ALTASIM TECHNOLOGIES
REALIZING TOMORROW'S TECHNOLOGY

COMSOL CONFERENCE 2019 BOSTON

Propagation of Radio Signal Over the Sea Surface

Kyle Koppenhoefer, Jeffrey Crompton and Sergei Yushanov

Motivation

- Ocean can be a hostile environment
- Ability to receive radio signals can save lives

Objective

- Calculate communication radio link budget between a transmitting and a receiving antenna
- Calculate the path propagation of signal (includes sea reflection and sea wave diffraction effects)

ALTASIM® TECHNOLOGIES
REALIZING TOMORROW'S TECHNOLOGY

Solution Method – Full Maxwell Wave Equation

- Axisymmetric formulation
- Frequency domain solution
- Transmitter antenna is magnetic dipole
- Sea surface is impedance boundary condition

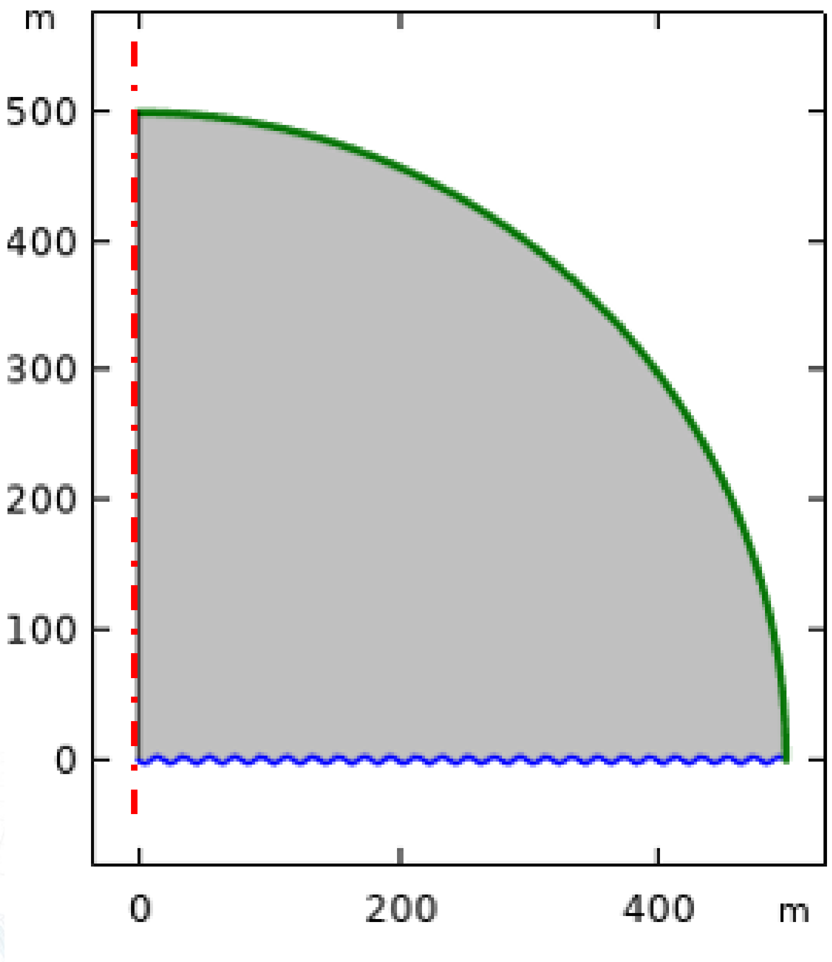
$$\nabla \times \mu_r^{-1}(\nabla \times \mathbf{E}) - k_0^2 \left(\varepsilon_r - \frac{j\sigma}{\omega \varepsilon_0} \right) \mathbf{E} = 0$$

$\mathbf{E}$: electric field (V/m)
k_0: free-space wave vector $(1/m)$
ε_r: relative permittivity
μ_r: relative permeability
σ: electrical conductivity (S/m)

ALTASIM® TECHNOLOGIES
REALIZING TOMORROW'S TECHNOLOGY

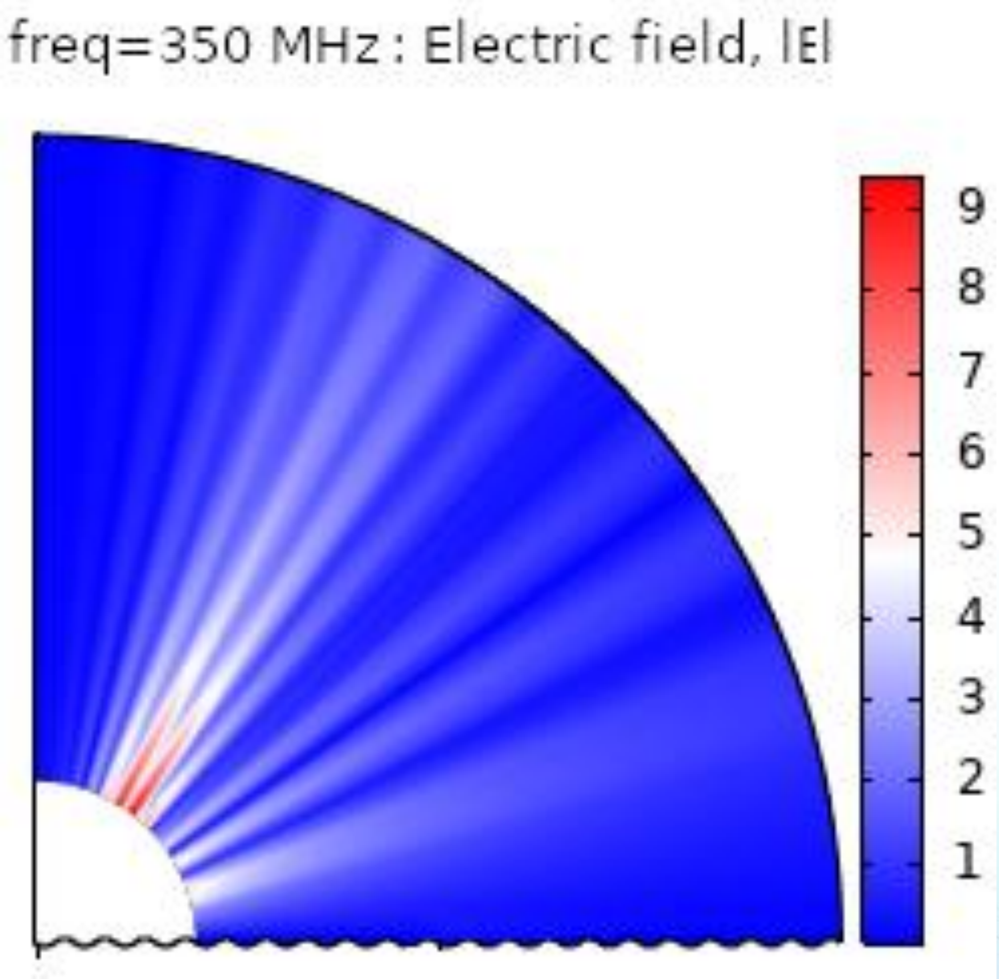
COMSOL Multiphysics Model

- Electromagnetic Waves, Frequency Domain (emw)
- Axisymmetric
- Open boundary – green
  - Scattering Boundary Condition
  - Transparent to transmitted and reflected waves
- Ocean surface – blue
  - Harmonic function with the predefined decay of the wave height
  - Impedance Boundary Condition
- Antenna located at r=0
  - Magnetic dipole - point offset from the symmetry axis
  - At specified distance from the sea level



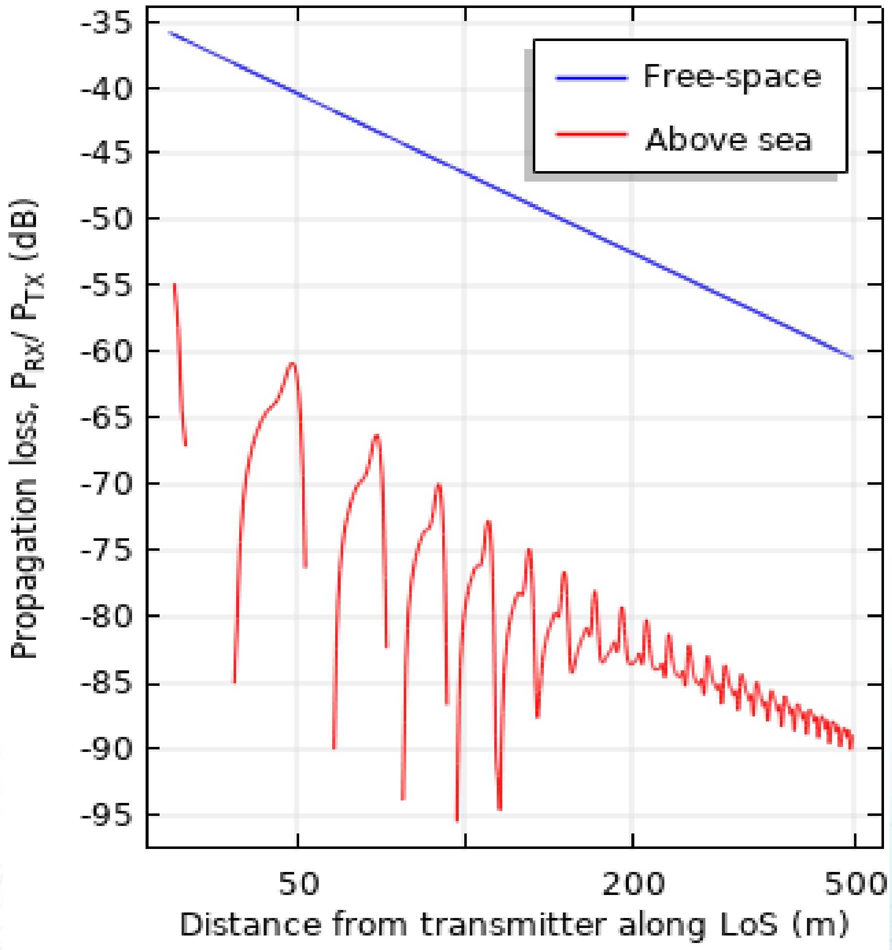
Electric Field Distribution (350 MHz)

- Visualization of electric field
- Provides understanding of energy distribution
- Internal 100 m core removed from plot



Path Propagation Loss

- Effect of distance on signal strength
- Ratio of received and transmitted power
- Free space reference shows effect of ocean surface



Conclusions

- Model developed to calculate effect of sea state on propagation loss from a radio transmitter located on ocean surface
- Strong effect of ocean demonstrated
- Simulation application developed to enable users to explore design space