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Insights into the dynamics of the Himalayan atmosphere using 206.5 MHz VHF radar

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The swath of the Himalayan ranges spans the vast diversity of climatic pattern varying from subtropical to boreal. This interaction between the tropical and extratropical weather systems combined with substantial modifications induced by highly elevated and complex topography frequently leads to weather extremes like cloud bursts, hailstorms, flash floods in this region. However, paucity of observational network over Himalayan region has restricted the analysis of these weather extremes up to synoptic scale only. It is essential to acquire the systematic observations at the finer scales for the better analysis of these weather extremes and improvement in their forecast skill. In the past three decades, VHF radars have contributed significantly in the study of lower and middle atmosphere and proved to be an indispensable tool to study the mesoscale convective systems over tropical and middle latitude regions. In this context, a Stratosphere Troposphere (ST) radar has been established at high altitude subtropical site of Nainital (29.4°N, 79.5°E; 1793m msl) and operates at high VHF frequency of 206.5 MHz. It has the capability to provide three-dimensional profile of winds up to about 20 km at a fine vertical resolution of 37.5 m/75 m/ 150 m and a typical temporal resolution of one minute. Quality of the wind profiles from ST radar have been validated against the co–located balloon–borne GPS radiosonde wind profiles resulting in a good agreement.

The probing of dynamics of Himalayan atmosphere using ST radar began with the first ever estimation of turbulence parameters over this region. The early experiments using simultaneous observations from radar and GPS-radiosonde have estimated turbulent kinetic energy dissipation rates, eddy diffusivity coefficients due to thermal and momentum fluctuations as well as inner and outer scales of turbulence regime. It was inferred that the strength of turbulence over this region were greater than those estimated for southern India. Further, the seasonal variation of these turbulence parameters were analysed. The kinetic energy dissipation rate and eddy diffusivity coefficient over the site varies from $10^{-2.4}$ m^2s^{-3} to 10^{-5} m^2s^{-3} and $10^{0.2}$ to $10^{2.8}$ m^2s^{-1} respectively. In the lower troposphere persistent layers of enhanced turbulence were observed and found to be correlated with the trapping of humidity within stable layers and Kelvin Helmholtz instability.

Attributes of the pre–monsoon and summer monsoon deep convective systems were delineated by observing the hailstorm and heavy rainfall events during these seasons. Pre–monsoon convective hailstorm was characterised by the intense updrafts and downdrafts of the order of 15 m/s in the mid–upper troposphere and lower troposphere respectively. Stable layer structures associated with tropopause seems to weaken during the intense convective activity. This penetrative convection generated upward propagating gravity waves in the upper troposphere and lower stratosphere region. Associated with gravity wave, a ten times enhancement in the exchange of momentum flux has been estimated both in upward and downward directions. Deep convective system in the monsoon season was observed with moderate vertical velocities (~ 5 m/s) and a trailing stratiform region identified by the double bright band structure in radar reflectivity.
In the present communication, an overview of the science results from ARIES ST radar will be presented.