

# **Decadal Variabilities in the Tropospheric Ozone over the Central Himalayas and Major Urban Centers in India**

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## **Abstract**

Systematic long-term ozone observations are sparse in regionally representative site in south Asia. In this reference, this work present long-term (2007-2022) changes in surface ozone observations from a high-altitude site in the central Himalayas (Nainital, 29.40 N, 79.50 E, 1948 m amsl). The average diurnal amplitude shows a positive trend during 2007-2022, which is largest in spring. The annual ozone average of MDA8 exceedance (50 ppbv) shows a slight negative trend during 2007-2022 but exceedance events peaked in 2022. The long-term trend analysis is done using the statistical method adopted by TOAR II and the trend is found to be negative during 2007-2022. Nevertheless, a positive trend (about 1.2 ppbv/yr) was observed during 2016-2022, while a negative trend (about 0.5 ppbv/yr) during 2007-2015. Trends are also estimated for different percentiles, which do not show systematic distribution around the mean/median trend. Reanalysis dataset from ERA5 showed a similar decreasing and increasing trend during the 2007-2015 and 2016-2022 for nearest pressure level, while trend in MERRA2.0, CAMS and AIRS ozone (700-925 hPa) showed some differences. The tropospheric column ozone over this region showed a slight positive trend (about 0.2 ppbv/yr) during 2007-2020. Long term ozone trend using WRF-Chem model output during 2007-2019 showed increasing trend and do not agree with the trend in surface-based observations. The model output aligns with actual seasonal variation, particularly in winter and spring, although with predominantly overestimated values. Investigation of meteorological parameters at the site doesn't conclude anything robust about the shift in trend in both periods. Furthermore, the decade-long trends in tropospheric ozone, tropospheric NO<sub>2</sub>, and columnar CO across six major metropolitan cities in India is also being studied. Columnar CO exhibits a consistent negative trend at all sites, while tropospheric ozone and NO<sub>2</sub> predominantly show increasing trends.

## **Early Career Scientist**

YES, I am an early career scientist.

## **IGAC Activities**

ACAM: Atmospheric Chemistry and the Asian Monsoon, TOAR: Tropospheric Ozone Assessment Report