Corinne Le Quéré, Robert B. Jackson, Matthew W. Jones, Adam J. P. Smith, Sam Abernethy, Robbie M. Andrew, Anthony J. De-Gol, David R. Willis, Yuli Shan, Josep G. Canadell, Pierre Friedlingstein, Felix Creutzig, Glen P. Peters. Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement. In press, *Nature Climate Change*.
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Further details and key figures

What we did:

- We developed a new method to estimate for the first time the change in fossil CO_2 emissions for each day and country during January to April 2020 as a function of the level of population confinement in response to the COVID-19 pandemic. We also provided a breakdown of the US by state and China by provinces.
- We also estimated the impact of confinement over the full year 2020, testing three hypotheses regarding the speed and extent at which mobility and the economy will recover to their pre-pandemic levels.
- To estimate the emissions, we compiled and analysed government policies on confinement for 69 countries representing 97% of global CO_2 emissions, categorizing confinement by three levels of intensity. Our Figure 1 shows that at the peak of the confinement in early April, regions responsible for 89% of global CO_2 emissions were under some level of confinement.
- We gathered data on activities that were indicative of how much each of six economic sectors was affected by the pandemic. The activity data represented:
    - Mobility, traffic and congestion reports
    - Electricity use and patterns
    - Industrial production

What we found[1]:

The activities data showed clear and consistent signals of decreases in different economic sectors during confinement:

- First for background, here is how much of the global CO_2 emissions comes from each of the six sector examined: (1) power (44.3%), (2) surface transport (20.6%), (3) industry (22.4%), (4) public buildings and commerce (4.2%), (5) residential (5.6%), and (6) aviation (2.8%).
- Our Figure 2 shows there were large decreases in *activity* in countries that were confined (note this is *not* emissions). On average when countries were under maximum lockdown, the decreases were as follows: aviation decreased by 75%, surface transport by 50%, power generation by 15%, with a small *increase* in the use of residential buildings of 5%. Data for industry were relatively sparse but what is available showed a decrease of about 35%. We had no data directly for the use of

[1] Full uncertainties ranges are reported in the paper. We only present central values in this briefing.

public buildings and commerce but assumed they decreased the same as power, so 15%.

The confinement had drastic effects on daily CO_2 emissions:

- Daily emissions decreased by 17% globally during the peak of the confinement on 7th April, compared to mean daily levels in 2019, dropping to levels last observed in 2006 (Figure 3).
- Emissions from surface transport accounted for almost half (43%) of the decrease in global emissions during the peak of confinement (Figure 4).
- Emissions from industry and from power together accounted for a further 43% of the decrease in daily global emissions.
- Aviation is the sector most impacted by the confinement, but aviation emissions account for only 3% of global emissions, or 10% of the decrease in global emissions during the pandemic.
- Emissions in individual countries decreased by 26% on average at their peak (see table at the end for individual values for countries, USA states and China provinces).

The impact of the confinement on annual emissions in 2020 is likely to lead to the largest single annual decrease in absolute emissions since the end of World War II:

- If pre-pandemic conditions of mobility and economic activity return by mid-June, we project a lower bound estimate of about 4% decline in CO_2 emissions in 2020.
- If some restrictions remain worldwide until the end of the year, we project a higher bound estimate of about 7% decline in CO_2 emissions in 2020.
- For a middle case where emissions return to pre-pandemic levels around the second half of July, we project a decrease of about 5% in CO_2 emissions in 2020.
- The full range of projections for 2020, including uncertainties, is for a decrease of 2% to 13%.
- The decrease in emissions this year has a minute impact on climate change, as it is extremely small compared to the emissions accumulated so far, and compared to the emissions cuts needed to tackle climate change.
- For comparison, rates of decrease of about 4-7% would be needed year-on-year for many years to limit climate change close to 1.5°C warming, one of the targets of the Paris Climate Agreement.
    - The UNEP gap report says decreases in GHG emissions of 2.7% per year are needed to keep warming well below 2°C, and 7.6% per year to keep below 1.5°C. Typically, decreases in CO_2 emissions need to take place more rapidly than full GHG because they are easier.
- Estimates for the full year do not attempt to quantify the effects of multiple confinement waves, or of deeper and sustained changes in the economy that could result from either the collapse of tens of thousands of small and medium businesses or government economic stimulus packages.

- A post-COVID rebound to higher emissions paths compared to pre-COVID levels is possible if large-scale investments go into fossil infrastructure and if vehicle emissions standards are relaxed. For comparison, the Global Economic Crisis of 2008-2009 led to a decrease in 2009 emissions of 1.5%, but a rebound in 2010 of 5.1%, essentially setting global emissions back to their carbon-intensive track as if the crisis had not taken place.

What are the implications:

- These extreme changes are likely temporary as they do not reflect structural changes in the economic, transport, or energy systems. The social restrictions implemented to control the COVID19 pandemic, as shown here, would not drive the deep and sustained reductions needed to reach net zero emissions and are not desirable because they do not improve wellbeing.

- Opportunities exist to set structural changes in motion by implementing economic stimuli aligned with low carbon pathways. In particular for mobility which accounts for half the decrease in emissions during confinement, and has the additional benefit for public health of reducing air pollution substantially.
    - Supporting active travel (walking and cycling, including ebikes) which has attributes of social distancing that are likely to be desirable for some time[28]. For example, cities like Bogota, New York, and Berlin are rededicating street space for pedestrians and cyclists to enable safe individual mobility, with some changes likely to become permanent.
    - Urban planning and new shared pooled mobility solutions.
    - Coupling clean energy and electric vehicles.
    - Supporting home working where desirable.
    - Reducing demand for aviation by supporting more local tourism and video conferencing for businesses.

- The extent to which world leaders consider the net zero emissions targets and the imperatives of climate change when planning their economic responses to COVID-19 is likely to influence the pathway of CO_2 emissions for decades to come.

Maximum change in daily CO_2 emissions for countries, USA states and China provinces (in percent).

Countries	Reduced CO_2 emissions
Country name	percent
Algeria	-27.1%
Argentina	-27.3%
Australia	-28.3%
Austria	-31.7%
Bangladesh	-23.7%
Belgium	-27.7%
Brazil	-25.2%
Bulgaria	-14.8%
Canada	-19.8%
Chile	-20.1%
China	-23.9%
Colombia	-36.5%
Croatia	-32.9%
Cyprus	-32.3%
Czech Republic	-23.7%
Denmark	-33.9%
Egypt	-16.7%
Estonia	-12.5%
Finland	-19.8%
France	-34%
Germany	-26.4%
Greece	-27.3%
Hungary	-27.1%
India	-25.7%
Indonesia	-18.2%
Iran	-15.3%
Iraq	-23.2%
Ireland	-30.6%
Israel	-29.1%
Italy	-27.7%
Japan	-26.3%
Kazakhstan	-10.3%
South Korea	-14.7%
Kuwait	-14.3%
Latvia	-26.3%
Lithuania	-35.6%

Countries	Reduced CO_2 emissions
Country name	percent
Luxembourg	-44.6%
Malaysia	-30.3%
Malta	-24.5%
Mexico	-20.1%
Morocco	-29.5%
Netherlands	-19.2%
New Zealand	-41.1%
Nigeria	-26.5%
Norway	-34.2%
Oman	-17.9%
Pakistan	-30.6%
Philippines	-19%
Poland	-23.4%
Portugal	-31.9%
Qatar	-18.6%
Romania	-27.3%
Russian Federation	-23.2%
Saudi Arabia	-28.9%
Slovakia	-16.7%
Slovenia	-21.2%
South Africa	-22.4%
Spain	-31.9%
Sweden	-27.6%
Thailand	-21.4%
Turkey	-17.4%
Turkmenistan	-4.5%
Ukraine	-12.4%
United Arab Emirat	-21.5%
United Kingdom	-30.7%
USA	-31.6%
Uzbekistan	-17.3%
Venezuela	-29.5%
Vietnam	-30%
Europe	-27%
WORLD	-17%

China	Reduced CO_2 emissions
Province	percent
Beijing	-24.6%
Tianjin	-24.7%
Hebei	-27%
Shanxi	-23.1%
Inner Mongolia	-20.1%
Liaoning	-26%
Jilin	-24.5%
Heilongjiang	-25.7%
Shanghai	-29.7%
Jiangsu	-23.2%
Zhejiang	-21.1%
Anhui	-22.4%
Fujian	-24.7%
Jiangxi	-25.3%
Shandong	-22.6%
Henan	-23.3%
Hubei	-26.6%
Hunan	-30%
Guangdong	-22.6%
Guangxi	-28.6%
Hainan	-25.7%
Chongqing	-27.1%
Sichuan	-30.4%
Guizhou	-22.4%
Yunnan	-31.6%
Shaanxi	-22.7%
Gansu	-22.8%
Qinghai	-13.2%
Ningxia	-19.8%
Xinjiang	-10.4%

USA	Reduced CO_2 emissions
State	percent
Alabama	-29.8%
Alaska	-40.4%
Arizona	-29.9%
Arkansas	-17.9%
California	-41.8%
Colorado	-29.3%
Connecticut	-30.4%
Delaware	-33.1%
District of Columbia	-30%
Florida	-33.6%
Georgia	-31.9%
Hawaii	-37.1%
Idaho	-38.6%
Illinois	-30.2%
Indiana	-28.1%
Iowa	-17.9%
Kansas	-30%
Kentucky	-27.8%
Louisiana	-36.3%
Maine	-34.5%
Maryland	-34.2%
Massachusetts	-32.2%
Michigan	-27.7%
Minnesota	-30.8%
Mississippi	-36%
Missouri	-26.8%
Montana	-26.7%
Nebraska	-29%
Nevada	-32.7%
New Hampshire	-31.9%
New Jersey	-36%
New Mexico	-28.8%
New York	-32.7%
North Carolina	-31.7%
North Dakota	-13.7%
Ohio	-28.9%
Oklahoma	-21.1%
Oregon	-36.8%
Pennsylvania	-29.5%
Rhode Island	-27.9%
South Carolina	-23.5%
South Dakota	-24.4%
Tennessee	-34.5%
Texas	-34.3%
Utah	-18.4%
Vermont	-33.8%
Virginia	-34.8%
Washington	-40.2%
West Virginia	-21.8%
Wisconsin	-27.4%
Wyoming	-11.6%