An Investigation Into the Effects of Sea Surface Roughness on RF Propagation in Evaporation Ducting Environments

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The atmospheric boundary layer in the immediate vicinity of the ocean surface tends to contain a sharp gradient in water vapor pressure. Due to the sizeable impact of water vapor on radio frequency (RF) refractive index, this gradient tends to create a shallow RF trapping layer in the region immediately above the ocean surface. The vertical extent of this trapping layer, called the evaporation duct, varies from a few meters to several tens of meters. Coupling of RF energy into the evaporation duct depends on transmission frequency. Typical cutoff frequencies fall between S-band (~3 GHz) and Ka-band (up to ~40 GHz).

Several numerical and experimental studies of the impact of the evaporation duct at S-, X- and Ku-band (up to ~14 GHz) have been conducted. Measurements have also been performed at frequencies above Ku-band (e.g., K.D. Anderson 1990, IEEE Ant. and Prop., 1990, J.R. Hampton, IEEE Ant. and Prop., 2006); however, the impact of ocean wave scattering and path-loss absorption at these higher frequencies has not been well characterized. Specifically, the relative impact of these effects – all of which have increasing significance at higher frequencies – has not been thoroughly studied.

This presentation reviews recent updates to the TEMPER (Tropospheric Electromagnetic Parabolic Equation Routine) RF propagation model. These updates have improved the model's ability to assess the correlated environmental effects within the evaporation duct layer, especially the impact of rough-surface scattering. The influence of surface roughness on over-the-horizon propagation, especially at higher frequencies, is explored along with the interaction of refraction and absorption due to the absolute level of water vapor within the evaporation duct.