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Imaging ice clouds at the edge of space: a novel use for wide-beam radars

Polar mesospheric summer echoes (PMSE) are radar returns that are detected from thin clouds of ice particles near the mesopause 80-90 km above Earth's surface. In summer at polar latitudes, the mesopause region of the atmosphere reaches the lowest temperatures in the terrestrial environment, sometimes below the sublimation point of water. Under these conditions, even the small quantity of water vapour present in the upper atmosphere can form ice crystals that produce a radar-detectable change in the local refractive index.

PMSE are normally studied with narrow beam radars, but this limits observations to a narrow segment of PMSE at any given time. Here, we present the results of a study using novel analysis techniques to observe PMSE with a VHF all-sky meteor radar located near Tromsø, Norway. The use of a wide beam to observe PMSE means that a greater lateral extent of PMSE is represented in the backscattered signal. The thin layer geometry of PMSE combined with off-zenith Doppler contributions enables the estimation of wind speed from the curvature of return intensity in the range-Doppler plot.

A technique has been developed to convert range/Doppler profiles of PMSE intensity to profiles of height/horizontal distance using this relation. The end result is a quasi 2-D image of the spatial distribution of received PMSE intensity along the wind vector, showing fine structure and evolution over time. This enables the estimation of the aspect sensitivity of PMSE at different heights, which holds clues about the structure of scattering bodies in the region. Doppler profiles are further improved by an algorithm to remove meteor echo contamination.

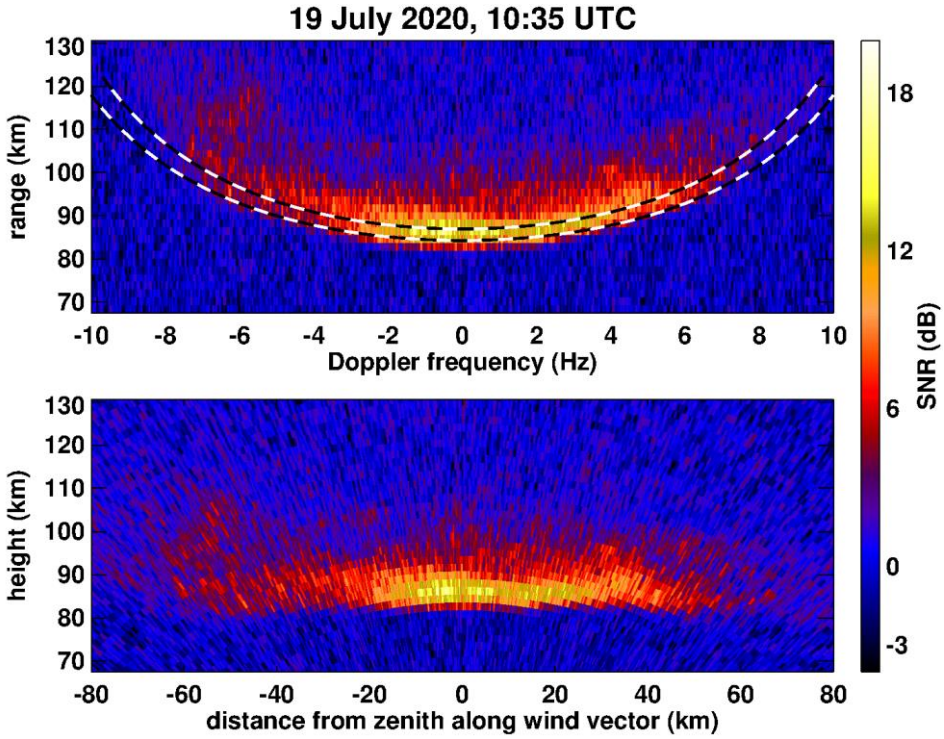

Figure: 1-minute observation of PMSE obtained from a 33 MHz all-sky meteor radar at Tromsø, Norway. Dashed lines are estimates of Doppler profile based on wind speed and layer height.