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Effect of Compression Waves on the Ionosphere Density Profile

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While the ionosphere is primarily driven by solar conditions, it can also be modified by earth-based events. Effects due to earthquakes and volcanic activity have been observed in the ionosphere by the Global Navigation Satellite System (GNSS), the Global-scale Observations of the Limb and Disk (GOLD) satellite, the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite, and the Hard X-ray Modulation Telescope (Insight-HXMT). Seismic activity and volcanic explosions propagate acoustic compression waves up to thermospheric altitudes, causing perturbations in the density profiles. Effects due to hurricanes and tornado-producing thunderstorms have been observed by GNSS, GOLD, the Ionospheric Connection Explorer (ICON), the Constellation Observing System for Meteorology, Ionosphere, and Climate-2 (COSMIC-2), and the Geostationary Operational Environmental Satellite-17 (GOES-17). Hurricanes and tornados modify thermospheric temperatures, circulation patterns, and atmospheric densities, which contribute to ionospheric changes through convective coupling. Various anthropogenic events cause effects similar to those of the naturally occurring events.

Density variations from these earth-based events pertain to bottomside interactions, particularly in the D and E regions. Very low frequency (VLF) and high frequency (HF) interactions with these regions could be modified as a result of the changing electron density profile. Starting with neutral profiles from the Naval Research Laboratory Mass Spectrometer and Incoherent Scatter radar Extended (NRLMSISE-00) model, we introduce a static compression effect (SCE) on the neutral density and temperature from a ground-to-sky direction, modifying the shape of its vertical profiles. This SCE can be applied at various altitudes over time to investigate the effect of a propagating atmospheric gravity wave. For these various SCE applications, the perturbed MSIS profiles will be used in IRI to calculate the electron and ion profiles. This perturbed ionosphere will then be run through the High-frequency Channel Impulse Response Function (HiCIRF) to simulate an over-the-horizon (OTH) wide-sweep backscatter ionogram (WSBI) and its signal power return will be compared with that of an unperturbed ionosphere.