EDGES MEMO #179

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To: EDGES Group

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Subject: Estimate of the effect of the Earth ground under the ground plane.

Previous studies of the ground loss have considered the antenna and finite metal ground plane to be in space. In this case the ground plane loss is calculated from the fraction of the antenna's far field beam which is in the lower hemisphere. So far the effect of the ground below the metal ground plane has been ignored.

To estimate the effect of the ground has been estimated using an infinite ground represented by a Green's Function (GF) with the FEKO MoM electromagnetic simulation software.

Figure 1 shows the ground pickup, which is 300 times the loss in kelvin, for a 2.5×2.5m metal ground plane in the top curve and 5×5 m ground plane in the lower curve. Comparing the top curve for 2.5×2.5m with figure of memo #88 the ground has reduced the loss by factor of 1.7. The ground specified by the GF was assigned a relative dielectric of 13 and conductance of 2×10^{-3} Sm^{-1}. If the scaling by a factor of 4 reduction in loss for a factor of 2 increase in size of the ground plane holds the curve for 5×5 m should be a scaled version with pickup of 3K at 100 MHz. What is not understood is the change in shape.

In another test FEKO was run with a 7×7m ground plane. In this case the loss at 100 MHz was -0.2% which indicates that 0.2% may be a limit to the accuracy of FEKO using the GF method. If we assume the loss for the current 10m×10m low band ground plane is given by the top plot in figure 1 scaled down by a factor of 4 the residuals for a 1 to 5 term fit of a simulation from 51 to 95 MHz are 3200, 1000, 311, 41, 10 mK for Galaxy down. If this is correct the ground plane is probably not a very significant source of error. Ignoring the effect of the ground plane in this simulation alters the estimate of spectral index by about 0.01.

The resistive loss of the 5cm ×5 cm steel wire grid in the 10m×10m ground screen which surrounds the 2m×2 m solid center of the low band antenna is estimated to be only about 0.01 % at 50 MHz. A conductivity of 10^6 S/m was assumed for the 4mm diameter welded wires.

Following the recognition that the ground dielectric at the MRO is in the range 3.5 to 4.5 and the realization that FEKO can be used to obtain the ground loss by setting the ground conductivity to zero. With the conductivity to zero FEKO calculates the beam pattern above and below the horizon from which the loss can be estimated from the ratio of power blow the horizon to the sum of power above and below the horizon. Figure 2 shows the ground loss for a ground plane over a soil dielectric of 3.5 for ground plan of 2.5×2.5m and 5×5m.

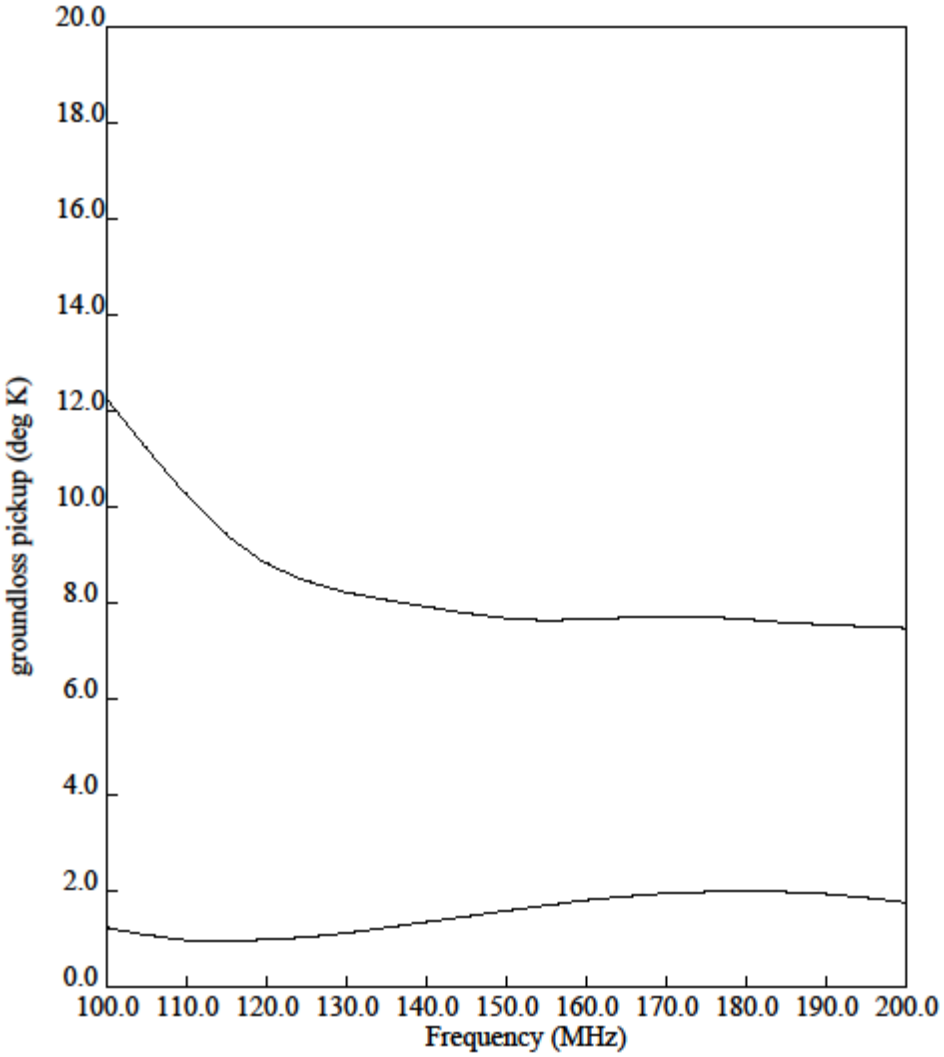

Figure 1. Groundloss in units of loss times 300K for ground planes of 2.5×2.5 m (upper curve) and 5×5m (lower curve) over GF ground.

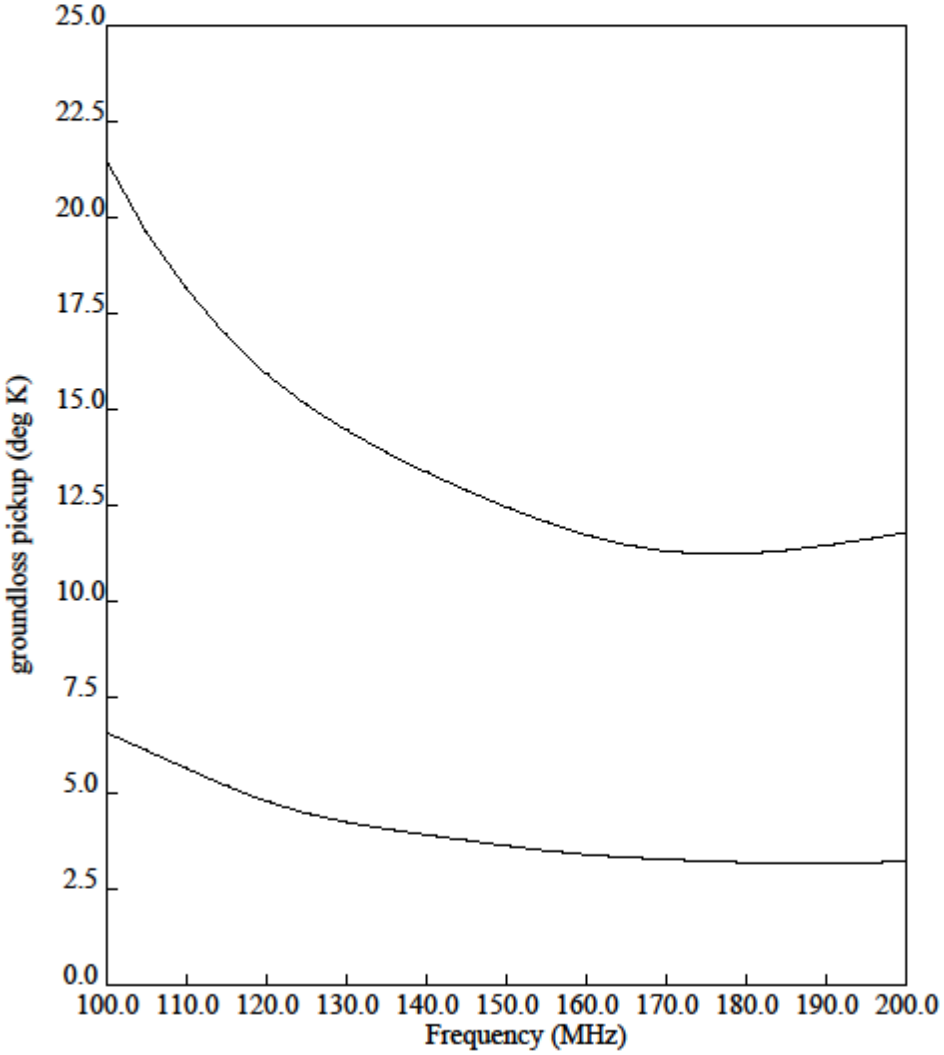

Figure 2. Ground loss for ground planes of 2.5×2.5m and 5×5m over soil of dielectric of 3.5.