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Investigation of Ozone Downward Transport Events over the Central Himalayas: Insights from Ozonesonde and remote sensing data

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Ozonesonde and GPS-radiosonde flights conducted between 2011 and 2024 from Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital (29.37°N, 79.45°E, 1958 m amsl), were used to investigate events of downward ozone transport over the central Himalayas along with MERRA-2 Eternal Potential vorticity (EPV) and Atmospheric Infrared Sounder (AIRS) version 7 ozone profiles. The Himalayan sites are relatively clean and free from local pollution [1,2], making them suitable for the study of downward transport of ozone from the stratosphere and long-range transport. Balloon-borne observations of the ozone profile over the central Himalayas shows strong seasonality in the lower troposphere (2-6 km), with higher concentrations (65-110 ppbv) during the late winter and early spring seasons and lower concentrations (20-50 ppbv) during the summer-monsoon, consistent with ground-based observations. In the middle-upper troposphere (6-14 km), ozone values were maximum during the late winter and early spring, with large enhancements in ozone profiles of 100-200%. This significant increase in ozone is consistent with lower relative humidity values (50-57%) of stratospheric air masses. Also, the influence of subtropical jets (wind speed: 30-70 ms^{-1}) is observed in the middle-upper troposphere (9-14 km altitude) more frequently during winter (wind speed: 45-70 ms^{-1}) and occasionally during spring and autumn seasons (wind speed: 30-50 ms^{-1}). Additionally, to confirm the presence of stratospheric air masses in the troposphere, the EPV from MERRA-2 is investigated during days of strong ozone transport event, which shows enhancements in EPV by more than 2 PVU at the 150-300 hPa region. Also, the AIRS ozone profile is investigated during those days, which also shows the enhancement in ozone value by ~ 100-150% in the middle and upper troposphere region. These observations indicate that while biomass burning, forest fires, and regional photochemistry significantly impact the ozone in the lower troposphere, the middle-upper troposphere, particularly the upper troposphere and lower stratosphere (UTLS) region, is significantly influenced by dynamical processes, including downward transport from the stratosphere, leading to increased ozone levels in late winter and early spring season in the subtropical Himalayan regions. Model simulations are also being attempted to better understand these events and the results will be presented.

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2. Rawat, Prajjwal & Naja, Manish & Fishbein, Evan & Thapliyal, Pradeep & Kumar, Rajesh & Bhardwaj, Piyush & Jaiswal, Aditya & Tiwari, Sugriva & Sethuraman, Venkataramani & Lal, Shyam. (2023). Performance of AIRS ozone retrieval over the central Himalayas: use of ozonesonde and other satellite datasets. Atmospheric Measurement Techniques. 16. 889-909. 10.5194/amt-16-889-2023.