Monte Carlo Simulation of Underwater Wireless Optical Communications in Turbulent Environments

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Underwater wireless optical communications (UWOC) is an emerging high bandwidth, low time latency and highly secure technology that can be used to facilitate high data rate, real-time communication over short to medium ranges among various underwater vehicles and sensors used in a variety of scientific, environmental and commercial purposes. The impact of scattering and absorption phenomena on UWOC has been modeled and studied previously with Monte Carlo simulation but turbulence has not. To fill this gap, a physical simulation model is required. However, methods for generating representations of turbulent media based on computational fluid dynamics (CFD) are generally too computationally intensive for routine use. In this paper, we propose a novel Monte Carlo simulation model especially for UWOC in turbulent oceanic clear water that is far less computationally intensive than approaches based on CFD. The model is based on the variation of refractive index in a horizontal link that has not been studied before.

Our results show that our simulation model correctly reproduces the lognormal and negative exponential probability density function (pdf) of the irradiance fluctuation for weak and saturation turbulent regimes respectively which are theoretically predicted and experimentally verified in atmospheric studies. Our results are matched with an experimental reported study in weak turbulent regime underwater. The shapes of the pdf obtained for moderate-to-strong regime of turbulence in our simulation model have not been predicted by theory nor are experimental observation readily available. Such results are however, testable predictions potentially useful in communication systems design. The acquired scintillation index (S.I) from our simulation model based on the refractive index variation for different link distances demonstrates the accuracy of the model. Furthermore, our results show that as the refractive index variation increases, path loss is observed especially for longer link distance.