Remote Sensing of Electromagnetically Penetrable Objects: Landmine and IED Detection– (RSEPOLID)

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Introduction: The present study models the propagation of electromagnetic waves introduced into a computational model of a landmine environment non-invasively. Depth, size, soil moisture, and frequency of incident wave variables were tested to generate a template for more informed future real-world detection.

Figure 1. An example of a subsurface hazardous IED scenario

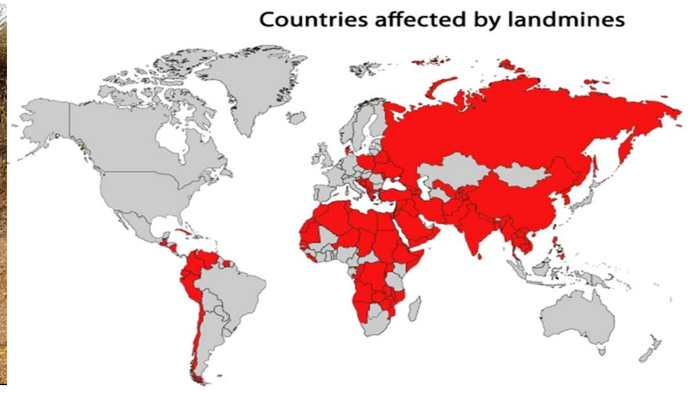

Figure 2. Map showing counties sown with landmines and IEDs worldwide [1]

Computational Methods:

The basic computational geometry with accurate dimensions was established and microphysical parameters (Table 1) were set according to the domain's properties.

Material	Relative permittivity	Relative permeability	Conductivity
Air	439.2	1	0
Dry Soil	1273+31i	2.9	0.004
Wet Soil	1756+395i	4	0.049
TNT	2.9	1	4.8e-4

Table 1. The microphysical parameters of all used materials [2]

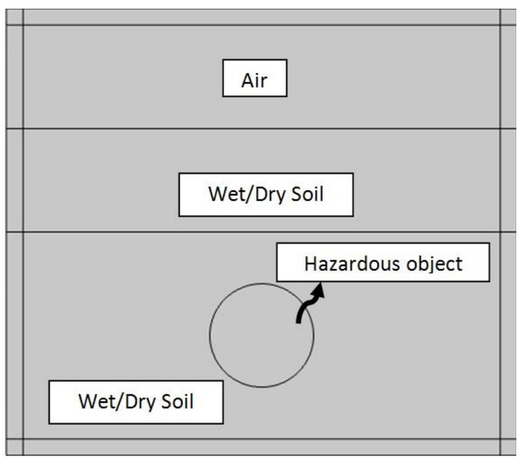

Figure 3. A 2D model used for the computational domain.

Governing Equations::

$$\nabla^2\vec{E}+\mu_r\mu_0\varepsilon_c\omega^2\vec{E}=0 \quad (1)$$

$$E=E_0 e^{\left(\pm i\vec{k}\vec{r}\right)} \quad (2)$$

$$\sigma_{2D}=\lim_{\rho\to\infty}\left[\frac{|E_s|^2}{|E_i|^2}\right] \quad (3)$$

The Electromagnetic Waves, Frequency Domain (emw) module in COMSOL was used as the computational physics. A transverse electric (TE) wave applied in the computational domain propagated in the z direction non-invasively. A parametric sweep stepping every 0.5 GHz starting at 0.5 GHz and stopping at 3.0GHz was preset in the Frequency Domain Model study to run with every environmental adjustment test in the computational geometry.

Results:

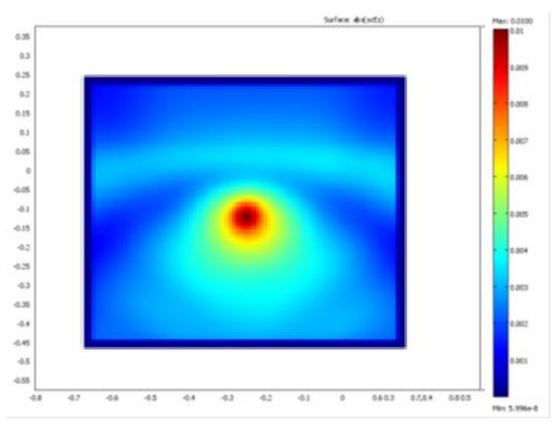

Figure 4. Dry Soil Scattering

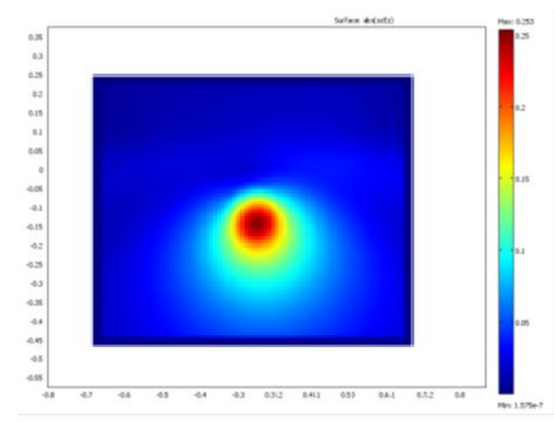

Figure 5. Wet Soil Scattering

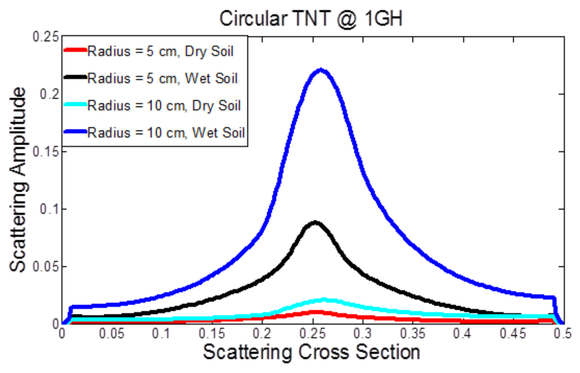

Figure 6. Size Variation

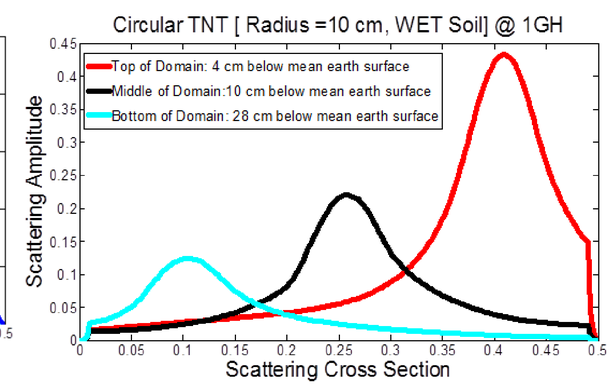

Figure 7. Depth Variation

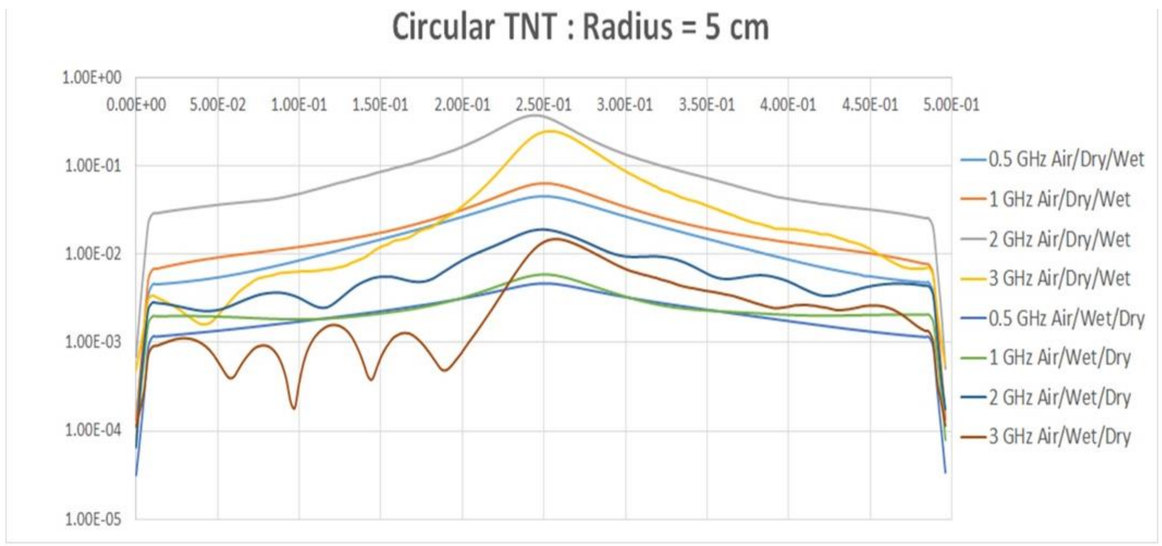

Figure 8. Parametric study of Frequencies on Multiple Layers

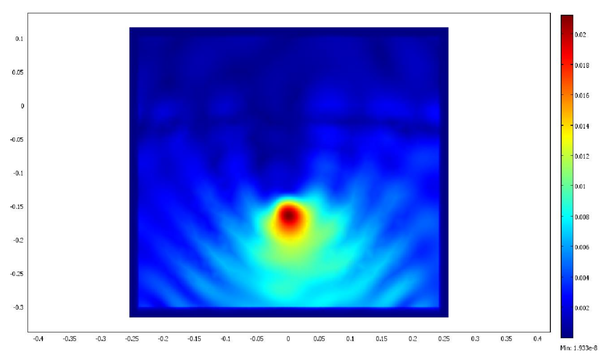

Figure 9. Air/Wet/Dry Soil Scattering

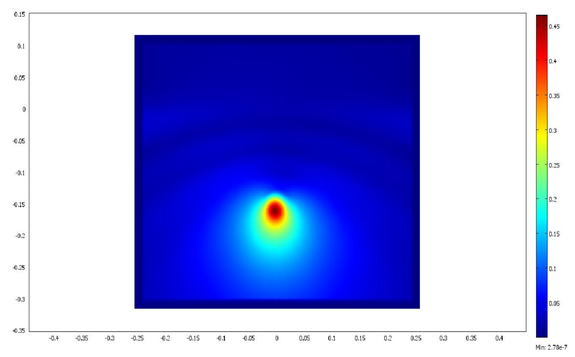

Figure 10. Air/Dry/Wet Soil Scattering

Conclusions: This study resulted in the successful creation of a comprehensive template for the remote subsurface detection of Landmines and IEDs. By increasing understanding of remote sensing behavior, technologies for more successful and safe detection techniques are on the horizon.

References:

1.Handicap International, ICBL, Landmine Monitor Report 2004: Toward a Mine-Free World (2004)
2.Hussein, E.M.A., Waller, E.J. "Landmine Detection: The Problem And The Challenge" Applied Radiation and Isotopes 53 (2014)

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