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Scintillation Effects on VHF/UHF Satellite Communications and Mitigation Techniques

Chaosong Huang(1), Ronald G. Caton(1), Richard T. Parris(1), and Jeffrey M. Holmes(1)
(1) Air Force Research Laboratory, Kirtland AFB, NM 87117, USA

Extended Abstract

VHF (very high frequency) and UHF (ultra-high frequency) are the most heavily used frequency bands for space communications. A critical issue for trans-ionospheric satellite communications is the occurrence of VHF/UHF signals' phase fluctuations and amplitude fading caused by scintillation. The objectives of this study are to quantitatively determine the scintillation effects on VHF/UHF signals and to identify mitigation techniques. We have two datasets for this study.

The first dataset is narrow-band VHF (250 MHz) data received at Kwajalein through the entire year of 2012. The fading of the VHF signals reached 20-30 dB under high scintillation conditions. A statistical analysis of the VHF data are performed, and the scintillation S4 index, fading level, and decorrelation time are calculated. The dependence of the fading level on the S4 index is derived. The fading level increases approximately linearly with S4 when S4 is in the range of 0.2-0.8, but the increase becomes more gradual when S4 is larger than 0.8. The occurrence probability of the VHF fading is calculated at different local times each month. The decorrelation time decreases with S4 when S4 increases from 0.2 to 1.0 and then remains essentially unchanged when S4 becomes larger. The dependence of the decorrelation time on S4 is also calculated at different local times. Figure 1 shows the statistical results.

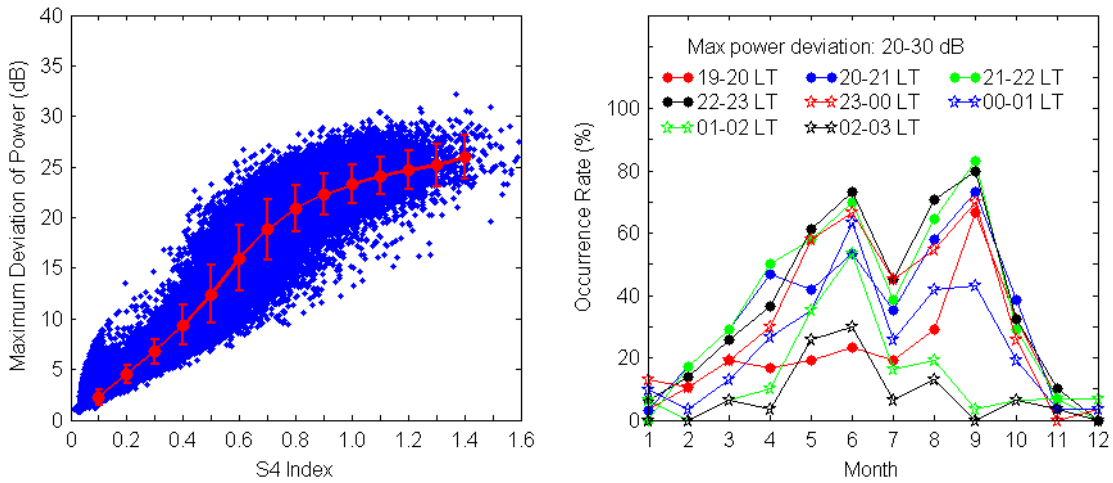

Figure 1. Scintillation effects on VHF signals observed at Kwajalein in 2012. This figure shows (left) the amplitude fading of the VHF signals as a function of S4 and (right) the occurrence of the amplitude fading at different local times and months.

Another dataset is wideband UHF (360-380 MHz) data received at Ascension Island during an observational campaign in October 2016. Different effects of scintillation on UHF signals were observed. (1) Scintillation caused flat fading of the UHF signals over the entire frequency range (360-380 MHz) simultaneously. (2) The UHF signals were reduced first at the lower-frequency channels and then at the higher frequency channels. This wave-like variation occurred with a cyclic time of a few seconds and repeated over and over. We also studied the scintillation mitigation with a spaced array of receivers in the east-west direction. It is found that the fading of UHF signals at different locations could occur with a time shift and that the signals with deep fading at one location can be compensated by the signals without significant fading at another location. A further analysis of the UHF data will determine the coherent bandwidth.

From this study, we are able to determine how the effects of scintillation on VHF/UHF signals depend on the frequency and bandwidth (narrow-band or wide band) of the signals and how the scintillation effects can be mitigated.