Satellite-based Studies of the Ionosphere Using MRM Radio Receivers

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The Department of Energy's Mission Response Module (MRM) payload was launched aboard a Department of Defense low-earth-orbiting satellite in 2011 to demonstrate and assess the performance of commercial off-the-shelf electronic components in space radiation environments and to study various aspects of trans-ionospheric signal propagation and detection in four frequency bands, 2 – 55 MHz, 125 – 175 MHz, 365 – 415 MHz and 825 – 1100 MHz. In this paper, we present an overview of the MRM on-orbit research and analysis effort with particular focus on an ongoing high-frequency (HF) study aimed at characterizing satellite-observed trans-ionospheric signal propagation and detection effects. MRM detects a variety of natural and man-made signals including a rich phenomenology of lightning impulses and various other research signals of opportunity. The ongoing HF study consists of three phases, (1) execution of a global HF noise survey, (2) use of the HAARP transmitter and antenna array in Gakona, AK and the WWV Time and Frequency Standard transmitters in Ft. Collins, CO to characterize trans-ionospheric signal propagation effects near foF2, and (c) an assessment of coherence bandwidth and scintillation limitations on our ability to both detect and characterize these signals. Early results from this study have provided a quantification of trans-ionospheric signal power loss due to bottom-side reflection and D-layer absorption as a function of signal frequency normalized to foF2. We have also been able to characterize some trans-ionospheric signal propagation modes, especially multi-hop circuits which appear to allow local sub-foF2 signals to escape the ionosphere by multi-hopping to adjacent regions where the ionosphere is characterized by a smaller foF2. Results of an ongoing global noise survey in the 2 – 55 MHz and 365 – 415 MHz bands will also be presented.