Equatorial upwelling in the upper troposphere lower stratosphere: Results from long-term equatorial atmospheric radar observations

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Abstract

Upwelling in the equatorial upper troposphere and lower stratosphere (UTLS) region is an important component of the large-scale circulation systems such as Hadley cell and Brewer-Dobson circulation. Recently, it has been observed that the Hadley is expanding towards the poles and the Brewer-Dobson circulation is intensifying. One more important processes associated with equatorial upwelling is the stratospheric moistening and cooling. There are several proposed mechanisms for the equatorial upwelling ranging from extra-tropical wave pumping to convection driven wave dynamics. It is uncertain to quantify the role of waves in driving the tropical upwelling. Owing to the lack of direct vertical wind measurements in the deep tropics, it is very difficult to assess the equatorial upwelling and to test the proposed mechanisms. There are few questions yet to be addressed regarding the equatorial upwelling such as the role of equatorial planetary waves, overshooting convection and extra-tropical waves. In order to elucidate these aspects, the direct measurements of vertical velocity are essential. in this regard, the equatorial atmospheric radar installed at Kototabang, Sumatra, Indonesia (0.20°S, 100.32°E) provides continuous measurements of vertical winds in the troposphere and lower stratosphere with few gaps in the UTLS height domain. The annual cycle of the vertical winds are constructed using radar observations during 2002-2014 and the same is used to study the long-term changes in the equatorial upwelling. The mean climatology of vertical winds shows persistence down drafts in the 2-7 km region and an updraft in the 8-17 km height region with seasonal variation in magnitudes. The observed magnitude of the mean climatological vertical winds ranges from ±0.03 ms^{-1}. The pattern of the observed annual cycle of the vertical winds are discussed in association with extra-tropical and equatorial planetary wave forcing along with the deep convective activity over the domain. Thus the present study focuses on the process responsible for the observed equatorial upwelling and its interannual variability using vertical wind observations from equatorial atmospheric radar. It is envisaged to shed light on the present debate on the equatorial upwelling.