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Global Impacts on Ozone of Reduced Economic Activity during the COVID-19 Pandemic (2020)

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We use the global Community Earth System Model to investigate the response of secondary pollutants (ozone O_3, secondary organic aerosols SOA) in different parts of the world in response to modified emissions of primary pollutants during the COVID-19 pandemic. We quantify the respective effects of the reductions in NOx and in VOC emissions, which, in most cases, affect oxidants in opposite ways. Using model simulations, we show that the level of NOx has been reduced by typically 40 % in China during February 2020 and by similar amounts in many areas of Europe and North America in mid-March to mid-April 2020, in good agreement with space and surface observations. We show that, relative to a situation in which the emission reductions are ignored, the ozone concentration increased only in a few NOx-saturated regions (northern China, northern Europe and the US) during the winter months of the pandemic when the titration of this molecule by NO_x was reduced. In other regions, where ozone is NOx-controlled, the concentration of ozone decreased. SOA concentrations decrease in response to the concurrent reduction in the NO_x and VOC emissions. The model also shows that atmospheric meteorological anomalies produced substantial variations in the concentrations of chemical species during the pandemic.

Zonally averaged ozone concentrations in the free troposphere during Northern Hemisphere spring and summer were 5 to 15% lower than 19-year climatological values, in good quantitative agreement with ozone observations. About one third of this anomaly is attributed to the drastic reduction in air traffic during the pandemic, another third to reductions in surface emissions, the remainder to 2020 meteorological conditions, including the exceptional springtime Arctic stratospheric ozone depletion.