Diurnal variation of the tropical tropopause and its impact on dehydration of air entering into the stratosphere

S. Satheesh Kumar* **and T. Narayana Rao**
National Atmospheric Research Laboratory, Gadanki 517 112, India

The amount of stratospheric water vapour in the tropics and the amount of dehydration of air entering into the stratosphere depend on the temperature at the tropopause. Tropopause temperatures are typically measured with radiosondes, and these temperatures are used to estimate the dehydration level. However, the tropical tropopause (both height and temperature) exhibits significant diurnal variation, and such variations are not accounted for in dehydration estimations. The present article quantifies the diurnal variability of the tropopause in different seasons and its impact on dehydration using three decades of Mesosphere-Stratosphere-Troposphere (MST) radar at Gadanki, India, and radiosonde observations. A novel algorithm has been developed to detect the tropopause height even when it is not sharp or has multiple layers in the vicinity of the cold-point tropopause. The performance of the algorithm is assessed using four years of radiosonde measurements and found that the radar-derived tropopause is very close to the cold-point tropopause with a very small bias. Overshooting convection and tidal amplitudes larger than 450 m are found to be the major contributors to the observed diurnal variability. The variation in height is converted to variation in temperature, and the amount of dehydration due to the diurnal variation of the tropopause is then quantified.

Keywords: Dehydration of air, diurnal variation, MST radar, radar signal processing, stratosphere-troposphere exchange, tropical tropopause layer.

the other hand, information on the inter- and intra-daily tropopause variability is highly essential for understanding and quantifying the stratosphere-troposphere exchange (STE), particularly the dehydration of air entering into the stratosphere. The STE in the tropics occurs over a wide range of scales, ranging from planetary scale, driven by Brewer-Dobson circulation[5], to mesoscale processes like penetrating convection[6] and turbulence by strong wind shears and breaking waves[7]. It is now known that the transport from the lower atmosphere to the stratosphere is a two-step process[8]. The above processes are well documented in the literature, while the missing part is the impact of diurnal variation of tropopause height on the dehydration. The magnitude of dehydration depends on the coldest temperature (and therefore the height of the tropopause) through which the air passes. As this information is available only at 00:00 and/or 12:00 Coordinated Universal Time (UTC), the dehydration estimates may be biased to those timings. It is, therefore, important to study the diurnal variability of tropopause temperature (or height) and quantify the biases in the estimations of dehydration of air entering into the stratosphere.

Very high frequency (VHF) radars provide an alternative but indirect means of obtaining the tropopause information on a continuous basis and can be useful for studying the diurnal variability. The method of detection of the tropopause, based on the enhancement of backscattered power and reduced spectral width of the vertical beam, has been fine-tuned by several researchers over the years[10–12]. Few studies investigated the day-to-day (or shorter) variability in TTL structure[4,9,13], but are confined to convective events or campaigns. Furthermore, earlier algorithms failed to detect the tropopause height in broader or multiple tropopause instances. Utilising the long-term radar