Simultaneous and co-located measurements of radar reflectivity, turbulence, winds, and electron density by VHF/MF radars during PMWE and PMSE

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Strong radar echoes were detected by the ALWIN VHF (53.5 MHz) radar in the altitude range 55 to 77 km on 17 to 21 January 2005. These echoes are called polar mesosphere winter echoes (PMWE). PMWE are rare phenomena of the winter mesosphere [1] with an occurrence rate of about 1-3% as compared to polar mesosphere summer echoes (PMSE) which regularly appear at altitudes of about 80 to 90 km during polar summer. The PMWE observed in January 2005 were highly correlated with solar radiation storms, solar proton events, and enhanced geomagnetic activity. For the first time the Saura MF radar nearby measured electron densities and turbulent energy dissipation rates at the same time [2], [3]. These observations and additional simultaneous and co-located VHF/MF radar measurements obtained in winter 2006/2007 are discussed.
The VHF radar observations of absolute reflectivities [4] of about 10^{-15}-10^{-14}m^{-1} during the appearance of PMWE are discussed in relation to turbulent energy dissipation rates and electron densities observed simultaneously by the co-located Saura MF radar (3.17 MHz). In general energy dissipation rates in the order of 20-120 mW/kg were observed before, during and after the PMWE events. The electron densities during PMWE are typically in the order of 10^9 m^{-3} and about one order of magnitude larger than electron densities measured under undisturbed conditions. These observations are also in quantitative agreement with model calculations of turbulent radar backscatter from weakly ionized plasma [5], [6].
In early summer 2007, May 18-28, strong radar echoes have been simultaneously observed at altitudes below 80 km (PMWE) and above 80 km (PMSE) during disturbed geomagnetic conditions. The occurrence of PMWE is highly correlated with enhanced riometer absorption observed by the co-located imaging riometer AIRIS. Turbulent energy dissipation rates varied between 5 and 100 mW/kg at altitudes between 55 and 90 km. A maximum radar reflectivity of $2 \cdot 10^{-13}$ m^{-1} is observed in the PMSE region above 80 km and a reflectivity of $7 \cdot 10^{-16}$ m^{-1} below 80 km in the PMWE region. In presence of strong radar echoes, the electron density around 70 km amounts about $1.5 \cdot 10^9$m^{-3}. The radar echoes from altitudes below about 80 km (PMWE) are characterised by low or no aspect sensitivity (a strong indication of turbulent backscatter) and, in contrast, the echoes from altitudes above 80 km show well expressed aspect sensitivity. This agreement between measured and calculated absolute radar reflectivities and the simultaneous appearance of PMWE and PMSE with quite different levels of aspect sensitivity support earlier conclusions that neutral air turbulence is the main cause of PMWE.

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