Indian MST Radar : A tool for studying exchange of minor constituents between the upper troposphere and lower stratosphere

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The upper troposphere and the lower stratosphere is one of the key regions in the Earth's atmosphere, where the interaction of three processes, *viz*., dynamical, radiative and chemical processes takes place through a transition layer, known as "Tropopause". The tropopause is a stable layer formed due to natural temperature inversion, which separates the troposphere from the stratosphere. In general, the troposphere is highly humid and considered to be in radiative-convective equilibrium (well-mixed), whereas the stratosphere is dry and ozone rich, and considered to be in the radiative equilibrium (stably stratified). The vertical structure of the tropopause layer and its variability at various time scales plays an important role in exchange of minor constituents, especially water vapour (H_2O) and ozone (O_3) between the stratosphere and the troposphere and also in the coupling processes between these two regions. These coupling processes are widely acknowledged by the atmospheric science community and is designated as "Stratosphere-Troposphere Exchange (STE)".

This exchange process plays an important role in removing the water vapour from the air as it enters the stratosphere and in the reverse direction intrusion of stratospheric ozone into the troposphere. It has an impact on global weather-climate system. Increase in stratospheric water vapor tends to cool the stratosphere and warm the troposphere and also enhance the rate of ozone destruction. Similarly, O_3 is an important greenhouse gas and in the troposphere it acts as an oxidant and thus has an important role in climate forcing. Increase in the tropospheric ozone is mainly due to (1) in situ photochemical formation, and (2) stratospheric flux. The tropical tropopause, plays a key role in controlling the flow of water vapour and ozone from the stratosphere to the troposphere and vice-versa. The tropopause altitude has influence on stratospheric intrusion, whereas the tropopause temperature controls the entering of water vapour into the stratosphere.

In this aspect, Indian Mesosphere-Stratosphere-Troposphere (MST) radar located at a tropical Indian station has been used to study the tropopause dynamics and STE processes using radar reflectivity, winds characteristics and turbulence intensity. The prime mechanism responsible for radar backscatter echoes are isotropic/anisotropic turbulence fluctuations in refractive index and Fresnel reflection/scattering due to sharp gradients in the radio refractive index. The radar backscattering echoes can be used as a proxy of stratospheric intrusion. Using this proximity, two decades (1995-2017) of Indian MST radar data have been analyzed to study the STE processes in short (fast) and long-term (slow). Seasonal characteristics of stratospheric intrusion and overshooting convection have been bought out. Observations show that the maximum backscattering signal strength in the upper troposphere is the cold point tropopause altitude which is also detected using COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) temperature profile measurement. During the Asian summer monsoon (June-July-August-September), the tropopause is lower, where we observed maximum radar backscattering during the entire season. The presence of enhanced signal strength during Asian summer monsoon is due to the enhancement in the refractive index gradient, indicating the possibility of exchange of ozone and water vapour in the vicinity of tropopause. Horizontal wind observed using Indian MST radar indicate the presence of easterly jet associated with Tibetan anticyclone. Due to the presence of jet stream, a strong vertical shear in horizontal wind is observed in the vicinity of tropopause, which is one of the prime candidates for the cause of turbulence. Thus, the turbulence further plays a crucial role in the inhomogeneous mixing of ozone and water vapour near tropopause which is observed as enhanced radar backscattering signal. These observations are also supported by in situ ozonesonde and space borne Microwave Limb Sounder (MLS) measurements. The detailed results will be presented in the upcoming URSI AP-RASC-2019.