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Footprints of Space Weather Coupling and the ROTHR System

Abstract:
The ionosphere generated by the quiescent flow of short wavelength radiation from sun is a natural enabler for ground based over-the-horizon radar (e.g. US Navy AN/TPS-71 Relocatable over the Horizon Radar (ROTHR)) and HF communication. There are special events that occur on sun which can disrupt the operation of these and other space based RF systems. During these events, there are unusually large bursts of particle and energy ejected from sun (e.g., Coronal Mass Ejection (CME) and Solar Flares). The CME's are huge bubbles of gas threaded with magnetic field lines that eject large quantities of matter and electromagnetic radiation into space.

The coupling between charged particles from CME's and the magnetosphere at high latitudes leads to very complex ionospheric physics including generation of magnetic storms. Some of the phenomena (e.g., TID's created by CME) are transported to lower latitudes. Solar flares, on the other hand, produce a burst of radiation across the electromagnetic spectrum, from radio waves to x-rays and gamma rays. The effects of solar flares can range from earth-wide radio blackouts to sudden increase in electron densities in ionosphere. The ionosphere is affected by the occurrence of CME and solar flares in a number of ways which in turn affects ROTHR tracking and performance.

For the present paper, we study the impact of solar flare and CME's on ionosphere with focus on the HF propagation specifically related to ROTHR system during and after the occurrence of these solar events. A solar flare was detected by NASA's Solar Dynamics Observatory on September 10, 2014 and ROTHR at Virginia site generated few or no tracks during the time span of this event. The quasi-vertical incidence (QVI) sounder and the nearby GPS receiver also showed increased electron densities during the event.

The impact of the solar flare was also evident on HF propagation as measured by wide sweep backscatter ionograms (WSBI). Following the solar flare event, a pair of CMEs hit Earth's magnetic field in quick succession on 11th and 12th September, 2014 and result was the creation of generation geomagnetic storm. The total electron content (TEC) derived from abundantly available dual frequency GPS receivers is utilized to detect the presence and propagation of Travelling Ionospheric Disturbances (TIDs) generated by these CME's.

The results of the impact of CME and solar flare on ROTHR, HF propagation (WSBI) and related ionospheric characteristics (e.g., effects on QVI and GPS) are discussed in the paper.