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Remote sensing study of Ozone, NO₂, and CO: Contrary effect of Indian lockdown in the free troposphere

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We utilized IASI, OMI, TROPOMI, and GOME-2 data to quantify the effect of lockdown on the changes in ozone, CO, and NO₂ concentration over India, with a primary focus on the tropospheric profiles of ozone and CO as compared to the years 2018 and 2019. Twelve populated cities and India's largest thermal power plants (TPPs) were further selected to quantify lockdown effects. Changes in ozone and CO have not been uniform over the different regions in India, including their vertical distribution. An increase (up to ~20%) in vertical ozone distribution during lockdown was observed over central and western India compared to both 2019 and 2018. However, it decreased over the southern coastal regions. Further, a significant reduction (> 20%) is observed over northern and northeast regions when compared with 2018 while a dramatic increase (> 20%) compared to 2019 is observed over northern regions. The increased ozone over north India, particularly in contrast to 2019 further shows a successive increase at higher altitudes and exhibits the role of dynamics, while, for other places like western and central India, the enhanced ozone decreases with higher altitude, which shows the effect of photochemistry and surface emissions. For CO, the lockdown effect seems to have emerged more effectively in the boundary layer, where a reduction in the range of 2 - 18% is seen except in western regions. In-contrast, a consistent yearly increase (as high as 29%) was observed from 2018 to 2020 in the free troposphere. Similar to the profiles, the total CO shows an increase (~20%) over central and western India while a moderate decrease (5%) over northern India. Like CO, an increase of NO₂ (~ 15%) over the western region is also observed, particularly compared to 2019. The persistent increase of CO and NO₂ over western India suggests to have contributed more from the nearby coal-based thermal power plants, which have increased their production in 2020. Contrary to other surface-based studies during the lockdown, which has shown an apparent decrease in pollutant levels, the present study shows an increase in CO, NO₂, and ozone at several locations and at different altitude regions. An analysis between OMI and TROPOMI tropospheric NO₂ columns show a considerable difference (> 30%) in NO₂ VCD retrieval around the remote locations, e.g., the Himalaya, the remote Tibetan plateau, and oceanic regions. Further, an investigation of the ozone production regime showed NO₂ limited regime over India's major part, while VOC limited regime over thermal power plants regions during the lockdown.