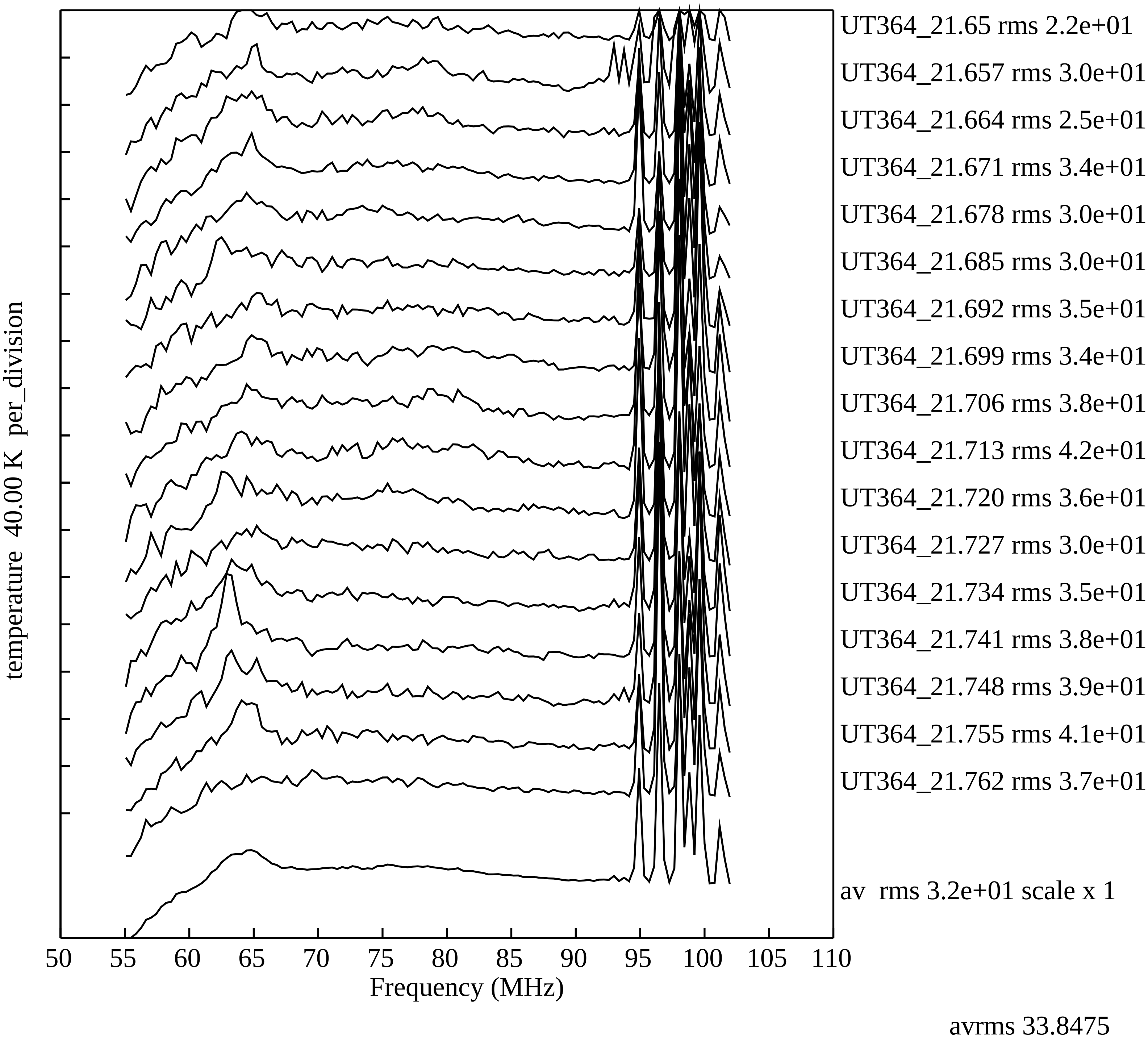

Figure 7. Data from 2023 day 364 spectra for each 3-position switch cycle 21.650-21.762 hours UT

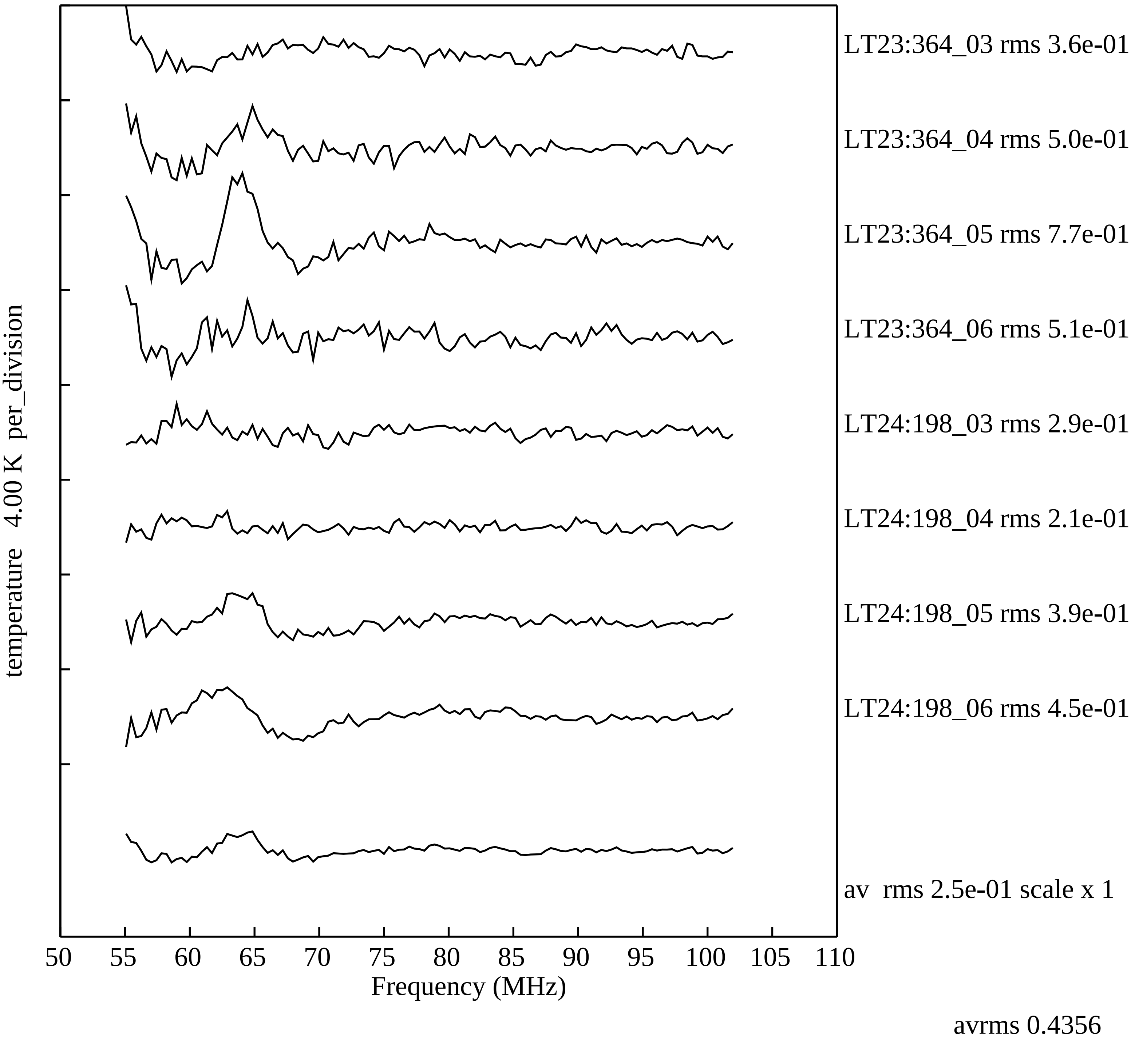

Figure 8. 5-term residuals of one hour blocks of LT 3-6 hours for 2023 day 364 and 2024 day 198