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Global to local impacts on atmospheric CO2 caused by COVID-19 lockdown

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The world-wide lockdown in response to the COVID-19 pandemic in year 2020 led to economic slowdown and large reduction of fossil fuel CO2 emissions 1,2, but it is unclear how much it would reduce atmospheric CO2 concentration, the main driver of climate change, and whether it can be observed. We estimated that a 7.9% reduction in emissions for 4 months would result in a 0.25 ppm decrease in the Northern Hemisphere CO2, an increment that is within the capability of current CO2 analyzers, but is a few times smaller than natural CO2 variabilities caused by weather and the biosphere such as El Nino. We used a state-of-the-art atmospheric transport model to simulate CO2, driven by a new daily fossil fuel emissions dataset and hourly biospheric fluxes from a carbon cycle model forced with observed climate variability. Our results show a 0.13 ppm decrease in atmospheric column CO2 anomaly averaged over 50S-50N for the period February-April 2020 relative to a 10-year climatology. A similar decrease was observed by the carbon satellite GOSAT3. Using model sensitivity experiments, we further found that COVID, the biosphere and weather contributed 54%, 23%, and 23% respectively. In May 2020, the CO2 anomaly continued to decrease and was 0.36 ppm below climatology, mostly due to the COVID reduction and a biosphere that turned from a relative carbon source to carbon sink, while weather impact fluctuated. This seemingly small change stands out as the largest sub-annual anomaly in the last 10 years. Measurements from global ground stations were analyzed. At city scale, on-road CO2 enhancement measured in Beijing shows reduction of 20-30 ppm, consistent with drastically reduced traffic during the lockdown, while station data suggest that the expected COVID signal of 5-10 ppm was swamped by weather-driven variability on multi-day time scales. The ability of our current carbon monitoring systems in detecting the small and short-lasting COVID signal on the background of fossil fuel CO2 accumulated over the last two centuries is encouraging. The COVID-19 pandemic is an unintended experiment whose impact suggests that to keep atmospheric CO2 at a climate-safe level will require sustained effort of similar magnitude and improved accuracy and expanded spatiotemporal coverage of our monitoring systems.