Understanding the characteristics of stratosphere-to-troposphere exchange associated with extremely severe cyclonic storm Fani 2019: results inferred from Advanced Indian MST radar and ozonesonde/radiosonde measurements

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Different plausible mechanisms for the occurrence of stratospheric ozone intrusion into the troposphere during the passage of tropical cyclone 'Fani 2019' (26 April to 4 May 2019) are investigated. Tropopause weakening/break and its modulation associated with turbulence are found to be the prime candidates for the stratospheric intrusion. An increase of ozone by 50–60 ppbv in the mid-troposphere and 20–30 ppbv on the surface is observed when the cyclone is close to the radar site. Strong downdrafts of ~0.75 ms^{-1} are observed in the vicinity of the tropopause well before the occurrence of stratospheric intrusion. It is also supported by the presence of dry air in the troposphere. An increase of mid-tropospheric temperature by 4 K associated with Fani is observed. Radar echoes show isotropic structures near the tropopause, whereas anisotropic structures are observed in the lower stratosphere. These observations quantitatively constitute experimental evidence for the redistribution of ozone during the passage of a cyclonic storm.

Keywords: Cyclone, MST radar, ozone, STE processes, vertical velocity.

an increased lifetime. Secondly, due to the difference in chemical compositions, the tropospheric air is distinct from the stratosphere. The inhibition of vertical mixing by the strong inversion layer, the stratosphere, results in concentration gradients in the several atmospheric constituents across the tropopause, which acts as a barrier for the mixing process. Tropospheric air is normally moist and ozone-poor, whereas stratospheric air is extremely dry and ozone-rich. The water vapour distribution in the air is largely influenced by the air temperature, as explained by the Clausius-Clapeyron relation.

The mixing of the air masses and minor constituents (mainly water vapour and ozone) in the UTLS region is known as stratosphere-troposphere exchange (STE), which is a two-way transport process between the troposphere and the stratosphere. STE takes place through several dynamical processes[2]. However, in the absence of a dynamical process, it is supposed that much mixing between tropospheric and stratospheric air does not take place due to these different characteristics, as mentioned above. When these exchange processes occur, they play a crucial role in controlling the Earth's radiation budget and are directly linked to the characteristics of the UTLS region. Thus, it has been an important topic of research from the past several decades[3].

Overshooting convection due to mesoscale and