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High spatiotemporal radar observation of the polar summer mesosphere using MAARSY in a MIMO configuration

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Atmospheric structures due to gravity waves, turbulence, Kelvin Helmholtz instabilities, etc. in the mesosphere are being studied with a varying of ground-based and satellite-based instruments. At scales less than 100 km, they are mainly studied with airglow imagers, lidars, and radars. Typical radar observations have not been able to resolve spatial and temporal ambiguities due to the strength of radar echoes, the size of the system, and/or the nature of the atmospheric irregularities. In this work we observed spatially and temporally resolved structures of PMSE with unprecedented horizontal resolution, using the improved radar imaging accuracy of the Middle Atmosphere Alomar Radar System (MAARSY) with the aid of a multiple-input multiple output (MIMO) technique. The studies are performed in both the brightness of the mesospheric echoes and their Doppler velocities. The resolutions achieved are less than 1 km in the horizontal direction, less than 300m in altitude, and less than 1 minute in time, in an area of ~15km x 15km around 85km of altitude. We present a couple of wavelike monochromatic events, one drifting with the background neutral wind, and one propagating against the neutral wind. Horizontal wavelengths, periods, and vertical and temporal coverage of the events are described and discussed. A theory of stratified turbulence is employed in the present study. In particular, it is shown that the structure that propagates with the background wind is a large-scale turbulent KHI event. Some important turbulence characteristics, such as a turbulent dissipation rate, buoyancy Reynolds number, and Froude number, support our conclusion.