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Variability in HF Absorption - Effects of Daily Variability and Sudden Stratospheric Warming of Neutral Atmosphere

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The absorption of high frequency (HF) radio waves is dependent on the state of the Earth's ionosphere. The ionosphere is influenced by many aspects of the neutral thermosphere in which it is embedded, including its temperature, wind field, and composition. In particular, the absorption of HF radio waves is known to depend on the electron-neutral collision frequency. Thus, it is important to investigate the impacts of the neutral thermodynamics on HF propagation, which has so far been rarely studied. The peak HF absorption occurs in the mesosphere and lower thermosphere (MLT) region. This study examines how the day to day variability in MLT region neutral atmosphere and a Sudden Stratospheric Warming (SSW) impact the HF absorption.

There is considerable meteorological variability in the mesosphere and lower thermosphere (MLT). This variability occurs through gravity waves, tides, and planetary waves, and it thus occurs across a wide range of spatial and temporal scales. Studies have shown that SSWs significantly disturb the MLT region. SSWs are large-scale and extended duration dynamical events and have recently drawn more attention due to their role in perturbing the Earth's atmosphere at larger scales. Though the SSW occurs at the polar stratospheric region they also influence the atmosphere at other latitudes. SSWs typically last for a few days or weeks and strongly affect vertical coupling over a large range of altitudes from the stratosphere up to thermosphere.

We study the impact of this variability on HF absorption using the NRL 3D magnetoionic ray trace code, MoJo (Modernized Jones Code). MoJo has previously utilized the climatological inputs for studying differences in HF absorption, which are suitable for studying local time, season, latitude, and solar cycle variations, but lacking in daily meteorological effects. The present study is based on using MoJo with the state-of-the-art Whole-Atmosphere Community Climate Model – eXtended (WACCM-X) nudged with the high-altitude version of the Navy Global Environmental Model (NAVGEM-HA) in order to include effects from terrestrial weather to specify the electron-neutral collision frequency. Results are presented around the 2010 and 2013 SSW periods. Our analyses show that day to day variability in MLT cause noticeable changes in HF absorption that increase significantly during SSWs. Results show increase in D-region HF absorption and decrease in the E-region HF absorption after the SSW onset. At high latitudes (e.g., Sondrestrom) in 2010, HF absorption in the D-region increased by ~57% and decreased in the E-region by 44%. In 2013, HF absorption in the D-region increased by ~70% and decreased in the E-region by ~59%.