EDGES MEMO #359

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To: EDGES Group

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Subject: Tests of averaging over GHA

Averaging over all GHA reduces the effects of fine structure in the antenna beam and aides in the evaluation of other instrumental effects as discussed in memo 352. The first test shows that it makes very little difference if the data is beam corrected for each 20 minutes of GHA and then averaged (method 1 in Table 1 below) or averaged over all GHA and then corrected by the average of all the beam corrections over GHA sampled every 20 minutes (method 2 in Table 1 below).

Antenna beam model	bump hgt cm	method	Average of rms mK	rms mK
Lowband pec	20	1	125	33
Lowband pec with round bump	20	2		32
Lowband pec	none	1	88	32
Lowband 30×30m	none	1	117	27
Midband 30×30m	none	1	57	6
Lowband pec with round bump	30	1	152	33
Lowband pec with round bump	50	1	200	33
Lowband pec with round bump	50	2		32
Lowband pec with round bump	50	3 PEC as ref.	165	6

Table 1. Simulations of beam correction at 20 minute increments for different beam models.

The average rms is the average of the rms residuals for a 5-term physical model fit 55 – 98 MHz and the rms is the rms residual for the average over all GHA.

In method 1 and 2 there is no beam correction of the simulated data. In method 3 a beam correction is made using the antenna beam derived for an infinite PEC ground plane. This shows that the PEC beam model should be used for beam correction of the average. All the beam models in Table 1 except one are for the lowband. The one for midband, which is a smaller antenna closer to being electrically small had less large scale structure to be corrected by the PEC beam. The simulations in Table 1 were made with the antenna at an azimuth of 42 degrees and an uneven ground plane with a bump, as in memo 356, 10m from the antenna at an azimuth of 68 degrees.

A separate simulation was made with the bump at an azimuth at 110 degrees and the lowband antenna was rotated. In this case it was found that the residuals were a minimum with the antenna NS and increased to a factor of about 2, while maintaining a similar shape, to a maximum with the antenna EW. These results are shown in Figure 1.

Five EDGES-2 data sets are processed using blocks of GHA and Table 2 shows the results of a 2-D grid search for the best fit signature center frequency and width with least squares fit absorption amplitude for the best fit for a fixed tau = 7. 5-physical terms were used for lowband and 6-terms for midband. The range of the flattening parameter, which results in less than 5 percent change of the best fit value of the residuals after fitting the absorption is also shown from a separate grid search which includes the added dimension of tau.

Dataset	freq range	rms0 mK	center MHz	SNR	width MHz	amp K	rms1 mK	rms2 mK	tau range	block size
Low1 2016_250-2017_095	55-95	189	78.1	24.0	21.1	0.69	55	20	5 – 7	10min
Low2 NS 2017_082-2017_142	55-95	234	78.5	19.9	18.3	0.50	70	32	5 – 7	20min
Low2 45 2020_050-2021_076	55-95	148	78.1	21.5	19.1	0.47	51	21	4 – 7	10min
Mid 2018_146-2018_174 6T	62-120	72	78.5	34.3	20.0	0.48	51	21	6 – 7	4hrs
Mid 2020_052_2020_175 6T	64-120	76	79.9	28.8	21.6	0.65	69	23	7 – 9	4hrs

Table 2. Results of signature grid search for center and width for fixed tau=7 using 5-physical terms for lowband and 6-quasi-physical LinLog terms for midband

rms0 is the average of the rms residuals with foreground terms removed for separate blocks. rms1 and rms2 are the residuals before and after fitting for the absorption feature. tau range is the range of best fit flattening which is the most poorly determined absorption parameter. The results, especially for Mid 2020, are effected by changes in the antenna S11 which occur on some days. These changes are the result of rain or condensation. Figure 2 is an example of these effects. The weak dips at about 65 and 85 MHz, due to a change in S11 cannot be detected in 10 or 20 minute integration so longer "test" integrations are needed to decide what data is acceptable to be included when processing data over 24 hours in short blocks of GHA. The midband S11 below 64 MHz require a very high accuracy and the S11 measurements require smoothing. Ten terms from 60 to 120 MHz were used for midband. The 2018 midband results using the recalibration of receiver in memos 281, 287 and 354 were analyzed with a VNA calibration load resistance of 50.12 ohms from 2017 calibration instead of a resistance of 50.027 ohms for the 2018 calibration. This error which was corrected in this analysis just happened to allow processing down to 60 and 55 MHz and it shows how critical the midband data is to s11 measurement below 65 MHz.

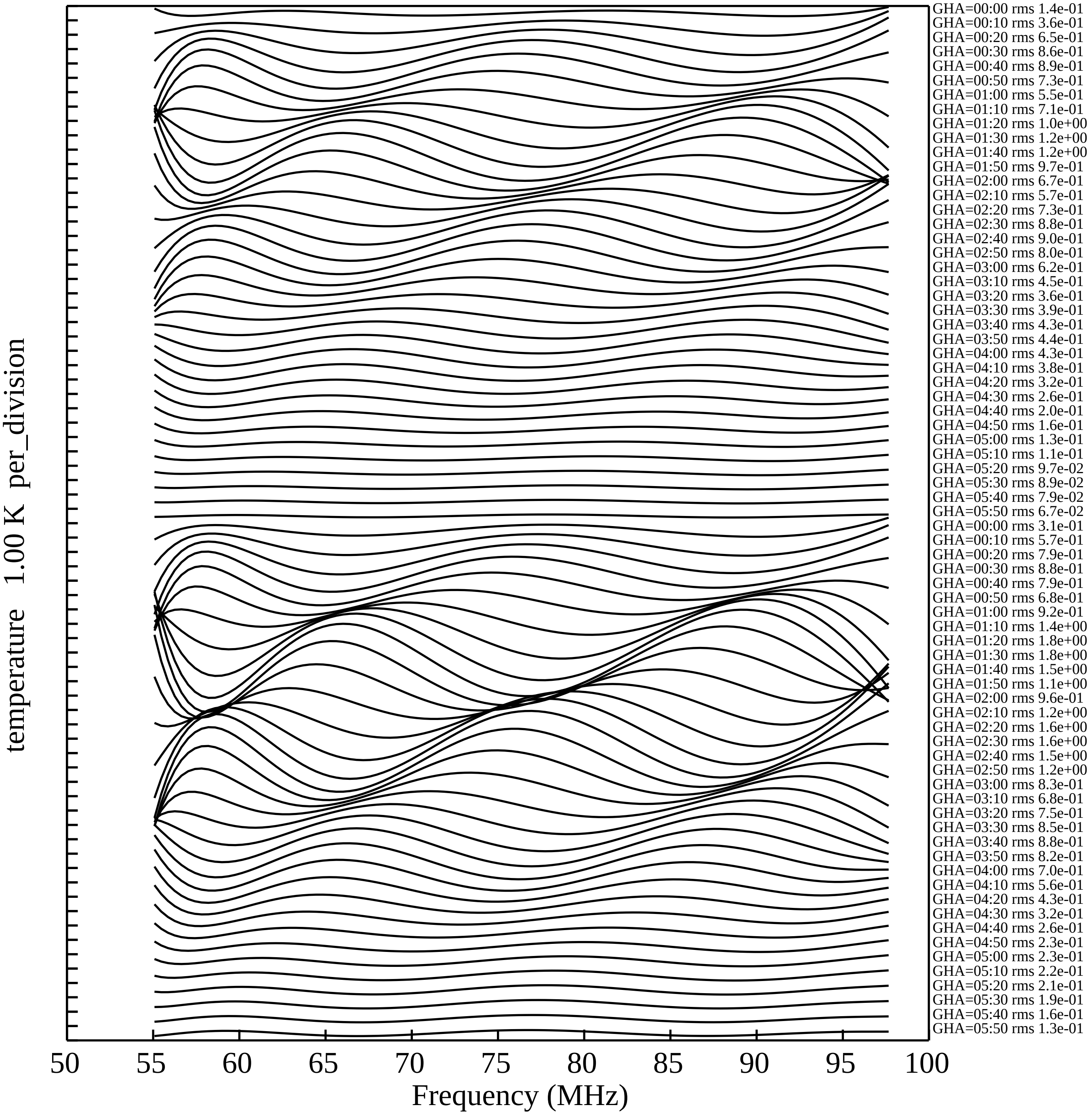

Figure 1. Shows the maximum and minimum effects of a 2.5 m diameter bump on the ground plane at an azimuth of 110 degrees at 10 meters from the antenna NS (top) and EW (bottom) GHA 0 to 06 hours. The variation with antenna azimuth is about a factor of 2 in amplitude. The Haslam map and 5-physical terms were used to model the sky.

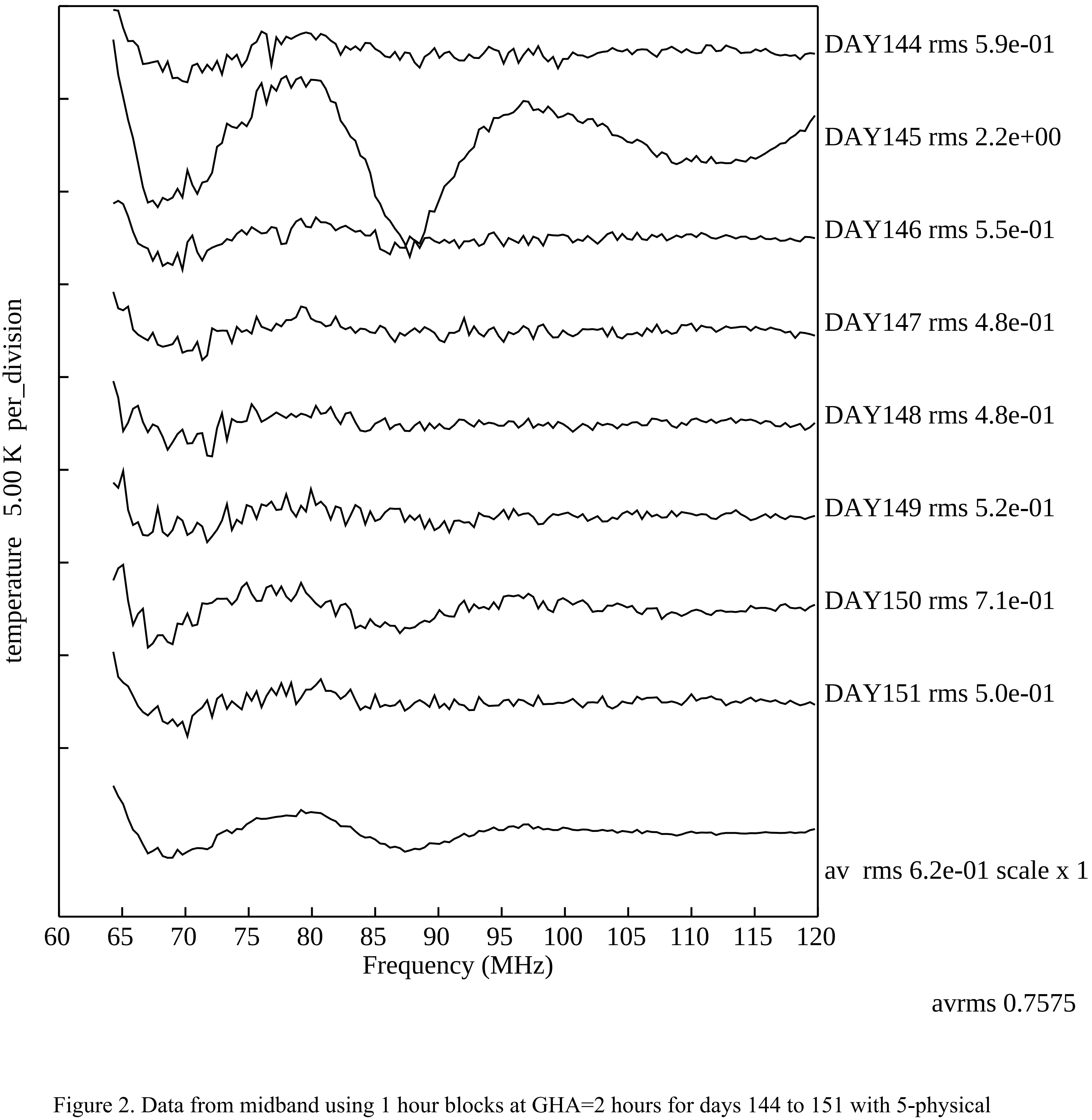

Figure 2. Data from midband using 1 hour blocks at GHA=2 hours for days 144 to 151 with 5-physical terms removed. The strong dips at about 65 and 85 MHz of day 145 are easily detected and excluded from the data average the much weaker dips on day 150 are hard to detect even with 1 hour integration.