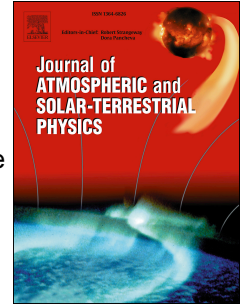


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The recent signs of total column ozone recovery over mid-latitudes: The effects of the Montreal Protocol mandate

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Abstract

After successful implementation of the Montreal Protocol, total ozone column (TOC) has considerably increased since the mid 1990s. However, the recovery is weak and statistically non-significant particularly at low-latitudes as the healing encounters many obstacles during the process. Decline trend of TOC over high-altitude (3000 m to 5000 m amls) entire region in Ladakh (32N - 35N, 77E - 80E), India located in the western trans-Himalayan region which extends upto Tibetan Plateau (TP) in mid-latitude, is approaching in an alarming rate of ~ -1.30 DU/year from the last few decades. The present work intends to examine whether the ozone recovery is already started or yet to start over the region using TOMS-OMI and SBUV-merged data during 1970-2017. During the TOC depletion, the estimated trends are deepening and statistically significant with -1.27 to -1.32 DU per year over the region. However, recovery of TOC has noticed over the region in the recent years and healing is still slow and statistically non-significant with 0.14 to 0.23 DU per year. Such non-significant trends are associated with variabilities from natural cycles, such as Brewer-Dobson circulation (BDC), Quasi-Biennial Oscillation (QBO), 11 year solar cycle, etc., and these effects can be removed using multiple linear regression (MLR) model. Solar maxima during the last four cycles (21-24) are nearly followed by the TOC maxima. Upward transport of air by BDC can move ozone poor air into the lower stratosphere as noticed by elevated vertical pressure velocity which may offset the ozone recovery over the region. With relevant to the TOC recovery, the surface temperature over Ladakh region is warming at a rate of 0.3 - 0.4 K per year during 1980-2016. Further, the study noticed recovery of TOC at both the hemispheres with maximum of 0.23 to 0.50 DU per year at high-latitudes (45-60) using the MRL model. However, results of the TOC recovery at low-latitudes (15-30) in both the hemispheres are weak with 0.03 to 0.10 DU per year.

Key words: Montreal Protocol; Total ozone Column; Quasi-Biennial Oscillation; TOMS-OMI; SBUV-merged

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