MF/HF/VHF radar observations of Polar Mesosphere Summer Echoes (PMSE)

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Abstract: PMSE, or Polar Mesosphere Summer Echoes, refers to a uniquely strong radar backscatter target that occurs during the summer season near the high latitude mesopause. The radar echoes are thought to be associated with noctilucent clouds (NLC), the highest clouds over the earth, due to the many similarities between both phenomena; e.g., altitude near the temperature minimum (mesopause region/85-km), seasonality, geographical location (northern and southern hemispheres), etc. An increased number of NLC sightings over the last century led to the suggestion that they are an indicator of climate change. Since the association of NLC with charged ice particles is now accepted as the source of PMSE, radar is the ideal observational technique to monitor long-term variations in the mesopause region and, possibly, the earth's atmospheric temperature. Lower temperatures in the upper mesosphere could be manifested in a larger number of NLC and PMSE events. Although PMSE have been well known since their discovery in the early eighties, the radar mechanism producing the echoes is not yet fully understood. Comparisons of VHF radar and rocket measurements during PMSE showed evidence of both turbulent and non-turbulent scattering mechanisms acting simultaneously or separately in the medium. The majority of the radar observations have been conducted at VHF/50 MHz, the reference sensors employed traditionally for PMSE studies; very few observations have been reported using radars operating at multiple frequencies. In an effort to extract new clues on this intriguing phenomenon, we conducted radar observations of PMSE at six different frequencies: 2.43, 4.53, 4.9, 28, 50, and 139 MHz, using radar facilities over the central Alaskan region. The echo morphology at the different frequencies is described in case studies wherein PMSE events were observed concurrently using at least two radar systems. The identity of MF and HF radar echoes as PMSE is resolved for the first time by means of simultaneous measurements made with VHF radars. On the basis of echo duration and signal strength, we suggest that HF radars would be optimal for PMSE monitoring. MF radars show highly organized PMSE layers quite often but are more susceptible to ionospheric absorption and higher altitude returns associated with geomagnetic activity. However, since a number of MF stations are located at polar or near polar latitudes, including Antarctica, it may be possible to use the PMSE signature studied here to investigate its long term variability as well as its low latitude boundary. The latter could be an indicator of global change and/or of lower temperatures in the earth's mesosphere, a necessary ingredient for NLC formation.

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