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Identification of tropopause height using 53 MHz CU ST radar and comparison with radiosonde observations through multiple turbulence parameters

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The tropopause, marking the boundary between the troposphere and stratosphere, is a critical feature that influences global atmospheric circulation, climate patterns, and environmental dynamics. This study investigated tropopause characteristics over Haringhata (22.93ºN, 88.50ºE), near Kolkata, using the Calcutta University Stratosphere-Troposphere (CU ST) Active-Phased Array radar operating at 53 MHz. Radar observations conducted between 17:00 and 18:00 IST in 2023 were utilized to determine radar-detected tropopause height using signal-to-noise ratio (SNR) and signal power gradient profiles [1]. The refractivity turbulence structure constant [2], C_n^2, obtained from radar observations, shows significant variability between 15 and 18 km altitude, highlighting areas of enhanced turbulence near the tropopause, crucial for mixing and stratosphere-troposphere exchange.

Additionally, radiosonde-derived parameters such as the turbulent kinetic energy dissipation rate (ε) and Brunt-Vaisala frequency (N^2) play instrumental roles in characterizing tropopause dynamics [3]. Radiosonde measurements provide lapse rate tropopause altitude based on temperature profiles. The turbulent kinetic energy dissipation rate (ε) identifies zones of enhanced turbulence near the tropopause, critical for vertical mixing and influencing stratosphere-troposphere exchange processes. The Brunt-Vaisala frequency (N^2), indicative of atmospheric stability, significantly contributes to determining tropopause sharpness and vertical extent, thereby enhancing its structural integrity. In the present study, radiosonde observations at 17:30 IST were procured from the India Meteorological Department (IMD) observatory at Dum Dum, which is 40 km away from radar site. Potential temperature data at different pressure levels were utilized to estimate parameters ε and N^2.

All these radar and radiosonde-derived parameters facilitate a comprehensive comparison between radar-detected and radiosonde-observed tropopause heights. In general, a good agreement was found between radar-detected tropopause height and radiosonde-observed tropopause height, with discrepancies typically ranging from 100 to 800 meters, partly influenced by the 40 km distance between the observatory and radar site. This study highlighted the pivotal role of radiosonde-derived parameters in validating and enhancing the reliability of tropopause height observations. Insights into the turbulent kinetic energy dissipation rate (ε) and Brunt-Vaisala frequency (N^2) significantly contribute to advancing atmospheric boundary assessments, supporting informed policy decisions for effectively mitigating the impacts of global climate change.

References:

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