EDGES MEMO #294

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To: EDGES Group

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Subject: Simulations of EDGES-3 chromaticity and ground loss for potential deployment in Oregon.

The primary deployment of EDGES-3 is expected to be on a large ground plane at the MRO. For this site the beam chromaticity is expected to be similar to that of the midband antenna on the 30×30 m ground plane and with this large ground plane the ground loss is estimated to be under 0.5%. A study is underway to optimize the design of an even larger ground plane for lower loss and beam chromaticity. Since a large ground plane is probably not practical for a deployment in Oregon two possibilities are considered. The first is to use a 30 m long grid of 128 parallel wires spaced 12.5 cm apart and oriented along the electric field of the antenna.

Figure 1 shows the beam chromaticity for 5 linlog terms removed vs GHA at the latitude of Oregon for a soil dielectric of 3.5 and conductivity of 3e-4 S/m. The ground loss estimate from FEKO is approx. 0.5% with a spectral structure which contributes 17 mK to the spectrum at GHA=0 with 5 linlog terms removed. Figure 2 shows the chromaticity for conductivity of 1e-2 S/m is not very sensitive to the soil conductivity. Reducing the size of the ground plane or wire grid not only increases the beam chromaticity it also results in larger frequency dependence of the ground loss so that for example a 4×4 m ground plane the beam chromaticity is 526 mK and the contribution of the frequency structure in the 7% ground loss is another 600 mK. These results are summarized in Table 1.

Ground plane size	Beam chromaticity (mK)	Loss %	Loss chromaticity (mK)
0	50	50	0
2×2 m	54	27	250
3×3 m	426	14	458
4×4 m	526	7	600
8×30 m	83	0.5	17
Infinite PEC	60	<0.5	0

Table 1. Average rms chromaticity and loss vs ground plane size over uniform soil.

The ground loss “chromaticity” in table 1 is obtained by fitting a 5-term linlog polynomial to

$$T = 300\left(f/150 \right)^{-2.5}\left(1 - loss(f)\right) + 300\, loss(f)$$

Where the loss is obtained from the integrated beam from FEKO obtained using the Green’s Function (GF) mode. This loss chromaticity is for GHA=12 which the beam chromaticity is the average rms for 2 hour blocks over the full range of GHA.

Several configurations of wires have been checked with FEKO. The simplest to construct and remove is one in which the wire is not cut and meanders back and forth looping around a pair of adjacent pegs placed 12.5 cm apart at each end of the 30 m long wires. The differences between individual wires each 30 m long, a meandering wire and adding wire connections between the pegs at each end is very small in both beam and loss chromaticity.

The area under consideration for deployment is the Catlow Valley region in Oregon. This area was studied in 2009 and the results are in memo #52. One specific location in the area around the Skull Creek Reservoir centered at about

42.401325 -118.763264

In the Skull Creek Ranch area which is part of the Roaring Springs Ranch. The typical maximum FM signal levels in this area are below -106 dBm from the propagation models of fmfool.com.

Depending on the exact location the sky coverage could be limited in the direction of the Skull Creek Butte by a horizon of 20˚ see map in Figure 3. For the relatively high beam of EDGES even a 20˚ horizon only reduces the signal from the sky by 4% and simulations show the high has no significant effect on the beam chromaticity. A test of the accuracy with which the antenna azimuth needs to be aligned with the wire grid shows that an error of 5.7 degrees has no significant effect on the beam and loss chromaticity. At 30 degrees the effect becomes significant with 14% loss at 60 MHz and beam and loss chromaticity of 128 mK and 680 mK respectively. A sample of a small ground plane of parallel wires used during 2011 EDGES tests in West Forks Maine is shown in Figure 3 of memo #75.

Increasing the wire spacing to 25 cm or reducing the width from 16 m to 8 m by using only 64 wires at 12.5 cm result in a significant increase in chromaticity and loss. Increasing the length from 30 m to 40 m makes a small improvement so the overall size of 16×30 m is close to a practical optimum for a 2-week deployment of a temporary ground plane.

The ground plane wire loss was estimated using FEKO to be 0.01% for copper wire with 0.4” diameter and 0.1% for 0.04” diameter wire. The use of #14 copper wire should result in negligible added loss.

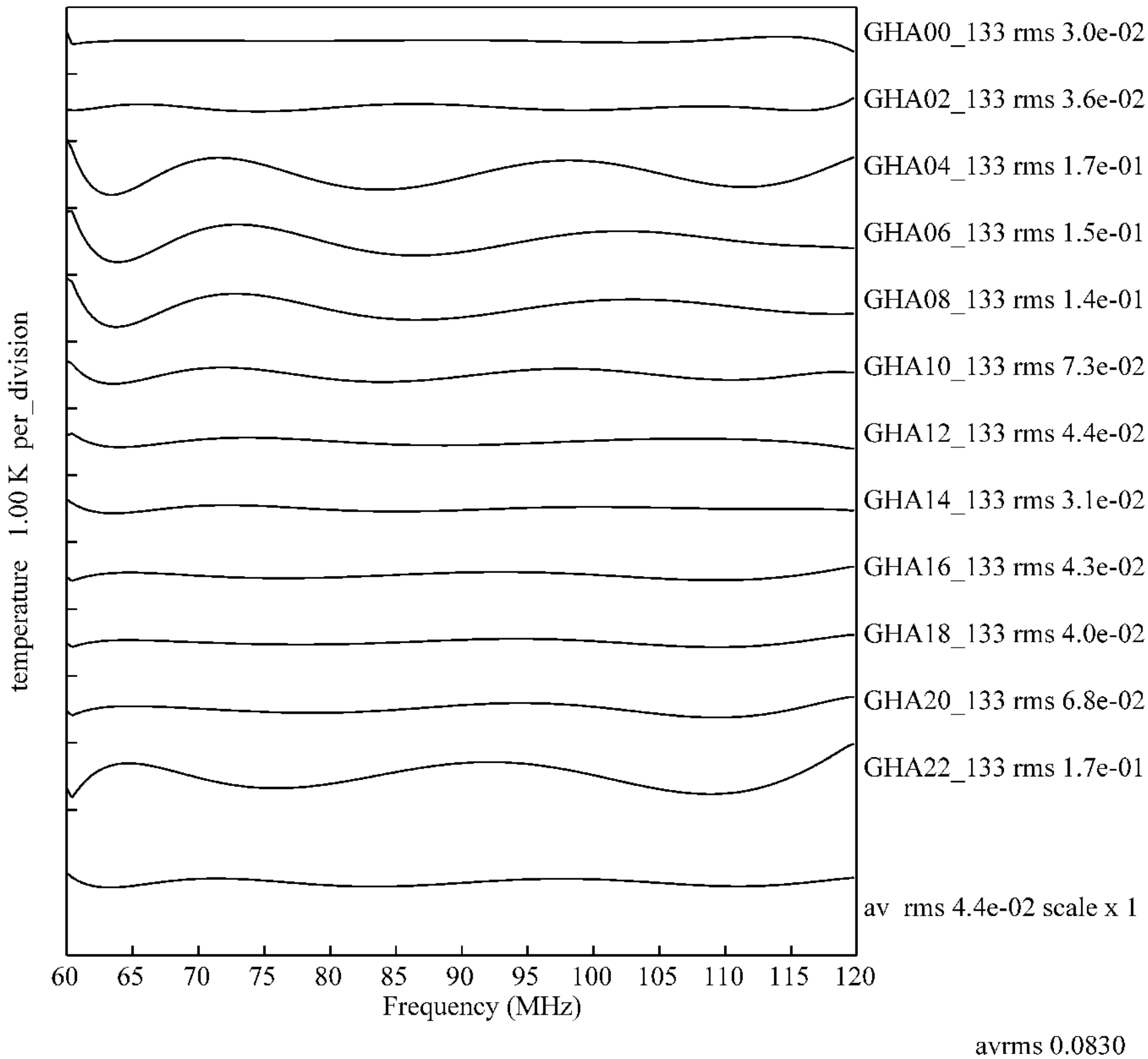

Figure 1. Residuals to 5-term linlog polynomial for simulations of beam of antenna on 30×16 m wire ground plane on uniform soil with dielectric 3.5 and conductivity 3e-4 S/m.

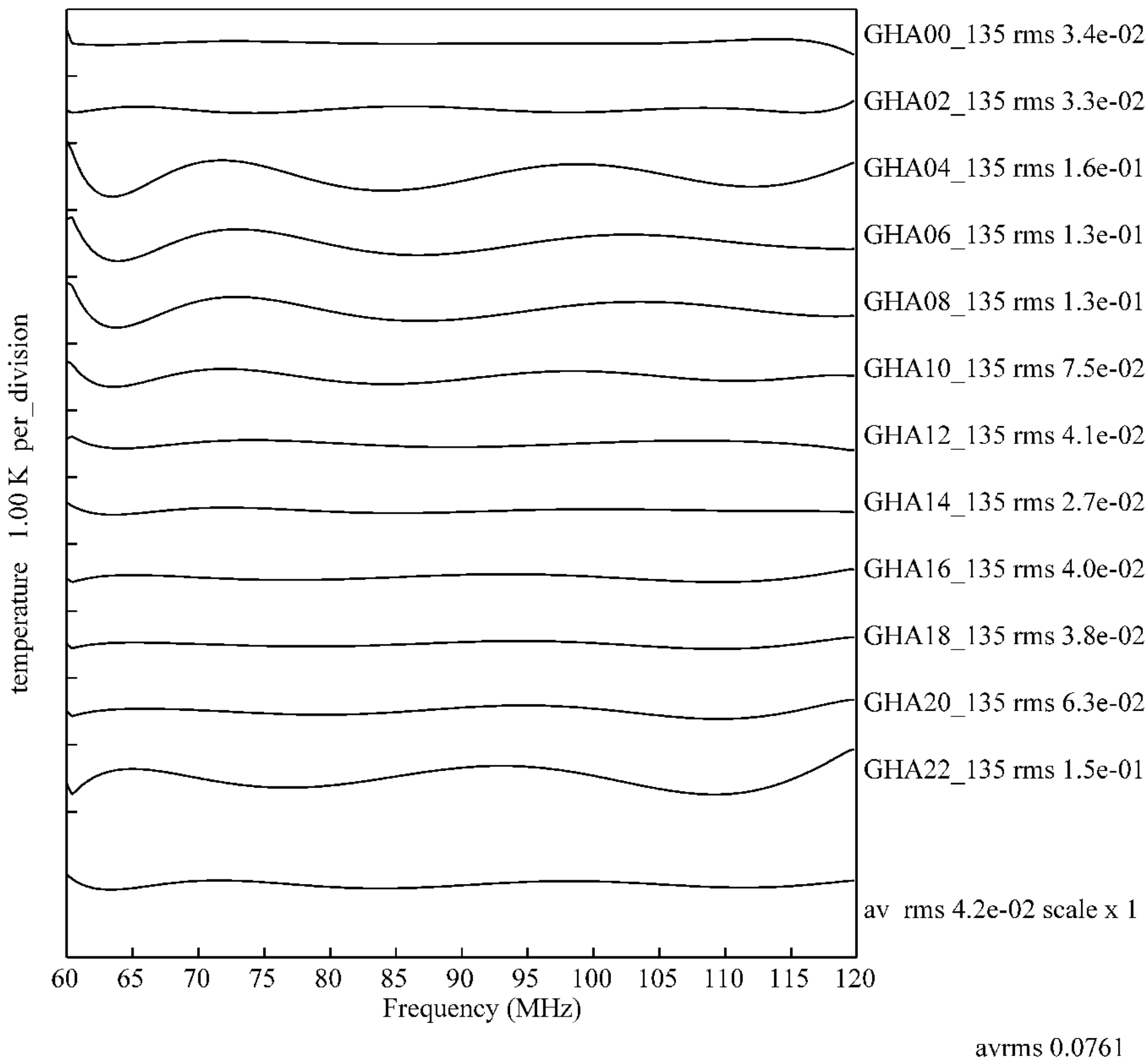

Figure 2. Beam effectors for increased soil conductivity of 1e-2 S/m.

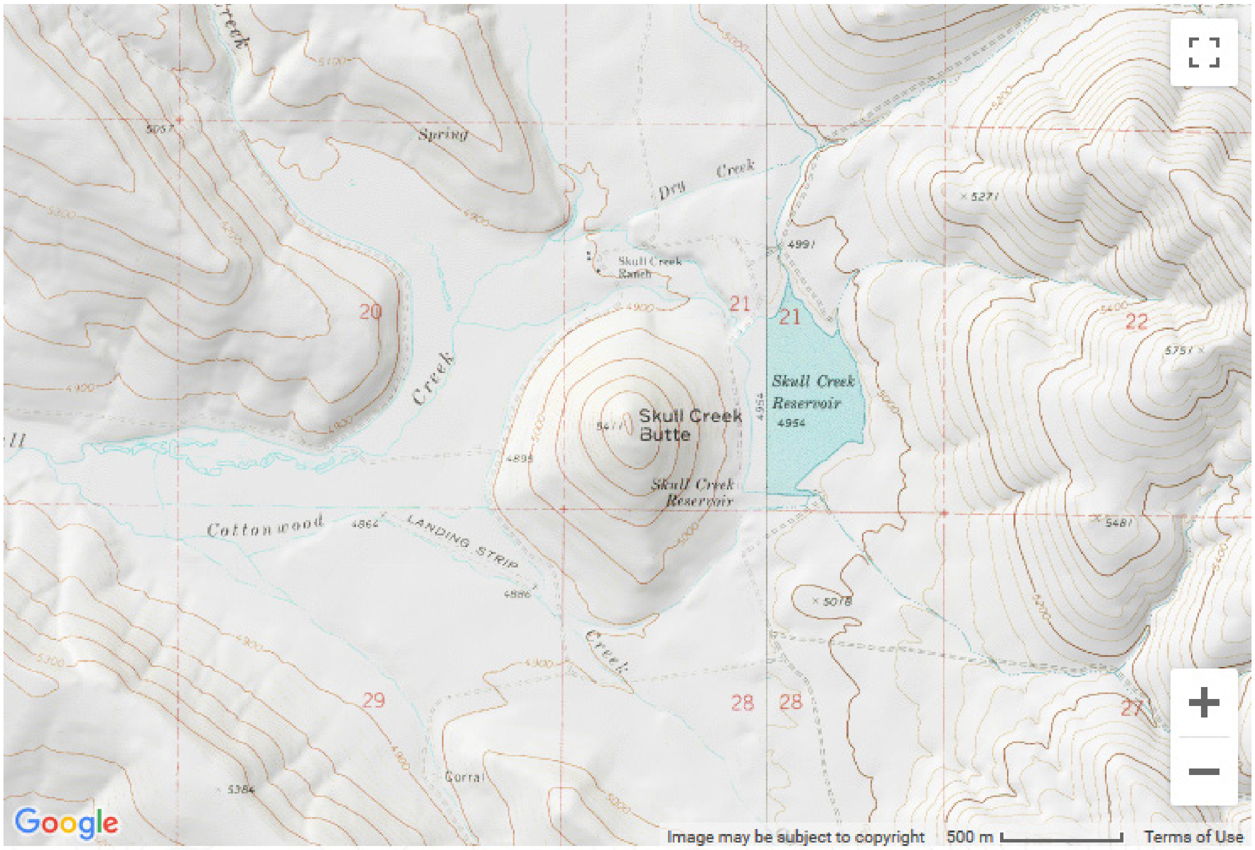

Figure 3. Topo map of Skull Creek area. Potential deployment of EDGES-3 next to Skull Creek Ranch.