Forecasting RF Scintillation and IR Beam Spreading Due to Turbulence from Numerical Weather Prediction Based Calculations of Refractive Index Structure Constant

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For radio frequency (RF) and infrared (IR) systems with relatively long paths in the turbulent prone atmospheric boundary layer, small scale variations in refractive index can impact performance. For RF systems, turbulence induced amplitude scintillations must be taken into account for tightly engineered link margins. Phase scintillations will impact the performance of coherent RF systems. Beam distortion will limit the performance of IR systems in strong turbulence. These impacts can be predicted if the refractive index structure constant (Cn^2) is known along the propagation path

Attempts at calculating vertical profiles of Cn^2 initially employed high resolution vertical soundings. Cn^2 can be estimated from the vertical gradients of potential temperature and specific humidity. At RF frequencies, both temperature and humidity gradients are factors. Humidity gradients can be ignored at IR wavelengths. Recently, RF and IR engineers have employed numerical weather prediction (NWP) models to forecast vertical profiles of Cn^2 and subsequent RF and IR performance parameters such as amplitude scintillation and Fried's coherence length for RF and IR respectively.

This technique involves challenges to NWP. A Richardson number test must be applied to each NWP layer for the possibility of turbulence in that layer. The vertical thermodynamic gradients become more suspect as the NWP model vertical resolution broadens. In addition, the outer scale or energy input scale of turbulence must be predicted for each layer. There are both empirical and internal NWP model parameter techniques for predicting the outer scale of turbulence.

This presentation will demonstrate calculations of the vertical profiles of Cn^2 derived from COAMPS® profiles, display Cn^2 variations based on the choice of Richardson number and the outer scale of turbulence and present the subsequent engineering results in terms of RF amplitude scintillations and Fried's coherence length for IR.