Polar Mesosphere WINTER Echoes – a Review of recent Results

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Polar mesosphere winter echoes (PMWE) are thin layers of strongly enhanced radar echo occasionally seen by high-latitude VHF radars such as the ESRAD (52 MHz), ALWIN (53.5 MHZ) and EISCAT (224 MHz) radars in northern Scandinavia. It has been known for more than two decades that layers of relatively weakly enhanced radar echo can be seen in the mesosphere at many latitudes, and that strongly enhanced from heights close to the mesopause occur at high-latitudes in summer.

The weak wintertime-high-latitude and lower-latitude echoes, observed first in the 1970's, were clearly correlated with dynamic processes (winds and wave motions) and it was considered that thin layers of turbulence in the neutral atmosphere , coupled to the weak plasma densities in the D-region, could provide an adequate explanation for the radar reflectivity. Indeed, co-located layers of such turbulence were reported from a few sounding rocket experiments.

It was realised in the 1980's that the strong summer-mesopause echoes, later named PMSE – Polar Mesosphere Summer Echoes, could not be explained simply by the action of neutral turbulence and it was proposed that charged ice particles could play a role in their formation. It was already well known that ice-clouds form at the very cold temperatures prevailing at the summer mesopause as these are visible from the ground as noctilucent clouds. This theory for PMSE has been largely substantiated by later in-situ and theoretical work.

When the strongly enhanced winter layers, PMWE, were first seen at the ESRAD radar, in connection with the many solar proton events accompanying the last solar maximum, it seemed that even these were too strong to be explained by layers of turbulence in the neutral atmosphere. Since temperatures in the winter mesosphere are too high for water-ice to form, it was suggested that other kinds of aerosol particles such as meteoric dust might be involved. Further much more detailed observations of the scattered signal by the ESRAD and EISCAT radars led, however, to a completely different proposal – that the echoes are due to evanescent ion-acoustic waves associated with reflection of infrasonic waves at wind-shears or temperature inversions. At the same time, other studies have argued that even PMWE could simply be explained by turbulence. This report will review the various observations and theories.