CASPER East Campaign LES-based RF Scintillation Study

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The Coupled Air-Sea Processes and Electromagnetic (EM) wave ducting Research (CASPER) is a multi-university research initiative to better understand the propagation of radar and communication signals in marine environments. The CASPER-East is the first of the two planned field campaigns, conducted on the months of October-November, 2015, offshore of Duck, North Carolina. The CASPER-East field campaign included extensive EM, atmospheric and marine measurements, which were backed by various EM and computational fluid dynamics (CFD) tools. The Large Eddy Simulations (LES) is one such CFD tool used for characterizing the turbulence in the atmosphere.

Small-scale fluctuation of the refractive index of the atmosphere leads to the amplitude variation of the signal received, a phenomenon termed as scintillation. Such scintillation, especially at high frequencies, may cause fast fading of the signals which becomes a major hindrance for low margin systems. Hence, it is essential to predict the worst case fading possible, given the atmospheric properties of a region. Earlier, ITU models were used for the prediction of fade depths at a location. But these models are empirical, work till 20 GHz and use the wet term of the refractive index, as the input for atmospheric variability. On the other hand, LES can capture the real-time condition of the atmosphere, depending either on local numerical weather prediction tools or measured data, and provide a 3D refractivity profile of the region. 2D parabolic equation (PE) based EM propagation models, like Advanced Propagation Model (APM), can be run on these refractivity profiles to obtain the propagation loss of the signal at the desired range and height of the receiver. Several realizations out of the 3D profile can be used to perform a Monte-Carlo analysis, providing us with the distribution of propagation loss.

The power spectral density (PSD) of the refractivity, obtained from LES, includes the effects of turbulence in the scale length of 10s of m. Turbulence in the order of 10s of m to 10s of mm, is said to be in the inertial subrange, whose PSD follows the Von-Karman Kolmogorov spectrum (V. Fabbro and L. Féral, IEEE Trans. Antennas Propag., 60, 4398-4407, 2012). Since the spectrum obtained from LES covers part of the spectrum, it can be extended such that it covers the entire scale length. The smaller scale turbulence has a pronounced effect on fading depth at higher frequencies. This paper focusses on the scintillation study using the LES results obtained from the CASPER East campaign. We compare our results obtained from simulation to ITU predictions, as well as to some measured data. Future work will incorporate the roughness of land/sea into LES-EM simulations, which would be a more in-depth study of scintillation.