EDGES MEMO #448

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

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Telephone: 617-715-5533

To: EDGES group

From: Alan E.E. Rogers

Subject: Tests of limiting data to when the sun is more than 20 degrees below the horizon

The possibility that the scintillation of 3c273 is limiting EDGES data from 2023/4 is studied in memo 438. More tests are now made using data from 2023_363 to 2024_135 taken at WA with EDGES-3. Memo 438 shows the variation in the spectra between 60 and 70 MHz with 5-terms removed at GHA = 18 hours in 1 hour blocks for each day and in 6 minute blocks for day 2023_364 from GHA = 17.0 to 19.2 hours.

The problem with scintillations is that they are relatively weak and intermittent but become significant for long integrations. The simplest method to exclude the effects of scintillations on the global 21-cm spectrum is to limit the data to a range the sun's elevation over which a significant scintillation cannot occur. More sophisticated scheduling of times when scintillations cannot occur because the radio source or the regions of the solar wind with high refractive index due to high electron content are below the horizon is possible. But the simplest is just to keep the high refractive index regions of the solar wind well below the horizon. This will avoid scintillations from all compact radio sources. In addition having the sun well below the horizon minimizes the effects of the ionosphere and solar emissions but does not eliminate reflections of FM radio from micrometeorites, the moon, starlink, other satellites and possibly regions in the F2 region above the horizon which are ionized by solar activity.

Figure 1 shows the results of a grid search for the global 21-cm absorption for 5-loglog polynomial terms removed for 1 hour GHA blocks from GHA = 06 to 18 hours for which the sun's elevation was below 0, -10, -20 and -30 degrees from the plot on the top left to the plot on the bottom right. The result for 0 degrees is on the top left and has significant residual structure below 70 MHz but this structure is reduced as the data is restricted lower sun elevations. These result are from 2023_363 to 2024_135.

Figure 2 shows the 21-cm absorption for 5-loglog polynomial terms removed from 2023_054 to 2024_142 for the sun elevation of 20 degrees below the horizon. I have also made a small change in the edges3.c code to be able to use a small antenna loss correction of 0.005 dB (0.1%) along with the 2.5 inch correction (lmode = 1) for the loss of the cable from the 8-position switch to the other antenna box. While the lmode = 1 setting has been used in most of the EDGE-3 data analysis a small overall antenna plus ground plane loss had not been used. I got a slightly lower residual with only lmode =1 and zero antenna loss in figure 2.

Figure 3 shows an example of FM reflections from what most are most likely high electron density regions in the F2 layer, which is the region of the ionosphere at an altitude of 220-800 km. What is surprising is that even with the sun more than 20 degrees between 13 to 19 UT (9pm to 3am Perth time) this region must still be above the horizon in order to produce the strong FM signals seen in figure 3.

In summary using only data with the sun more than 20 degrees below the horizon is helpful in improving the rms residuals below 70 MHz and while the removal of the FM signals is still needed fortunately there are relatively few FM stations in Western Australia.

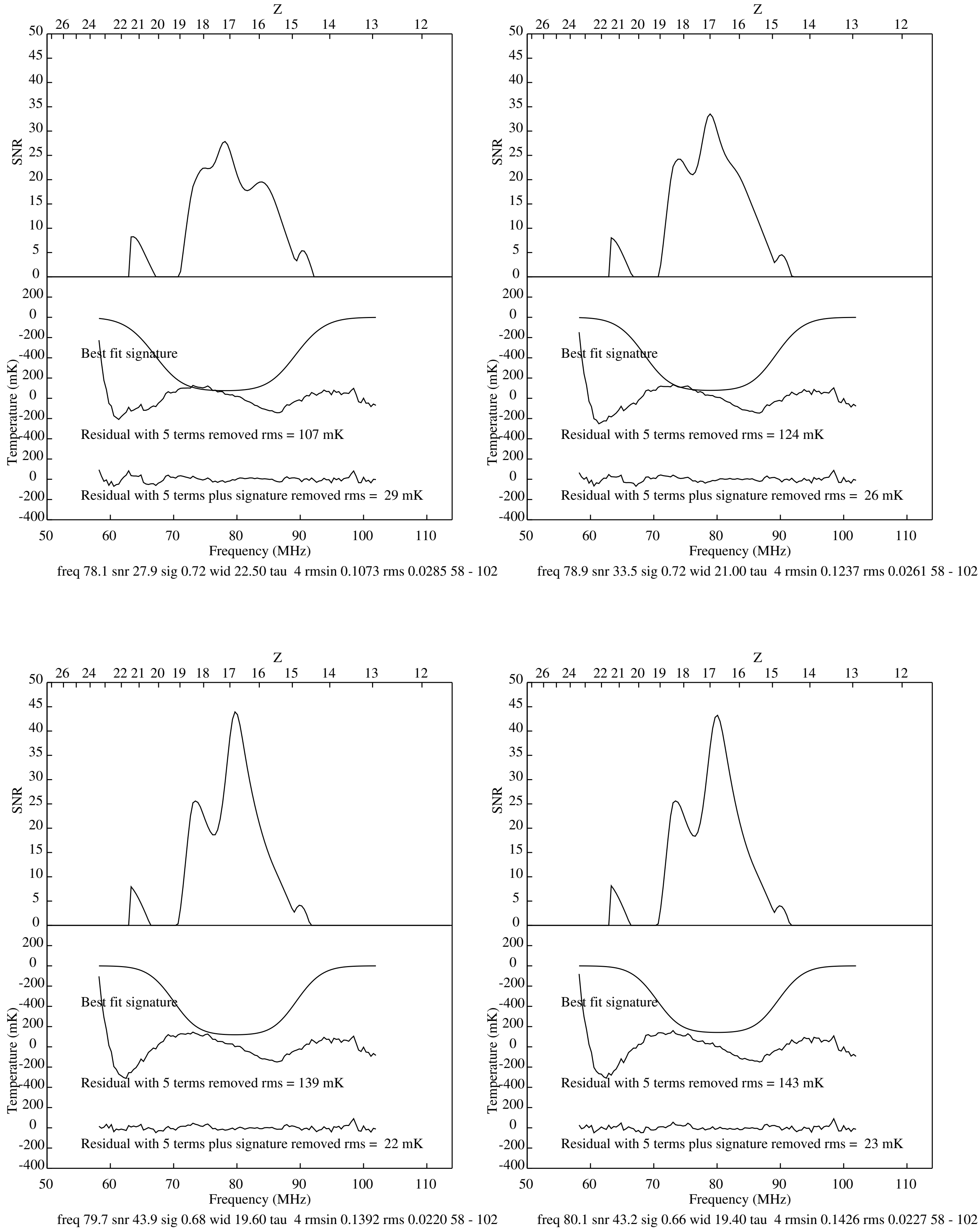

Figure 1. Global 21-cm absorption results with sun elevation limit from 0, -10, -20 and -30 degrees

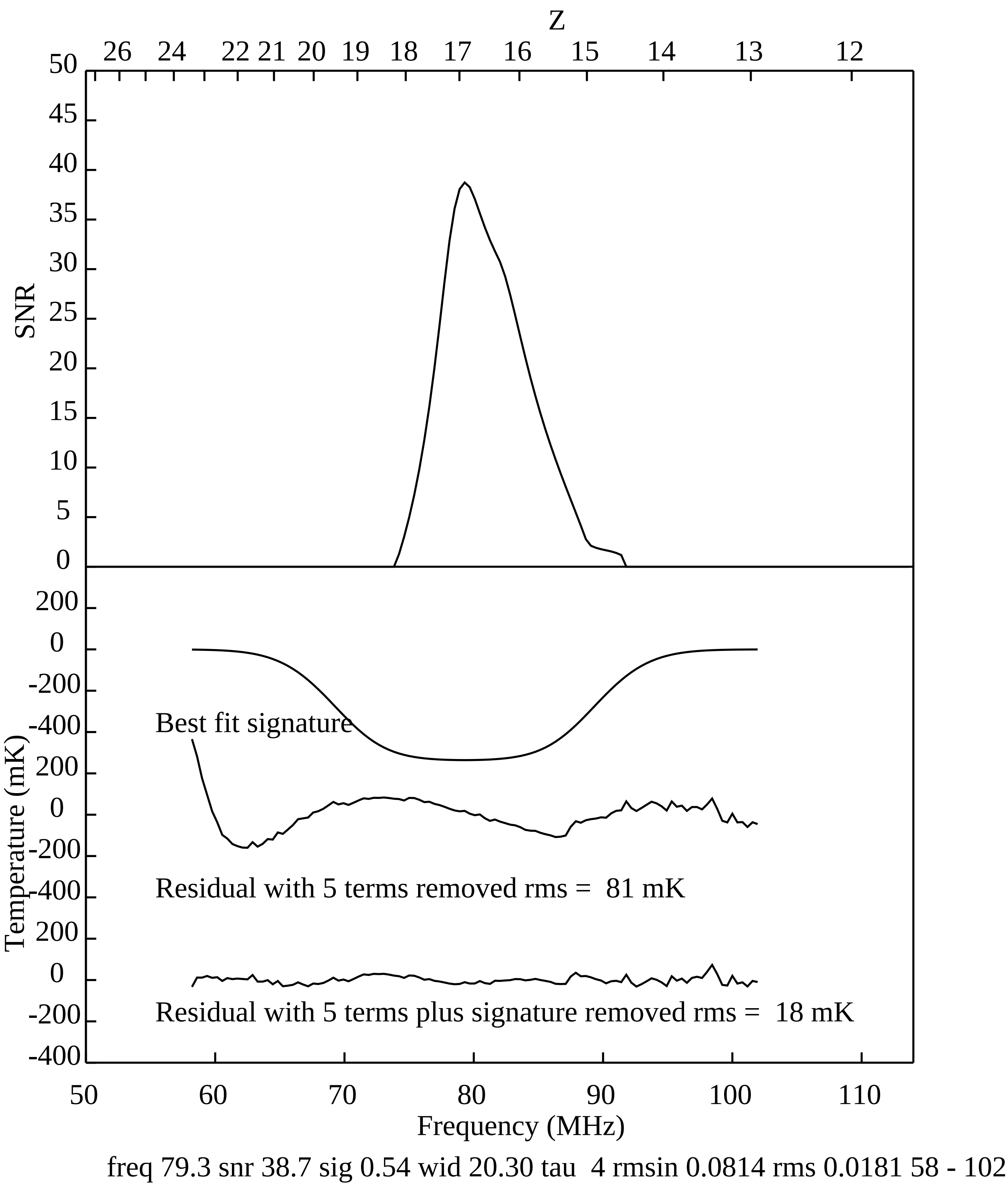

Figure 2. Global 21-cm absorption result with sun elevation limit of -20 degrees 2023_054 to 2024_142

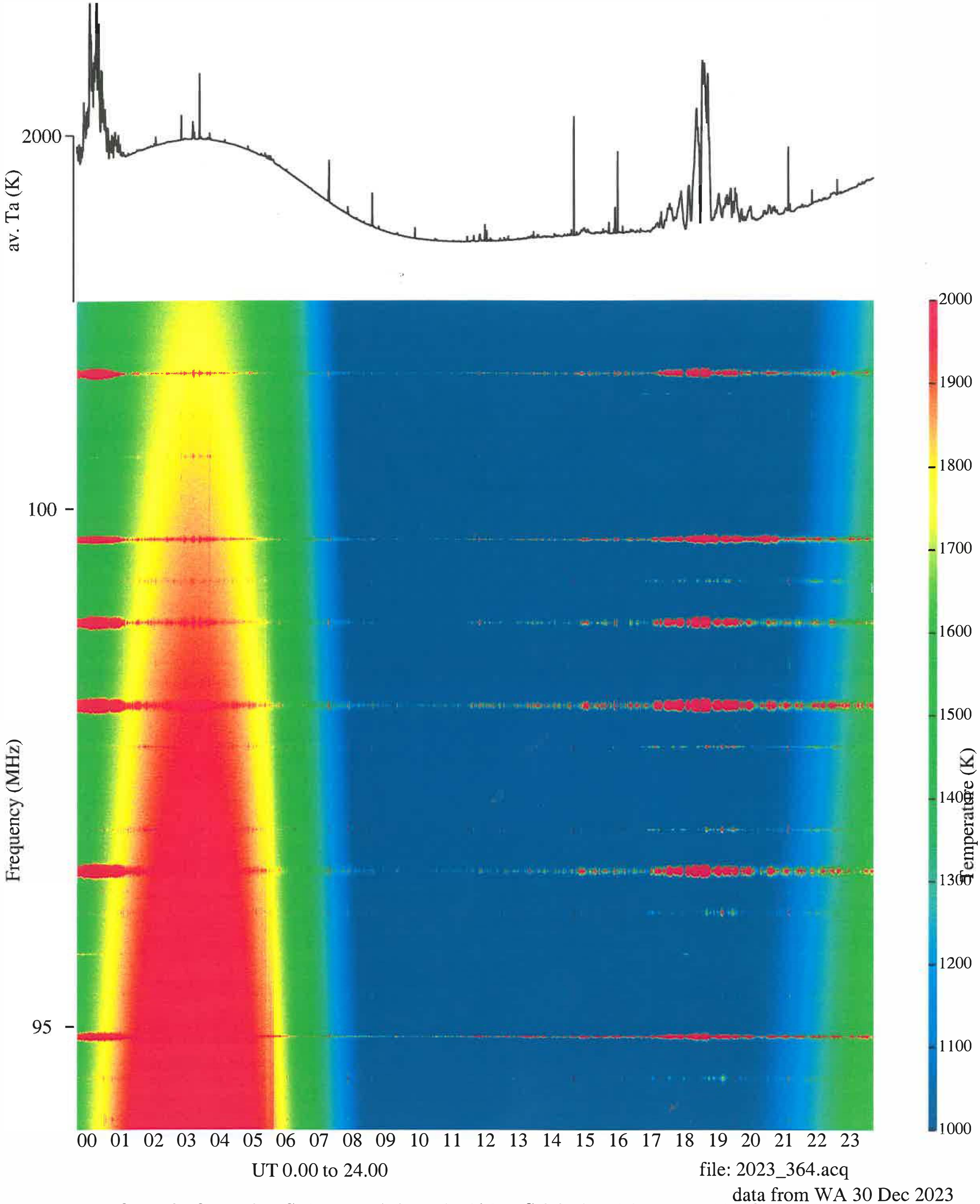

Figure 3. Waterfall plot of FM reflections on 2023_364