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## Fingerprints of a New Normal Urban Air Quality in S5P TROPOMI Tropospheric NO<sub>2</sub> Observations

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Most countries around the world took actions to control COVID-19 spread that included social distancing, limiting air and ground travel, closing schools, suspending sports leagues, closing factories etc., leading to economic shutdown. The reduced traffic and human movement compared to Business as Usual (BAU) scenario was tracked by Apple and Android cellphone use; the data showed substantial reductions in mobility in most metropolitan areas. We analyzed reductions in on-road mobile NO<sub>x</sub> emissions from light and heavy duty vehicles in four major metropolitan and one rural areas in the United States that showed a reduction in NO<sub>x</sub> mobile emissions from 9% to 19% between February and March at the onset of lockdown in the middle of March; between March and April, the mobile NO<sub>x</sub> emissions dropped further by 8% to 31% when lockdown measures were the most stringiest. These precipitous drops in NO<sub>x</sub> emissions correlated well with tropospheric NO<sub>2</sub> column amount observed by Sentinel 5 Precursor TROPospheric Ozone Monitoring Instrument (S5P TROPOMI). Further, the changes in TROPOMI tropospheric NO<sub>2</sub> across the continental U.S. between 2020 and 2019 correlated well with changes in on-road NO<sub>x</sub> emissions ( $r=0.78$ ) but correlated weakly with changes in emissions from the power plants ( $r=0.44$ ). These findings confirm that power plants are no longer the major source of NO<sub>2</sub> in the United States. We also examined correlation between increase in unemployment rate between 2020 and 2019 to decrease in tropospheric NO<sub>2</sub> amount. The negative correlation indicates that with increased unemployment rate combined with telework policies across the nation for non-essential workers, the NO<sub>2</sub> values decreased at the rate of 0.8  $\mu\text{moles}/\text{m}^2$  decrease per unit percentage increase in unemployment rate. There is a substantial amount of scatter in the data with some cities such as Atlanta, Dallas, and Houston showing no noticeable trend in tropospheric NO<sub>2</sub> changes during the time period when unemployment rate increased from 6% to 12%. We examined the trends in on-road and power plant emissions for five different locations (four urban areas and one rural area) and show that the changes in NO<sub>x</sub> emissions during the lockdown are detectable in TROPOMI tropNO<sub>2</sub> data, the economic indicators are consistent with emissions changes, and the trends reversing with the removal of lockdown measures in the major metro areas have not come back to pre-pandemic levels. The COVID-19 pandemic experience has provided the scientific community an opportunity to identify emissions reductions scenarios that created a new normal for urban air quality and if the environmental protection agencies should look at this new normal as a guidance for instituting new policies.