On the detection of COVID-driven changes in atmospheric CO_2

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Background: COVID pandemic lockdowns abruptly slowed the rate at which we burned fossil fuels and released carbon dioxide into the atmosphere; yet we cannot find any significant reductions in the growth of carbon dioxide in the atmosphere from our measurements. In this paper, we explore the plausible causes and consequences of this conundrum.

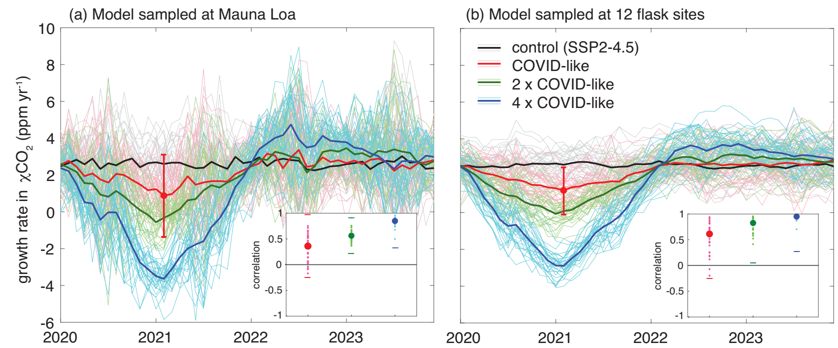
Methods: Utilized a climate model, the Canadian Earth System Model version 5 (CanESM5) to mimic the changes in atmospheric CO_2 with different amounts of reductions in fossil fuel burning. Analyzed output from five simulations of CanESM5, each with 30 ensemble members – a historical ensemble, a control ensemble, & the remaining three ensembles have: (a) COVID-like CO_2, (b) 2x COVID-like CO_2, (c) 4x COVID-like CO_2 emissions reductions beginning December 2019 and ending December 2021.

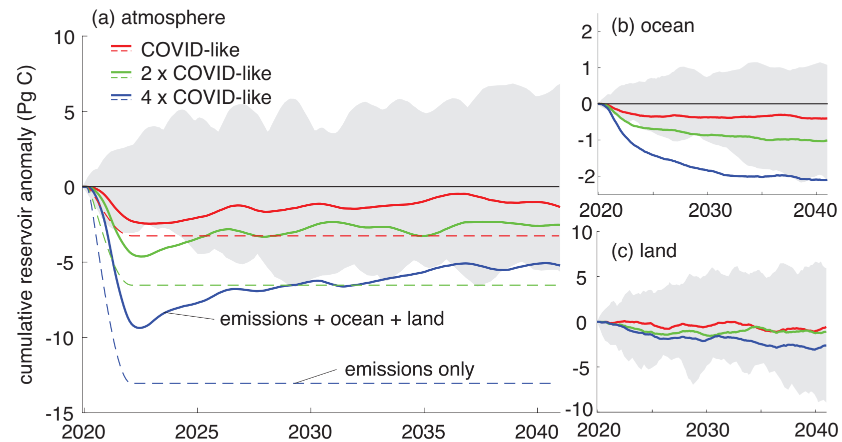
Results:

i. Each of the COVID-like emissions perturbations leads to a forced change in the cumulative atmospheric reservoir, lasting well beyond the emissions recovery in 2022

ii. Natural internal variability of the system as well as carbon-concentration feedbacks obscures the detection

iii. Ocean and land carbon sinks also respond to the emissions reduction, i.e., COVID-like emissions reductions cause both the ocean and the land to absorb less carbon than usual





Significance

If not for the slowing ocean and land carbon sinks, the COVID-like emissions reduction signal in the atmospheric carbon reservoir ***may have been detectable above the noise of internal variability*** for at least 2 - 3 consecutive years.

Notes

Top Figure: Temporal evolution of the growth rate of de-seasoned, monthly χCO_2 from the CanESM5 COVID ensemble sampled at (a) Mauna Loa, and (b) the average of 12 flask sites over 2020-2024. Growth rate is calculated as the difference in χCO_2 for a given month relative to the same month in the previous year. Thin lines show individual ensemble members, and thick lines show the ensemble mean for each emissions scenario. Red dot and range illustrates the mean and 2σ (95%) confidence interval in February 2021 for the COVID-like emissions scenario. Subplots show the temporal correlation coefficients of individual ensemble members with the ensemble mean over Jan 2020 - Dec 2021 for each emissions scenario. Small circles show the correlation coefficients across the 30 ensemble members, large circles show the mean correlation coefficients, and dashes indicate 2σ (95%) confidence intervals.

Bottom Figure: Cumulative changes in the (a) atmosphere, (b) ocean, and (c) land carbon reservoirs from December 2019 onwards, as simulated by the CanESM5 COVID ensemble. Colored lines show the anomaly in the ensemble-mean reservoir size relative to the control ensemble mean (SSP2-4.5), and gray shading indicates the spread in the cumulative reservoir anomaly across the control ensemble. Dashed lines in (a) show the cumulative changes in atmospheric carbon due to anomalous emissions alone.

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