Wideband characterisation of equatorial ionospheric scintillation using MUOS transmissions

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1. Introduction

UHF satcom has a number of advantages over operation at higher frequencies; these include better coverage in built up areas where the visibility of the satellite may be impaired and better propagation through tree canopies. Typically, UHF satcom systems have low capacity being limited by the simple 25 kHz narrowband waveforms. Wideband waveforms can overcome this capacity issue; however, our understanding of the wideband trans-ionospheric channel is poor. This is particularly so at equatorial and high latitudes where ionospheric irregularities, which scatter the signal, are prevalent in the evening and early night. These disturbances cause rapid changes in signal direction, delay, phase and amplitude, known as scintillation.

Except for a few exceptions [eg *Cannon et al.*, 2006; *Knepp and Houpis*, 1992] trans-ionospheric studies of UHF scintillation effects have been limited to narrowband measurements (i.e. measurements with bandwidths of less than the channel coherency bandwidth) and usually with continuous wave signals. This paper will describe results from a new wideband experiment deployed at the Cape Verde Atmospheric Observatory (CVAO) (16.8°N, 24.8°W geographic; 22.85°N, 50.86°E geomagnetic) close to the ionospheric equatorial region. The experiment's ultimate purpose is to measure the effects of ionospheric irregularities on 5 MHz wideband UHF signals transmitted by the COSMIC-II satellites. However, delays in the launch of COSMIC-II has required that the experiment be redirected towards other wideband UHF satellite signals, including the Mobile User Objective System (MUOS) signals.

2. The Experiment

MUOS is a wideband UHF geosynchronous satcom system serving the United States Department of Defense (DoD). Its downlink covers 20 MHz and consists of four 4.5 MHz wideband code division multiple access (WCDMA) channels centred at 370 MHz. The capacity to make measurements over 20 MHz is comparable to those reported by *Cannon et al.* [2006] and the fixed geometry to geosynchronous orbit is particularly advantageous for synoptic monitoring. However, the spreading codes and modulation are unknown. Consequently, only measurements of the signal power can be made, as opposed to the full scattering function as made by *Cannon et al.* [2006] and as anticipated for COSMIC-II.

The data acquisition system, consisting of a helical antenna with a gain of 13.5dBi, a USRP B200 software defined radio (SDR) and a 24 TB RAID0 disc array has been operated (apart from minor outages) between 2000 UT and 0500 UT from 16 December 2018 to 30 April 2019. Data are I, Q sampled at 20 MHz (50ns) per channel. Data are ingested by the processing routine in 2000 sample blocks, each lasting 100μs. Each block is FFTed to generate a 20 MHz power spectrum with a spectral resolution of 10 kHz. One thousand of these power spectra are then averaged and the result stored every 0.1s. Recently the average I and Q spectra have also been stored.

3. Results

Variations in S4 from a narrow frequency sub-band are used to isolate periods of scintillation (S4 > 0.2) in over 500 hours of data, providing an opportunity to investigate the occurrence statistics during the current low sunspot number period. The active periods are then further analysed to explore the mutual coherence of the fading over the 20MHz measurement bandwidth and thereby assess the probability and characteristics of flat and frequency selective fading under different geophysical conditions. The fade rate during scintillating periods is also evaluated.

By way of illustration, Figure 1 shows a sequence of four spectra, each three seconds apart, during a period of flat fading. Each figure represents an average over 0.1s.

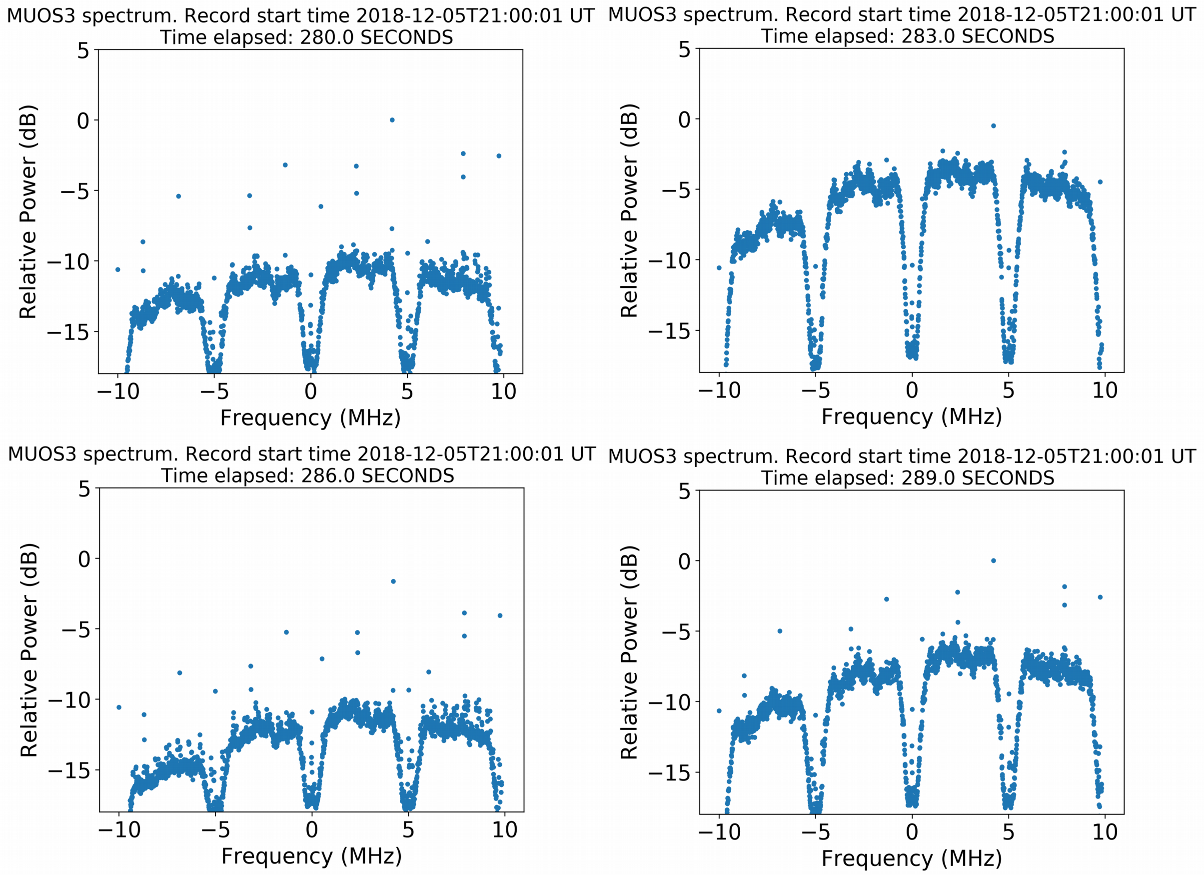

Figure 1: A sequence of four MUOS spectra three second apart during a period of flat fading, recorded on 5 December 2019, starting at 21:00:01 UT.

4. References

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