Role of Tropical easterly jet (TEJ) in stratospheric-troposphere exchange: Observations inferred from Indian MST Radar

Siddarth Shankar Das[1], K.V.Suneeth[1], M.V. Ratnam[2]

(1)Space Physics Laboratory, Vikram Sarabhai Space Centre, Trivandrum-695022, India
(2)National Atmospheric Research Laboratory, Gadanki-517112

The tropical upper troposphere and lower stratosphere (UTLS) is a complex region of the earth's atmosphere, where the exchange of minor constituents i.e. ozone and water vapour takes place through the tropical tropopause. 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. Water vapor plays a key role in controlling the chemical, radiative and dynamic processes in the atmosphere. Increase in stratospheric water vapor tends to cool the stratosphere and warm the troposphere and also enhance the rate of ozone destruction. Similarly, Ozone (O_3) is an important greenhouse gas and O_3 in the troposphere 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, which acts a barrier between the troposphere and the stratosphere, 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 Gadanki (13.5^{o}N, 79.2^{o}E) has been used to study of 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 (1995-2015) of Indian MST radar data have been analyzed to study the stratospheric intrusion. Seasonal characteristics of stratospheric intrusion have been bought out. Observations show that the maximum signal (SNR) strength in the UTLS regions corresponds to the cold point tropopause altitude (CPT-A) detected using COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) temperature profile measurement. During the Indian Summer Monsoon (ISM), i.e. June-July-August (JJA), the CPT-A is lower, where we observed maximum radar SNR during the entire season. The presence of enhanced signal strength during ISM is due to the enhancement in the refractive index gradient, indicating the possibility of exchange of ozone and water vapour at UTLS region during ISM months. Horizontal wind observed using Indian MST radar indicate the presence of tropical easterly jet (TEJ), which is the ISM phenomenon where the zonal velocity reaches as high as -40 ms^{-1}. The altitude at which the core of TEJ is observed to be 14-16 km. Due to the presence of TEJ, a strong vertical shear in horizontal wind is observed at UTLS region. The shear is one of the prime candidates for the cause of turbulence. Thus, the turbulence caused by TEJ at UTLS region cause the inhomogeneous mixing of ozone and water vapour near tropopause which is observed as enhanced radar backscattering signal. The results are supported with the ozone and water vapour profiles observed using space borne Microwave Limb Sounder (MLS) onboard the Aura satellite observations. The focus of this paper is to present and discuss some of the unique features of stratospheric intrusion associated with TEJ and Indian summer monsoon.