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All-sky Tracking of Sporadic-E Irregularities as a Novel Probe of Thermospheric Winds

Coherent backscatter of HF/VHF transmitters/radars by field-aligned irregularities (FAIs) is commonly employed to study ionospheric disturbances. VHF radar observations of FAIs associated with sporadic-E have provided valuable insight into the structure and dynamics of sporadic-E layers. Given the high ion/neutral collision rate at sporadic-E altitudes, the movements of structures that harbor FAIs are predominantly wind-driven. Thus, the ability to track these movements provides a novel method for exploring lower thermospheric winds up to heights unreachable by meteor radars or airglow-based methods, and in a highly localized way.

Here, the results of a campaign to observe backscatter of a transmitter of opportunity with an all-sky imaging HF/VHF array are presented. The array is the first station of the Long Wavelength Array (LWA1) in New Mexico, and the signal used was the 55.25 MHz video carrier of the analog television station XEPM in Ciudad Juarez, Mexico. While the main targets of the campaign were meteor trail reflections, backscattering from sporadic-E FAIs was seen within several (18) one-hour data collections along arcs to the north of LWA1. These often appeared in groups, or “clouds” (75 in total), which could be tracked over the entire backscattering region, sometimes with multiple layers and/or clouds appearing simultaneously. Using an assumed dipole magnetic field model to estimate distances, the motions on the sky were converted to horizontal motions, which were largely consistent with predictions from the updated horizontal wind model (HWM14). However, several localized gusts of 100—200 m/s or more were detected, especially pre-midnight, that HWM14 is incapable of reproducing. These are consistent with extreme profiles observed previously with chemical release experiments and can be difficult to catch with methods that necessarily assume a spatially invariant profile over a relatively large area (e.g., meteor radars). In addition, during the pre-midnight time period specifically, there was a systematic westerly offset (~20 m/s) between the LWA1-derived zonal winds and HWM14 predictions. There is some evidence from tropospheric/lower stratospheric wind profile data that this could be due to modification of the semidiurnal tide by mountain waves in the Arizona/New Mexico region.

Finally, there were three notable instances of two clouds detected simultaneously at roughly the same height, but at different horizontal locations (~100—200 km apart) that also had opposing zonal motions. These indicate that horizontal zonal wind shears are sometimes present with magnitudes that are roughly ±1 m/s/km, or about an order of magnitude weaker

than the vertical wind shears that form sporadic-E layers. Given the relatively large separation among the sporadic-E clouds that revealed the presence of these wind shears (~20°—40° on the sky), the all-sky imaging mode of LWA1 provided a unique opportunity to detect and characterize this phenomenon.