E-region decameter-scale plasma waves observed by the dual TIGER HF radars

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The dual Tasman International Geospace Environment Radar (TIGER) HF radars regularly observe E-region echoes at sub-auroral magnetic latitudes 58°-60°S including during geomagnetic storms. We present a statistical analysis of the E-region backscatter observed in a period of approximately 2 years (late 2004-2006) by the TIGER Bruny Island and Unwin HF radars with particular emphasis on storm-time backscatter. It is found that the HF echoes normally form a 300-km-wide band at ranges 225-540 km. In the evening sector during geomagnetic storms, however, the HF echoes form a curved band joining to the F-region band at ~700 km. The curved band lies close to the locations where geometric aspect angle is zero, implying no to little refraction during geomagnetic storms, which is an opposite result to what has been reported in the past. The occurrence, Doppler velocity, and spectral width of HF echoes are also examined in order to determine whether new HF echo types are observed at sub-auroral latitudes, in particular during storms. The datasets of both TIGER radars are found to be dominated by low-velocity Type 2 echoes, with only a minor portion exhibiting the characteristics of high-velocity Type-1-like echoes (< 10%). A separate population of storm-time echoes is identified within the datasets of both radars. Most of these echoes are similar to Type 2 echoes. The storm-time backscatter observed by the Bruny Island radar, on the other hand, includes near-range echoes ($r < 405$ km) that exhibit some characteristics of what has been previously termed the High Aspect angle Irregularity Region (HAIR) echoes. We show that these echoes appear to be a storm-time phenomenon and further investigate this population by comparing their Doppler velocity with the simultaneously measured F- and E-region irregularity velocities. It is suggested that the HAIR-like echoes are observed only by the HF radars with relatively poor geometric aspect angles when electron density is low and when the electric field is particularly high.