All-sky Tracking of Irregularities Associated with Mid-latitude Sporadic-E using the Long Wavelength Array Radio Telescope

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The phenomenon of mid-latitude sporadic-E (E_S) has been well established to be the result of a combination of zonal wind shears, ion/neutral coupling, and E×B forces at altitudes of ~100 km. The time scales on which these processes work require relatively long-lived metallic ions. Thus, it has been surmised that the likely seeds for E_S are meteors, which deposit significant amounts of metallic material as they ablate within the E-region. As they ablate, these meteors leave dense trails of ions, capable of backscattering radio-frequency (RF) signals at frequencies well into the VHF regime. In addition to these, other transient structures, or "clouds" are known to exist within E_S layers, giving them a patchy appearance. These clouds are often detectable via coherent backscatter of RF signals from field-aligned irregularities (FAIs) associated with them. Thus, a single mono- or bi-static RF system can observe these two different phenomena simultaneously to investigate the formation, evolution, and dynamics of E_S structures.

We will present observations of both meteor trails and FAIs and how they relate to E_S using a RF telescope with a unique all-sky capability. This telescope, LWA1, is the first station of the planned Long Wavelength Array (LWA). It was used for a yearlong program for all-sky monitoring of meteor activity via reflected analog TV transmissions at 55.25 MHz. Located in western central New Mexico, LWA1 is a 100-meter diameter array of 256 bent dipole antennas. It can be operated in a transient buffer (TB) mode where the signals from individual antennas are recorded to be combined later, allowing for all-sky imaging. While other 55.25 MHz sources were frequently detected such as transmitter ground waves and reflections off airplanes, analysis of the temporal structure of bright sources shows that above 30° elevation, >90% of sources are meteor trail reflections. In addition, bright sources of backscatter from FAIs were routinely observed along expected arc-like loci to the north when E_S was present.

We have made all-sky maps of 55.25-MHz peak signal-to-noise ratio (S/N) for 27 pre-midnight (03-04 UT; 19.8-20.8 local time) and 66 pre-dawn (11-12 UT; 3.8-4.8 local time), one-hour observations from Feb. to Oct. 2014. The typical peak S/N per hour is significantly higher in the region dominated by meteor trails (elevation>30°) when E_S was strongly indicated by the Boulder, CO digisonde. In addition, we have also found evidence of a correlation between E_S plasma frequency and peak meteor-trail S/N. LWA1's unique TB mode also allowed for all-sky tracking of unresolved groups of FAIs. The observed FAI motions are consistent with neutral-wind-driven dynamics when compared with TIMED Doppler Interferometer (TIDI) measurements at 82-100 km altitude. However, FAIs were observe at altitudes as high as 120-140 km, implying that tracking of FAIs may provide a novel method for measuring winds at altitudes not accessible to either meteor radars or TIDI.