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To: EDGES Group

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Subject: Dependence of the low band spectra on the Galactic center Hour Angle (GHA)

The low band spectra show considerable structure with GHA most of which matches that expected as a result of the frequency dependence of the beam convolved with the sky noise. For this study the frequency range from 72 to 97 MHz is examined. Figure 1 shows the GHA dependence for 4 hour integrations centered at 2 hour intervals of nighttime data from 2015_286 to 2016_149 with beam correction. Figure 1b shows the result without beam correction. The spectrum covers 72 to 97 MHz and is fit with a 4-term polynomial. Fitting with a 4-term physical polynomial makes very little difference. With this narrow frequency range fitting with more terms removes wide Gaussian signatures. Table 1 shows the simulated rms residual for a 200 mK Gaussian signature of 10 MHz FWHP at 84 MHz over 72 to 97 MHz.

Number of terms	Physical rms (mK)	Polynomial rms (mK)
1	72	72
2	68	68
3	33	31
4	27	29
5	12	10

Table 1. rms residual for 200 mK Gaussian FWHP=10 MHz at 84 MHz in window of 72 to 97 MHz.

At 4 terms the rms is 40% and a 6-term fit to about 35%. If the width is increased to 20 MHz a fit with 4-terms or less is needed to avoid reducing the residual to under 30%. This emphasizes the difficulty of seeing the profile or detecting a relatively wide signature.

Figure 2 shows the simulated effect of the beam chromaticity from 72 to 97 MHz for 4 ground planes of increasing size from top left to bottom right. In each case the soil below the ground plane is assumed to have a dielectric constant of 3.5 and a conductivity of 2×10^{-2} S/m. The first case is the current ground plane of 9.8×9.9m and blade antenna oriented at an azimuth of -6 degrees. This can be compared with the spectra using the data without beam correction shown in Figure 1b. The second case is a ground plane made from 5 10×10m sections arranged as a “plus” sign. The third case is a “plus” shape of 20×20m sections and the last case is an infinite ground plane for comparison. From Figure 2 it is clear that a really large ground plane is needed for the low band. The 20×20m “plus sign” shaped ground plane is 60 m in the N-S and E-W dimension which corresponds to 10×10 wavelengths at 50 MHz compared with 1.7×1.7 wavelengths for the current ground plane. The size could be reduced by resistive termination of the edges of the ground plane with an absorber as in Wang and Liepa or using a V-shape Edge-Groove as in Chen et al. Alternately a design in which stakes are driven into the ground and connected to the edges of the ground plane mesh using resistors might be worthy of a study but it is unlikely that the added complexity of the ground termination would simplify the overall design. Some of these alternate designs have been implemented at the Open-Area-Test Sites (OATS) of NIST, NPL, NIM, ETS-LINDGREN, and Liberty Lab as described by Meng 2015.

Figure 3 shows the simulated effects of the beam chromaticity over the 52-97 MHz band with 5 polynomial terms removed. The effects are very large for the current ground plane and needs to be made of 5 20×20m sections to approach the level of an infinite ground plane.

Figure 4 compares 50×10×10m, 5×20×20m, with a 20×20m ground plane with 4 5m high triangle along each edge for a total mesh area of 600 m^2. This alternative is based on the examples of OATS optimization reported by Meng. These ground planes have areas of 500, 2000 and 600 m^2.

From this it looks like addition of triangular perforations on the edges of a square ground plane is worthy of further study in order to optimize the design for EDGES within the available resources.

R. Wang and V. Liepa, "Reduction of the edge diffraction of a circular ground plane by using resistive edge loading," *Antennas and Propagation Society International Symposium, 1985*, Vancouver, Canada, 1985, pp. 769-771. doi: 10.1109/APS.1985.1149390

H. F. Chen, M. Y. Lin and K. H. Lin, "A V-shape Edge-Groove Design for a Finite Ground Plane to Reduce Pattern Ripples of a Monopole," in *IEEE Antennas and Wireless Propagation Letters*, vol. 7, no. , pp. 561-564, 2008. doi: 10.1109/LAWP.2008.2001546

D. Meng, “Reducing Unwanted Reflections in NIM’s OATS Optimization,” APEMC 2015.

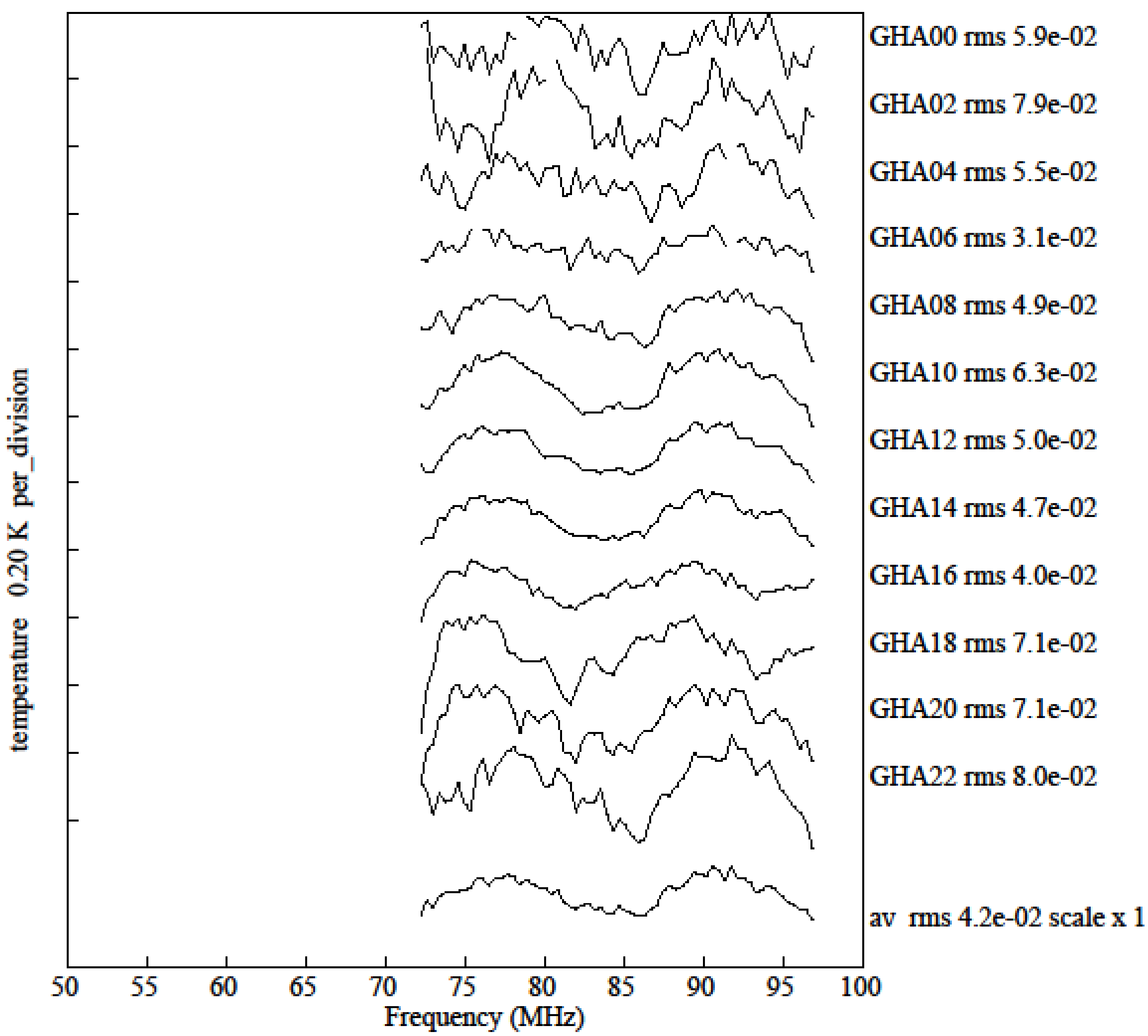

Figure 1a. Results from 2015_286 to 2016_149 with 4 polynomial terms removed vs GHA. Beam correction has been applied using the FEKO model of the blade antenna on the 9.8×9.9m ground plane on soil with dielectric constant 3.5 and conductivity of 2×10^{-2} S/m.

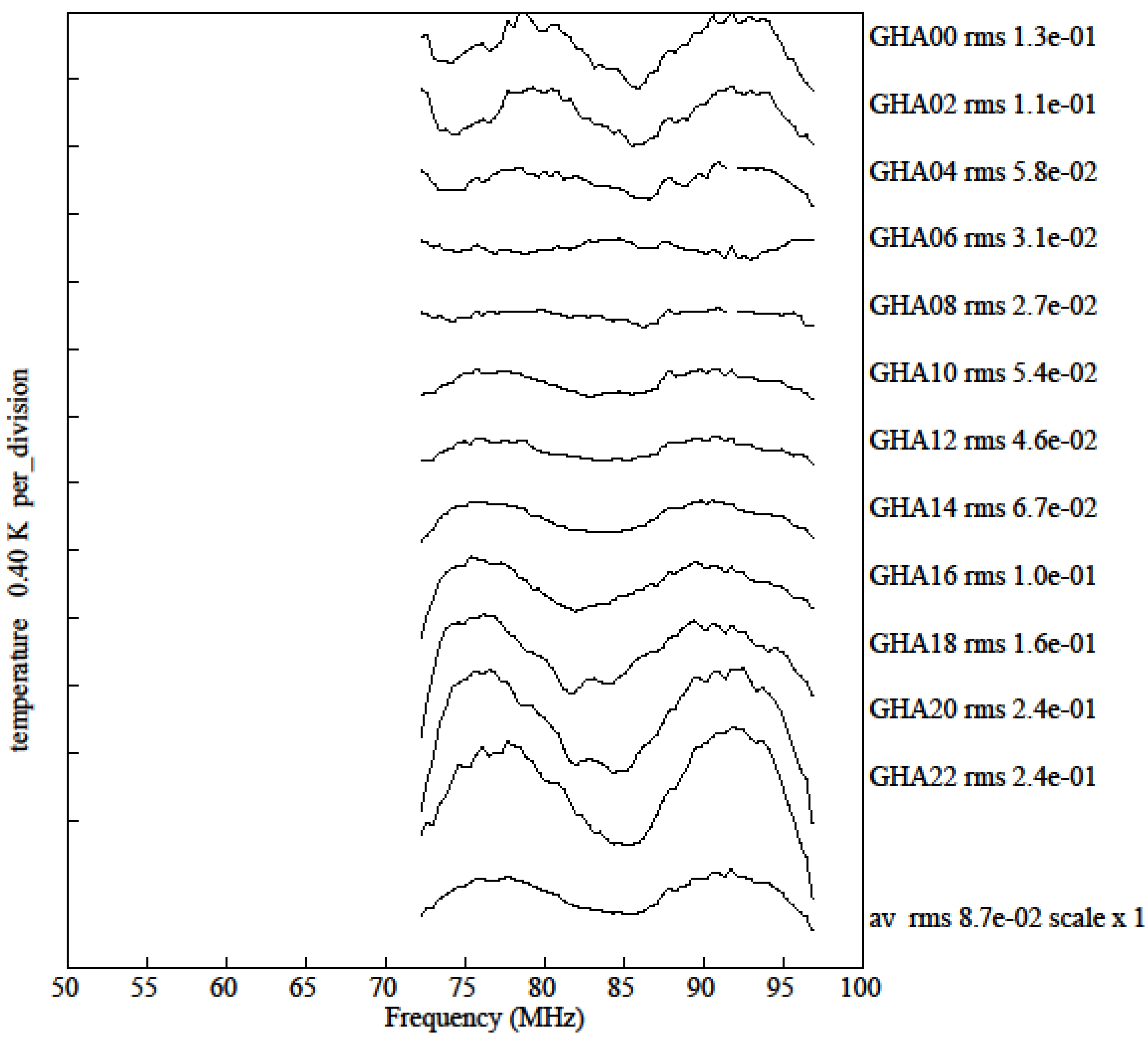

Figure 1b. Same as figure 1a without beam correction. Note the scale change.

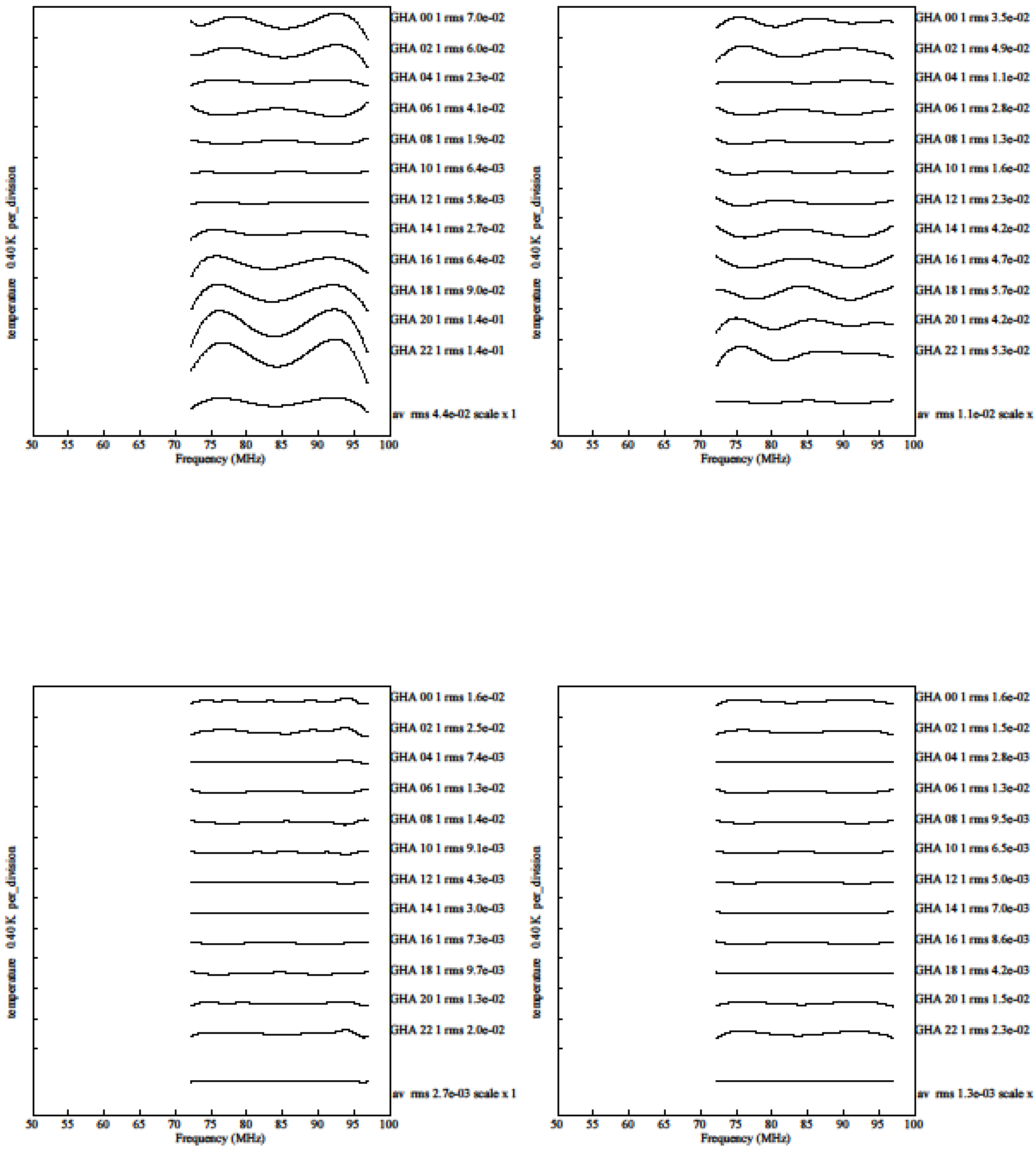

Figure 2. Simulated beam effects for 72-97 MHz with 4 polynomial terms removed. Top left is current 9.8×9.9m ground plane. Top right is for a "plus sign" shaped ground plane of 5×10×10m. Bottom left is for plus of 5×20×20m and bottom right is for infinite ground plane.

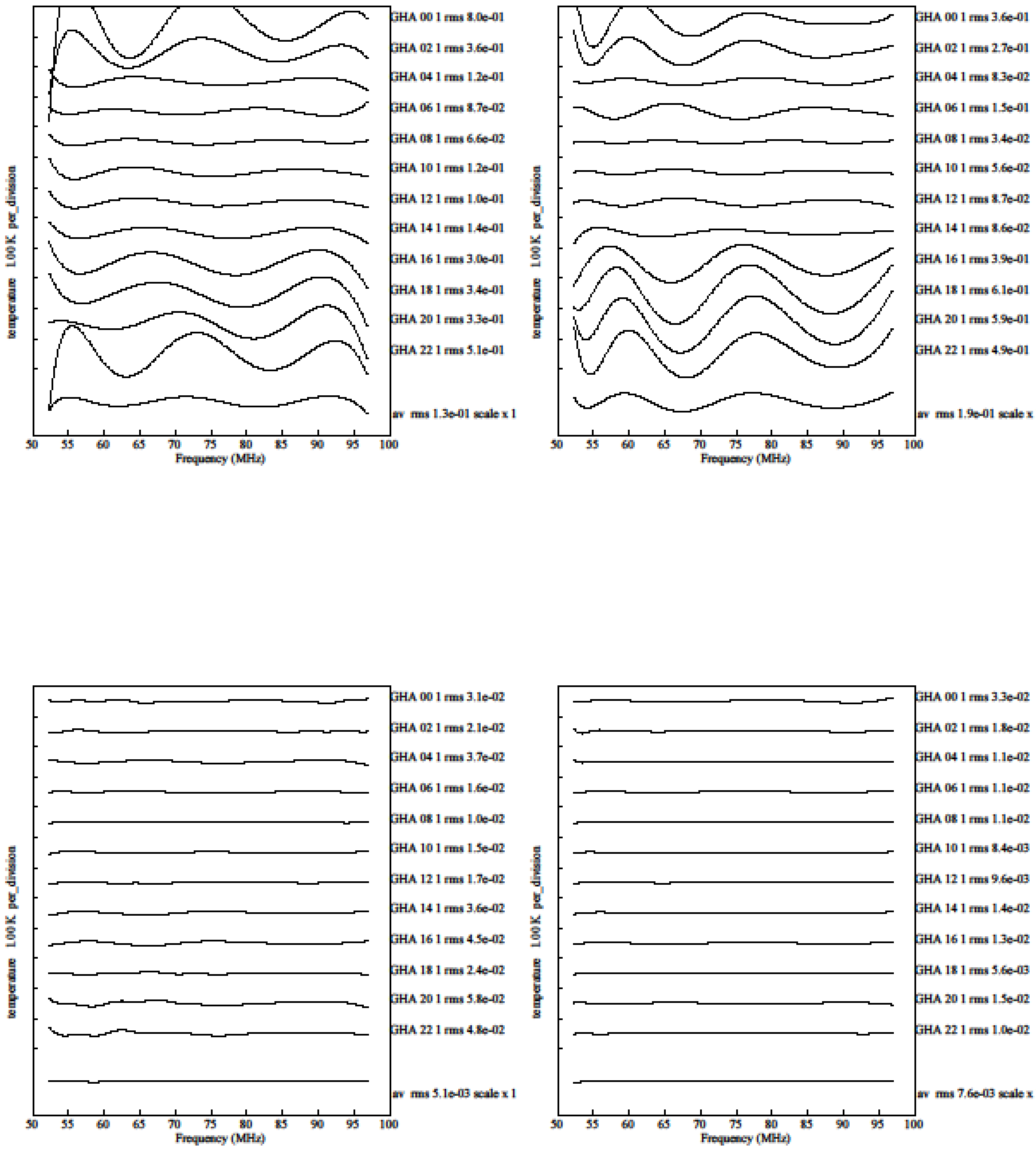

Figure 3. Simulation of beam effects for 52-97 MHz with 5 polynomial terms removed. Note scale change.

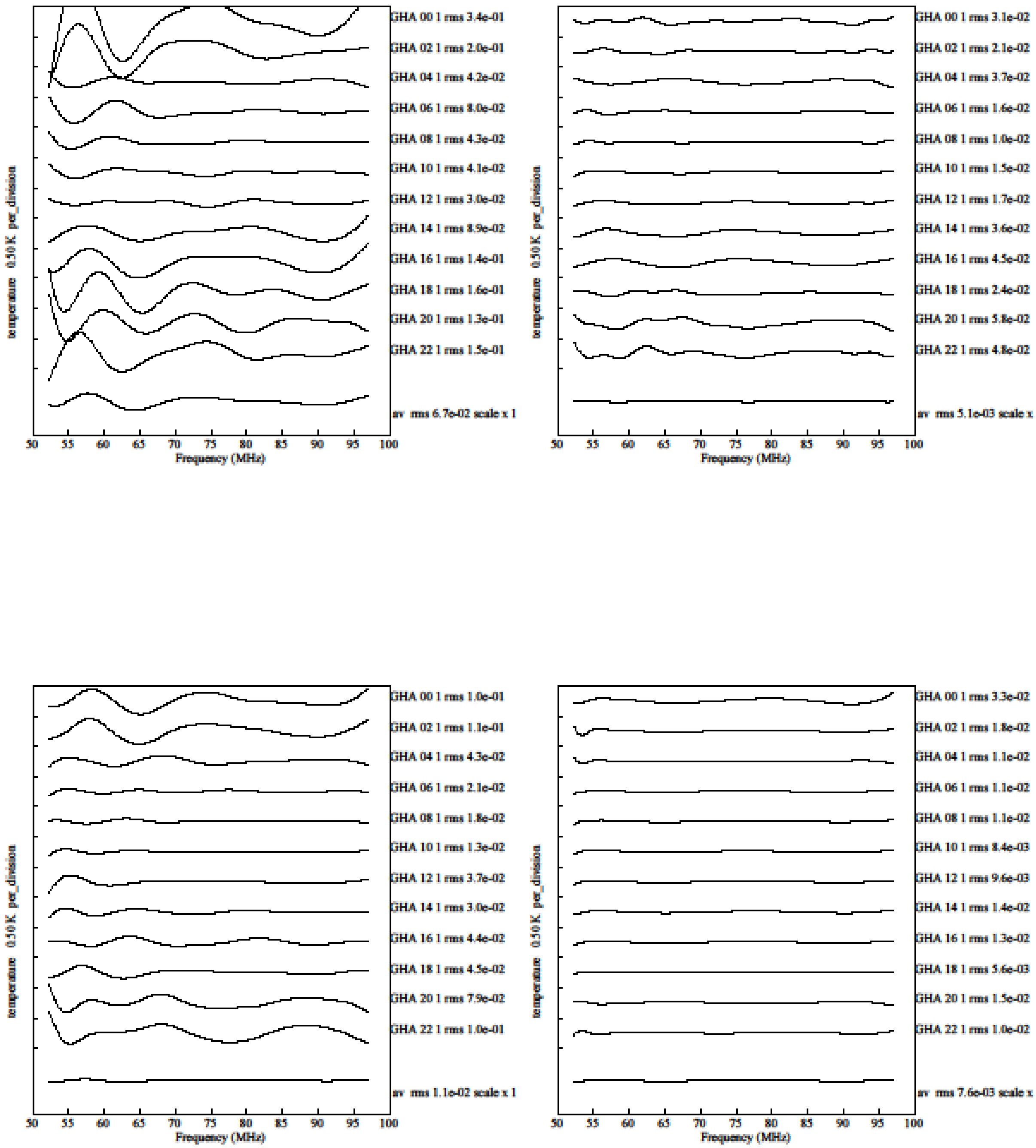

Figure 4. 5×10×10, 5×20×20, 5×10×10 with triangles along edge, and an infinite ground plane.