

Effects of COVID-19 on CO₂ emissions globally and in the U.S.

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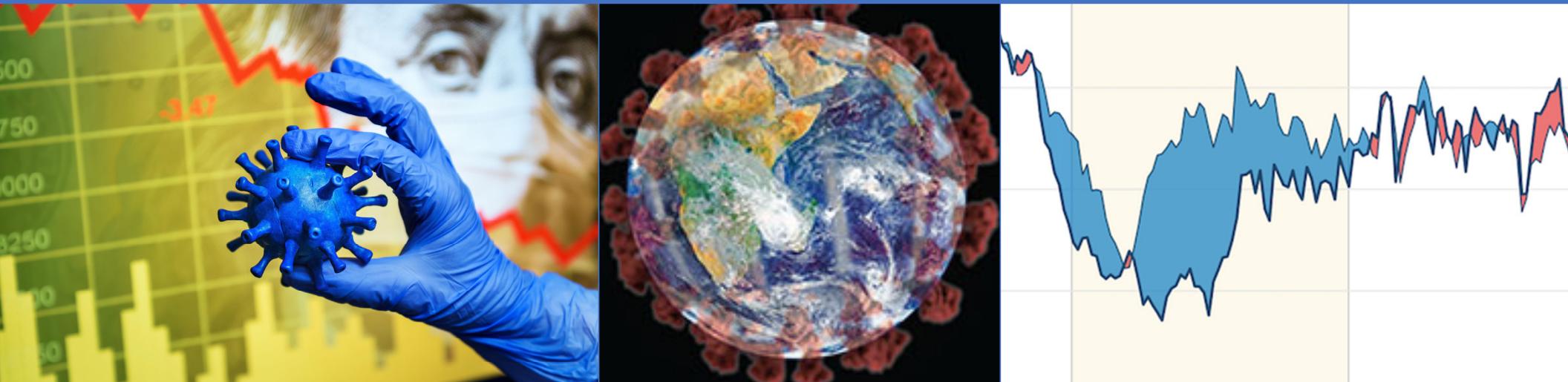
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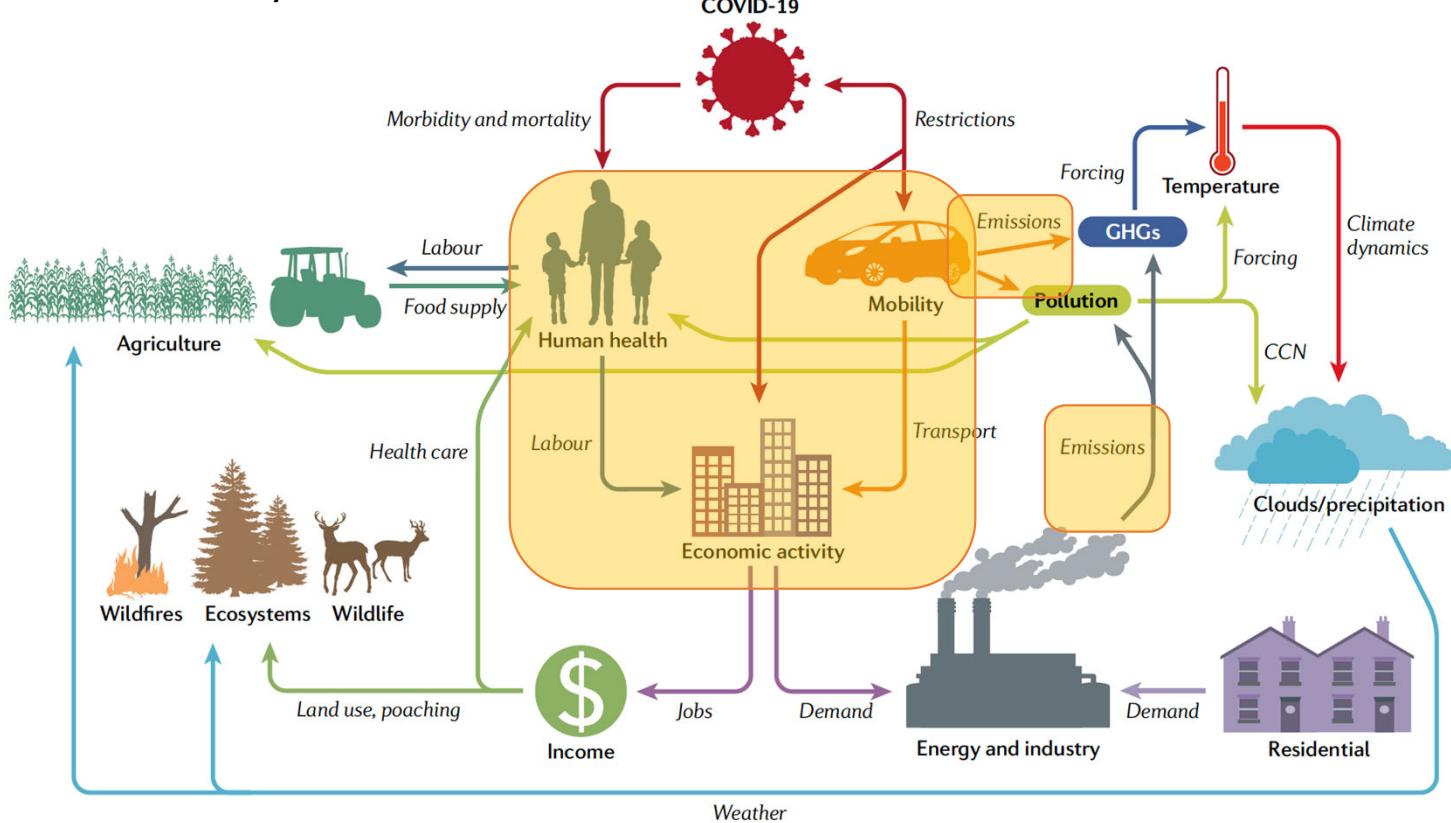
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November 16, 2020
CalPlug Workshop



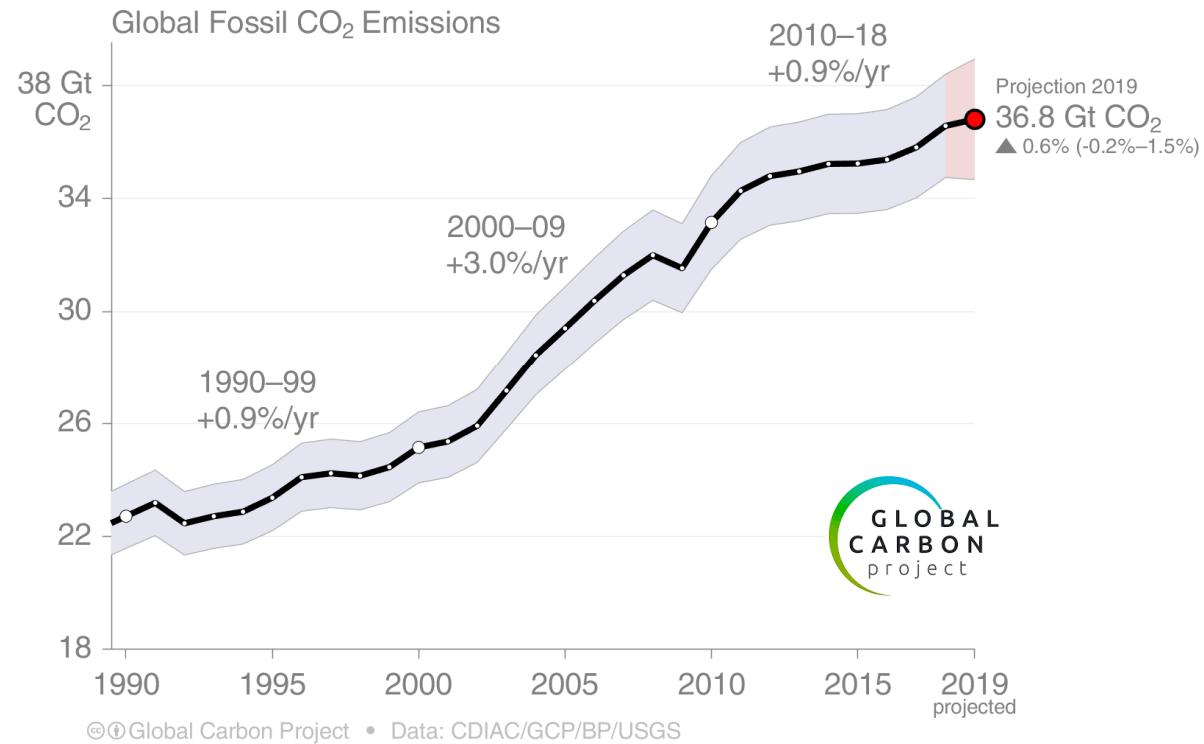
COVID disruptions to activity and emissions



Public health responses that limit mobility reduce transportation emissions and affect energy and industry emissions via changes in economic activity.

Diffenbaugh et al., *Nature Reviews Earth & Environment*, 2020

Fossil fuel CO₂ emissions



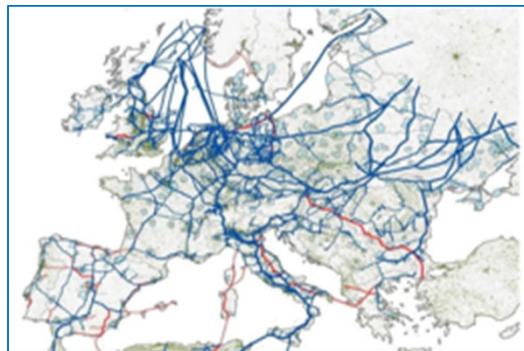
But global (and national) emissions have in recent years been reported *annually*, and even then projected based on partial data and assumptions.

Hourly or daily activity data related to CO₂ emissions in different sectors

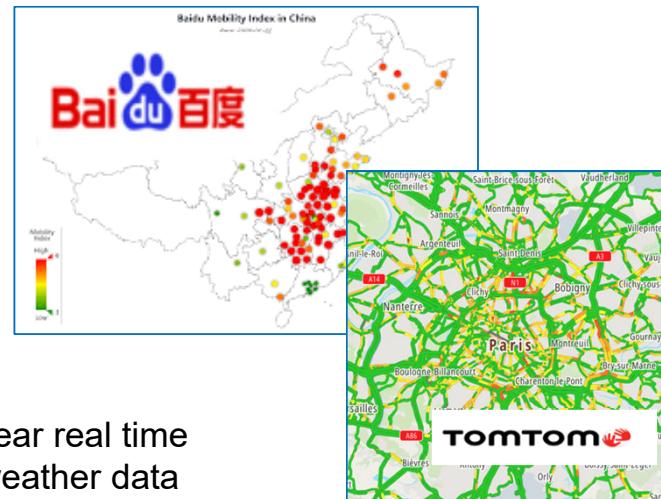
Aircraft and ship tracks



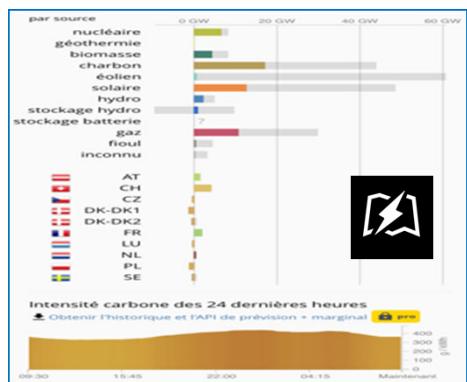
Pipeline delivery of gas to residential & commercial buildings



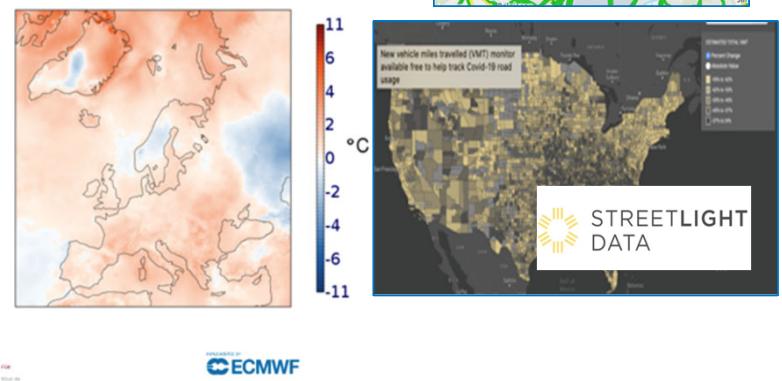
Traffic & mobility data from city to county scale



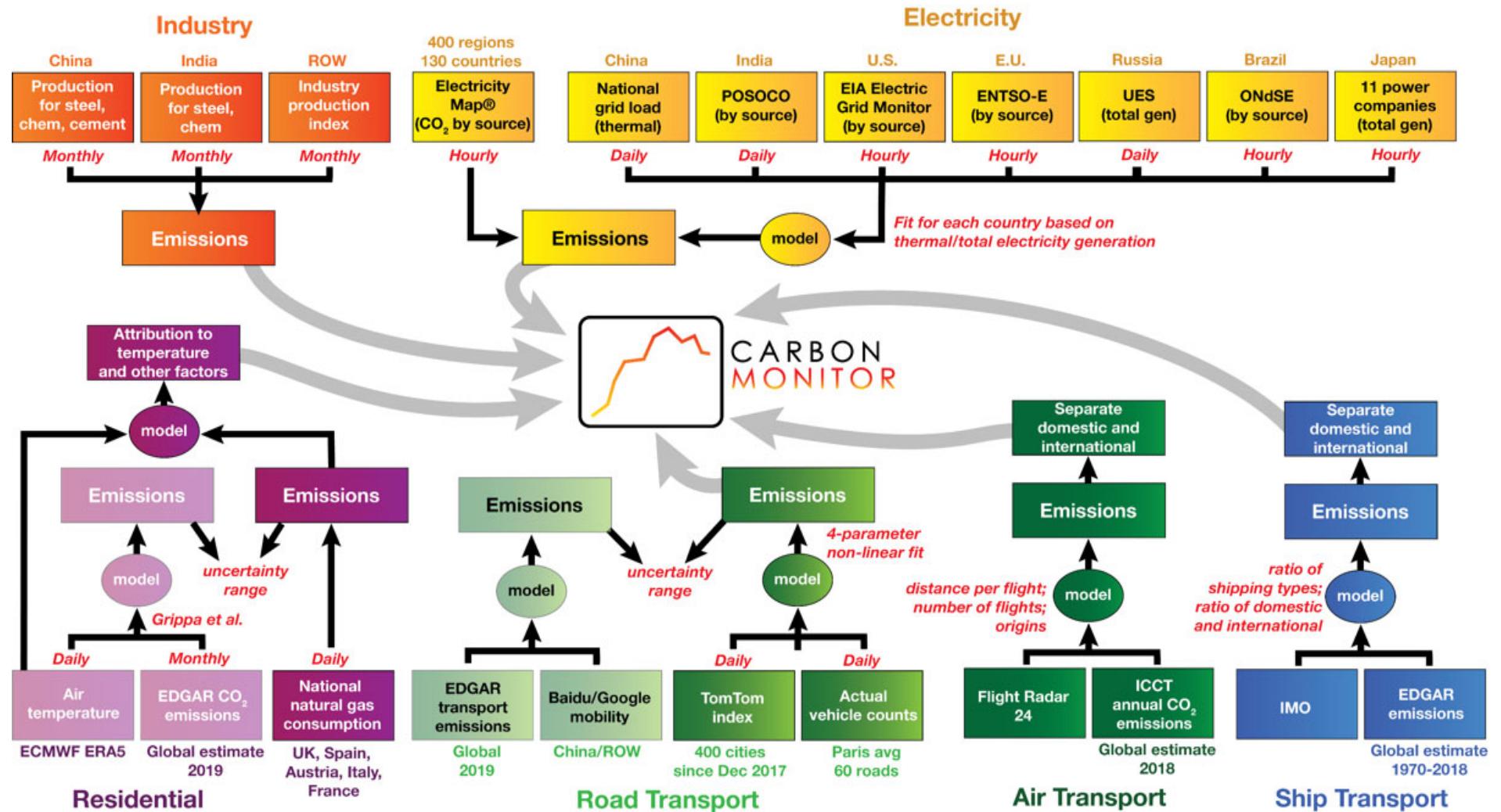
Hourly to daily electricity data
Including fossil & low carbon mix



Near real time weather data

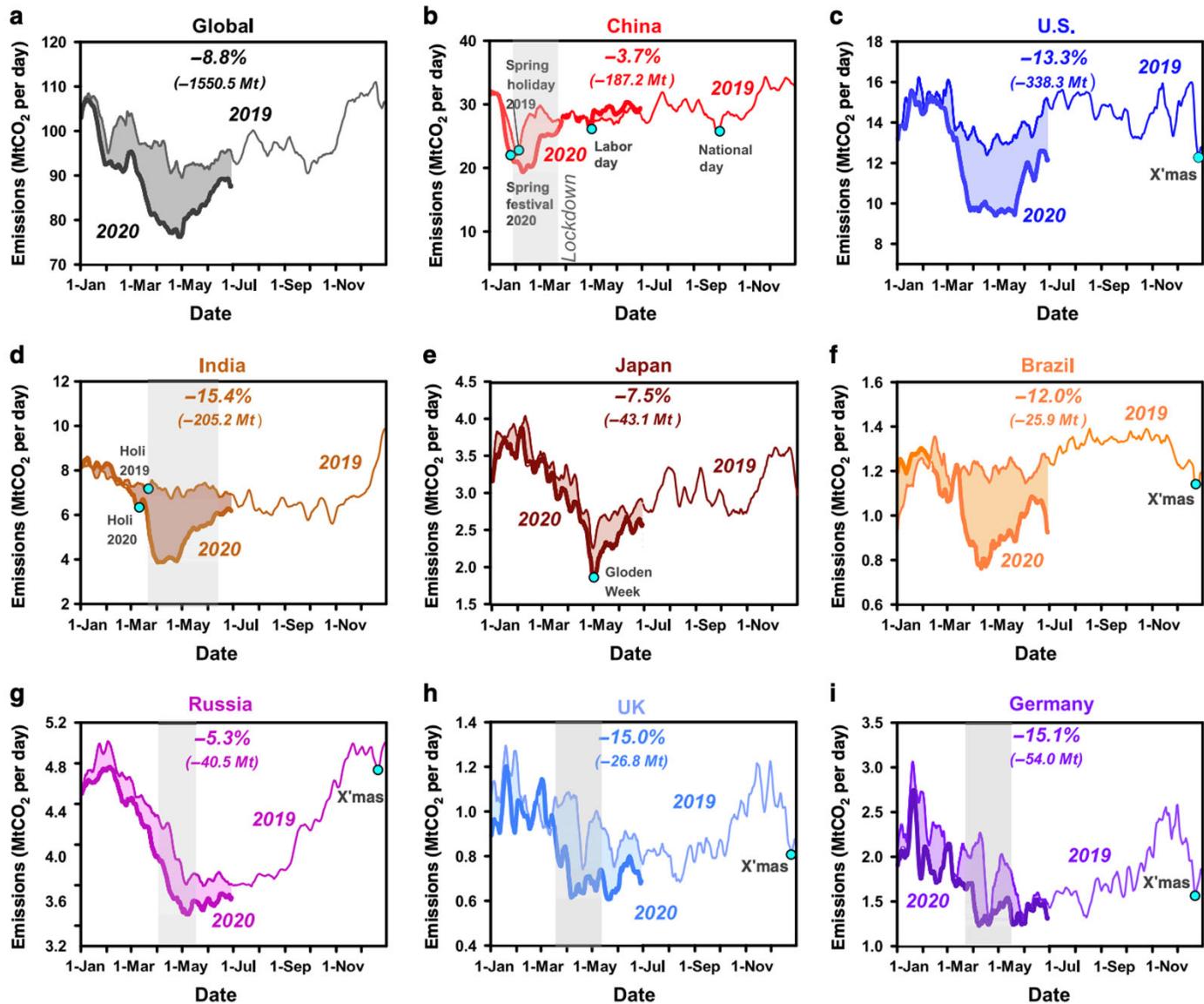


CO₂ emissions operational analysis system for six sub-sectors



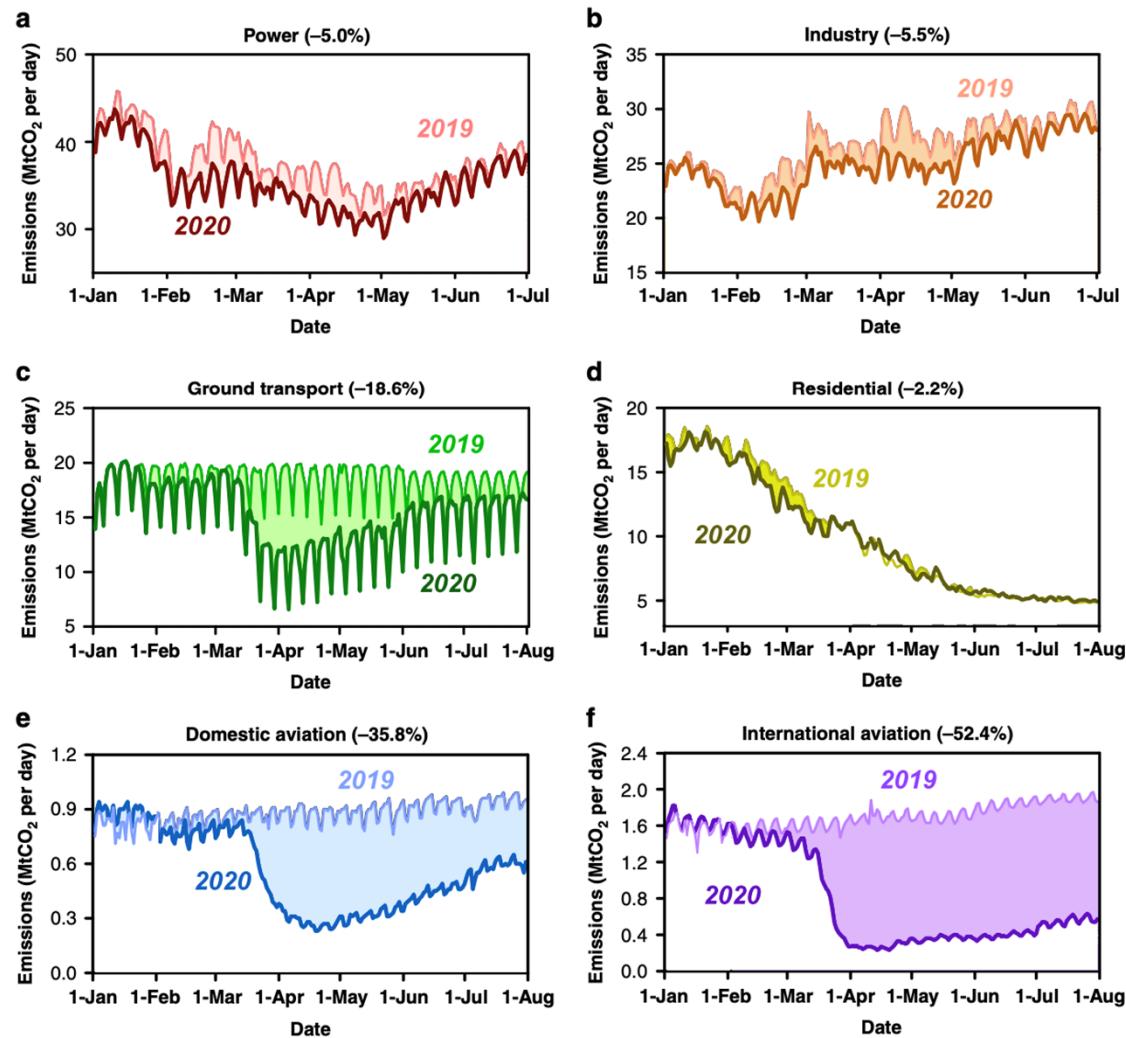
Daily emissions estimates show COVID-related reductions

- Daily emission estimates reveal all variations caused by energy price, weather, climate, weekends and holidays and COVID
- Global emissions were down 8.8% January through June
- Return to pre-COVID levels in China and some EU countries



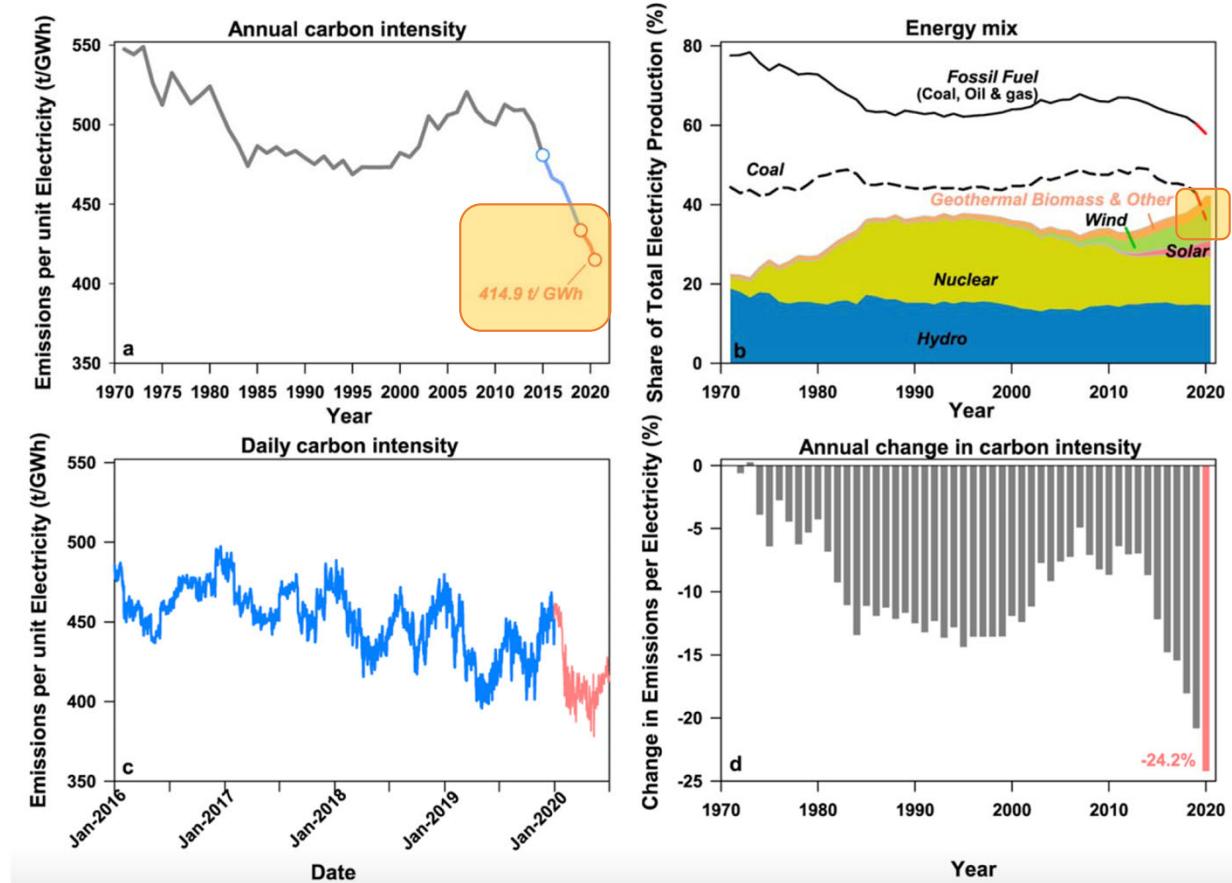
Different sectoral impacts (globally)

Emissions from **ground transportation** and **aviation** have decreased most.

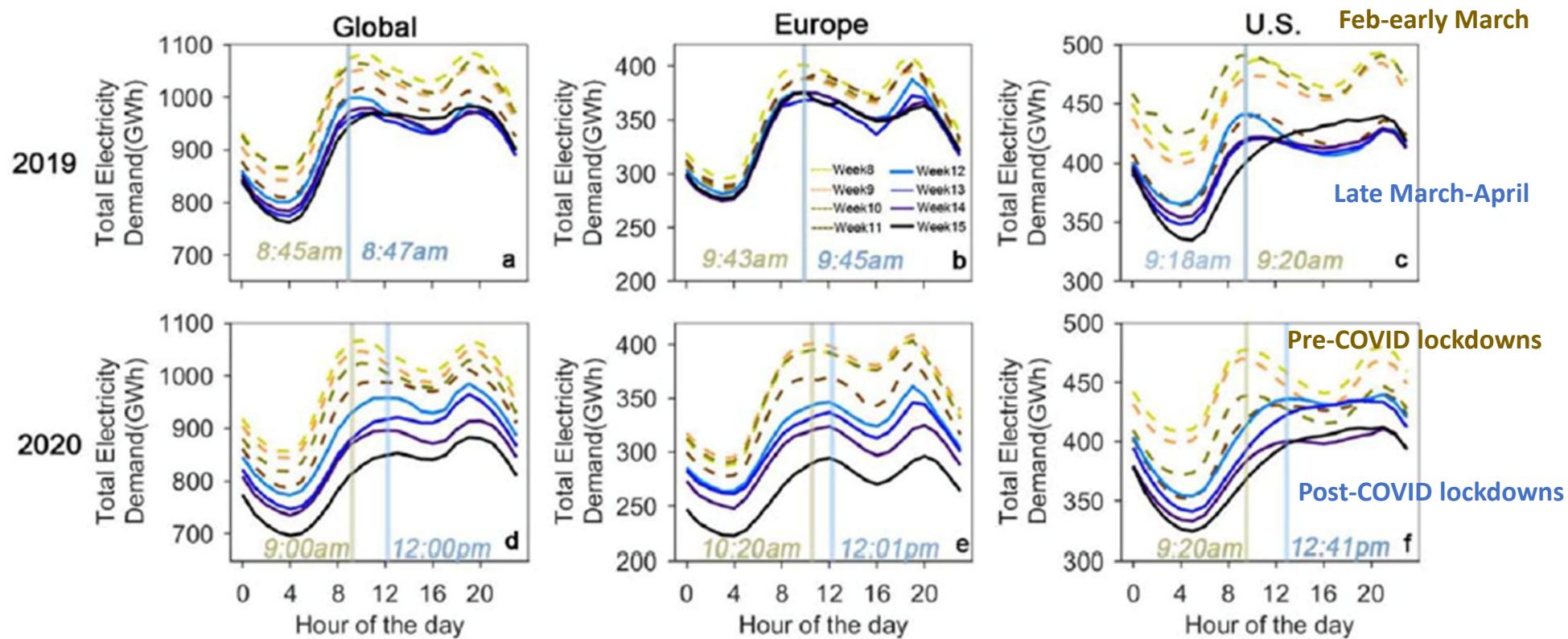


Liu et al., *Nature Communications*, 2020

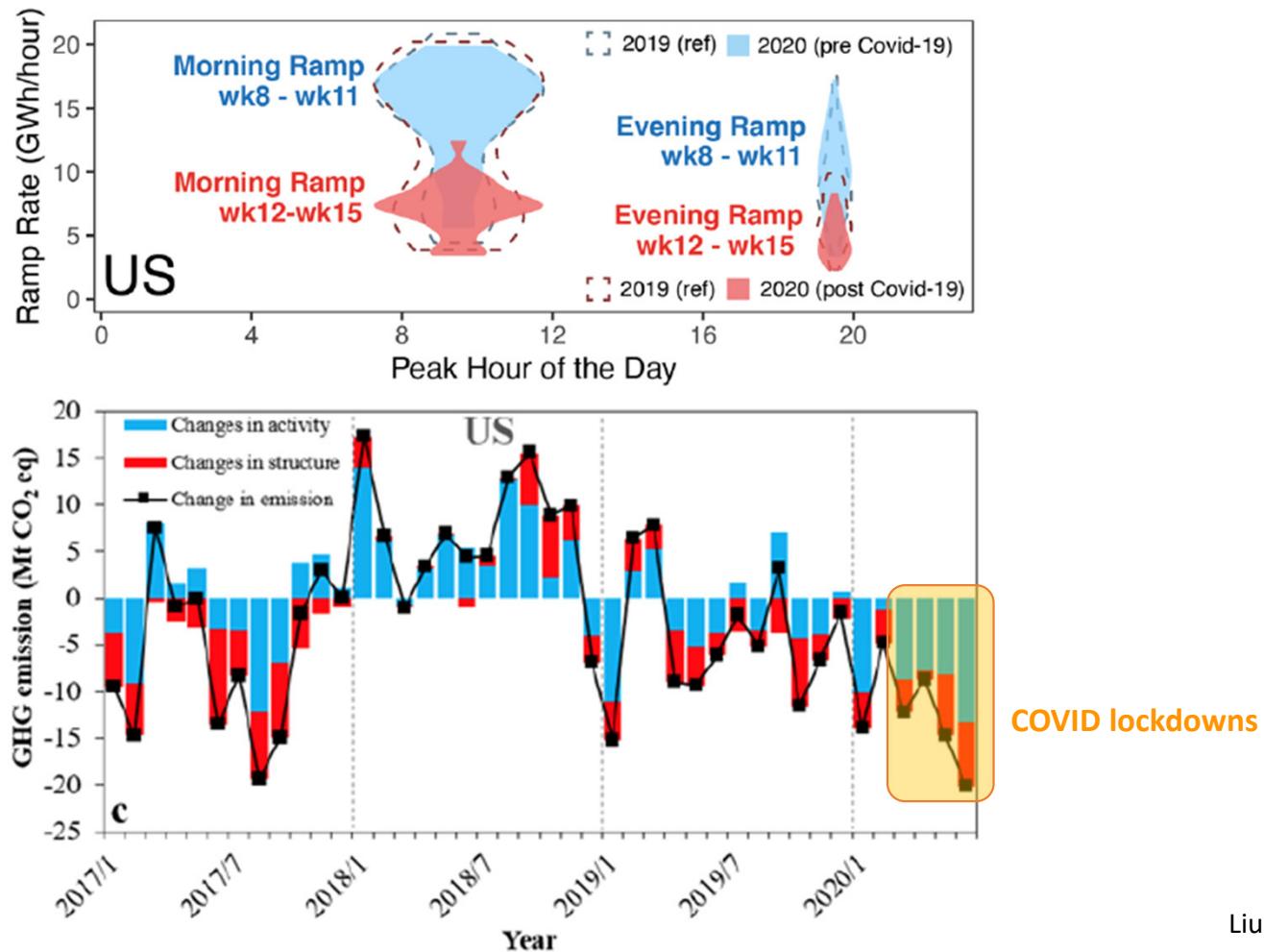
Also changes in the carbon intensity of the power sector worldwide



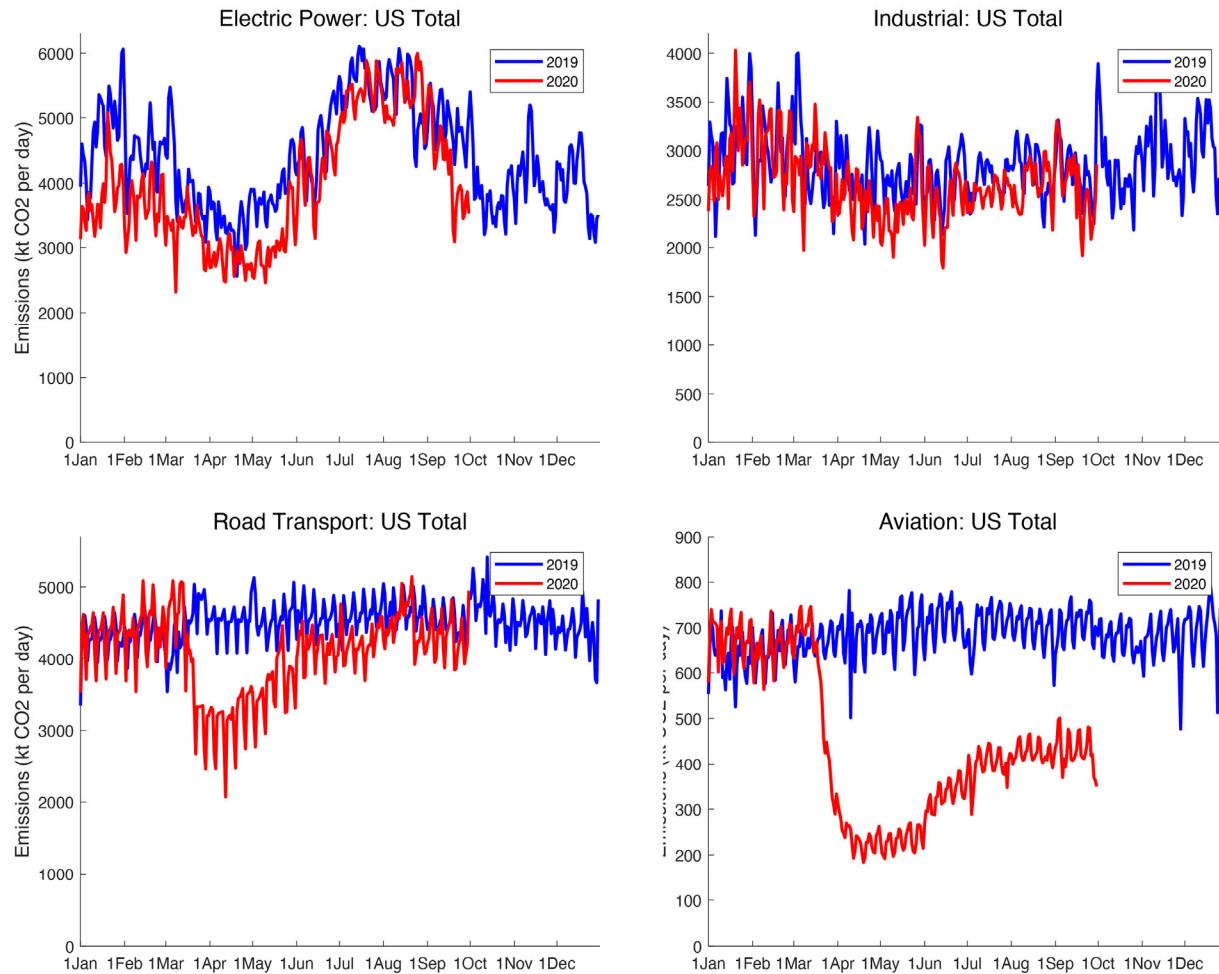
Changes in timing of demand also favored renewables



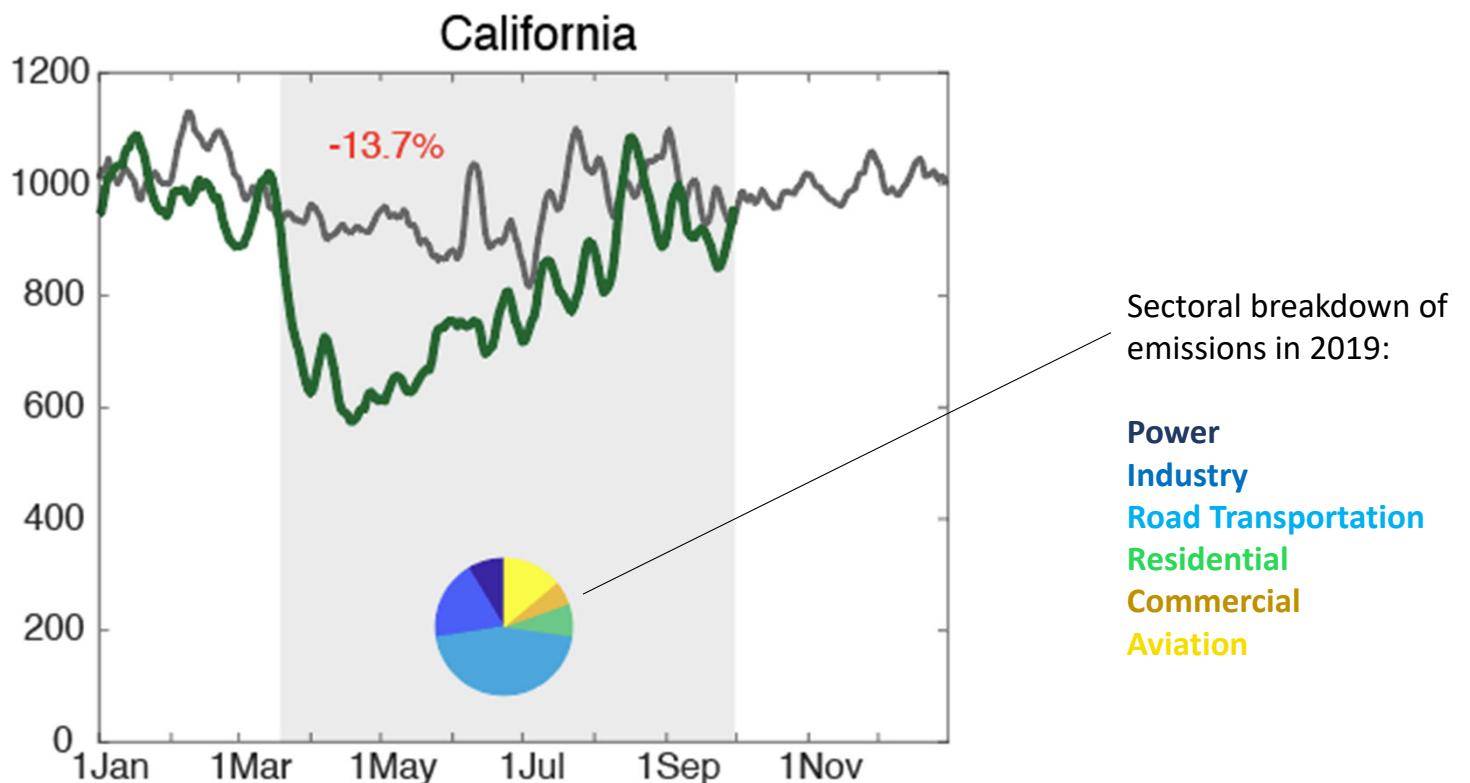
Changes in timing of demand also favored renewables



Digging into sector-specific differences in U.S. emissions



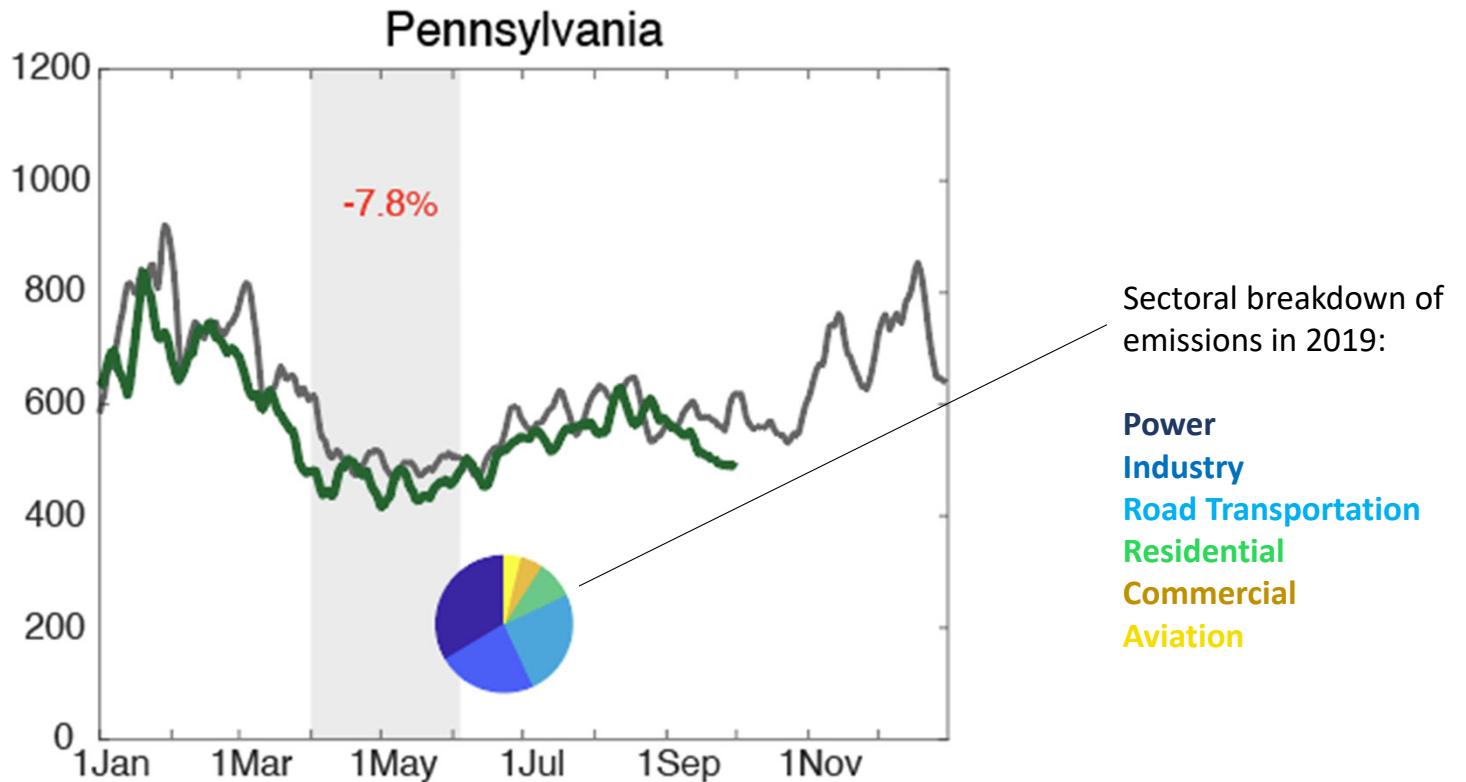
Now making estimates at the U.S. state-level



Note the large share of emissions from road transport and aviation.

Hong et al., *in prep*

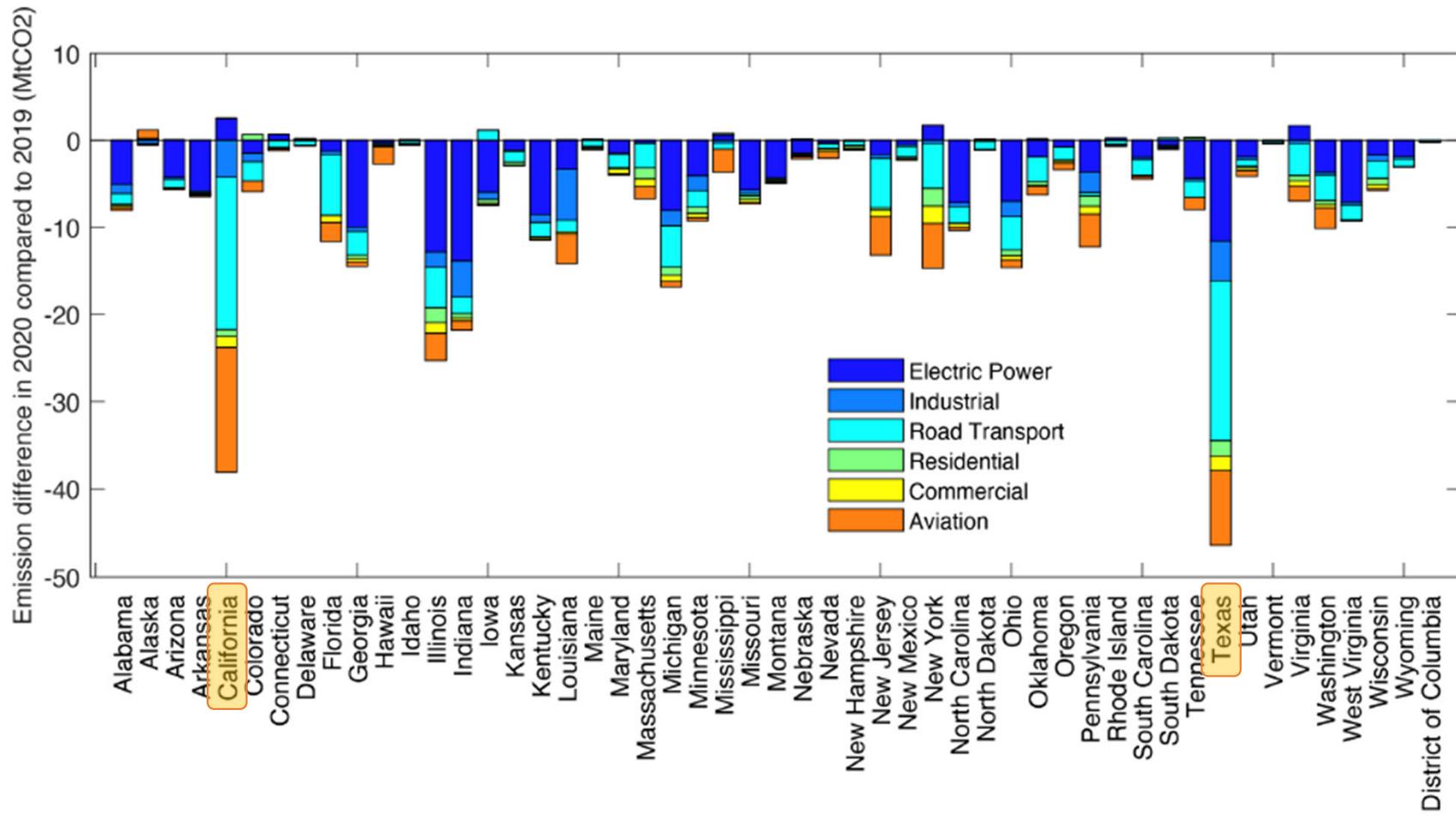
Now making estimates at the U.S. state-level



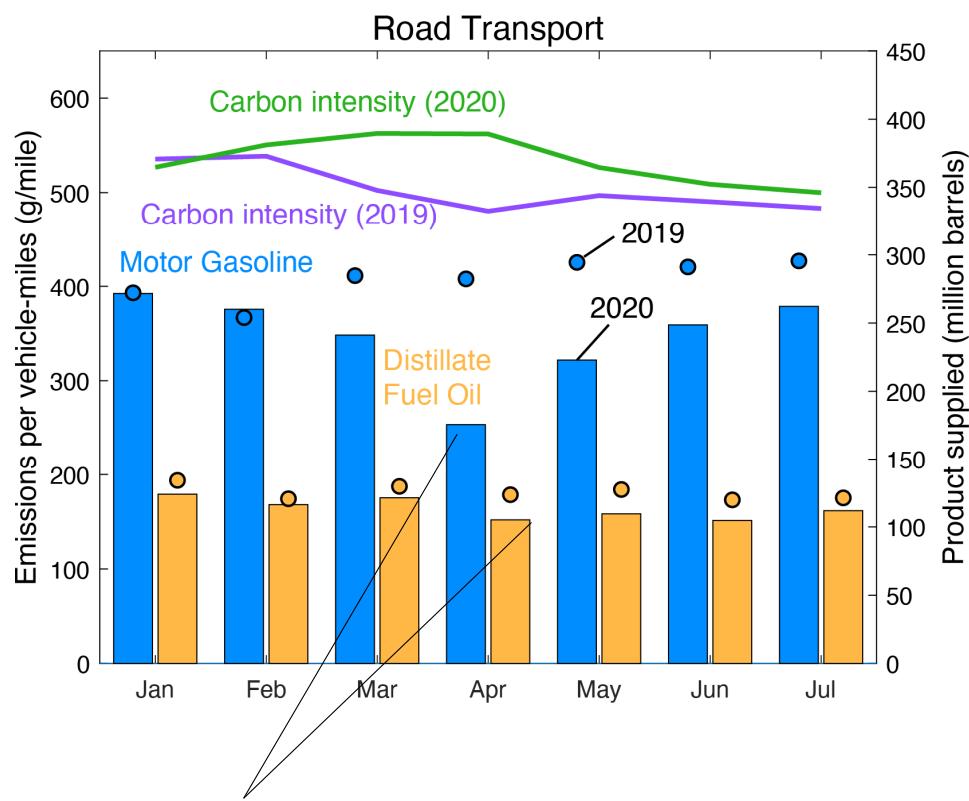
With a lower share of emissions from transport,
difference between 2019 and 2020 is less.

Hong et al., *in prep*

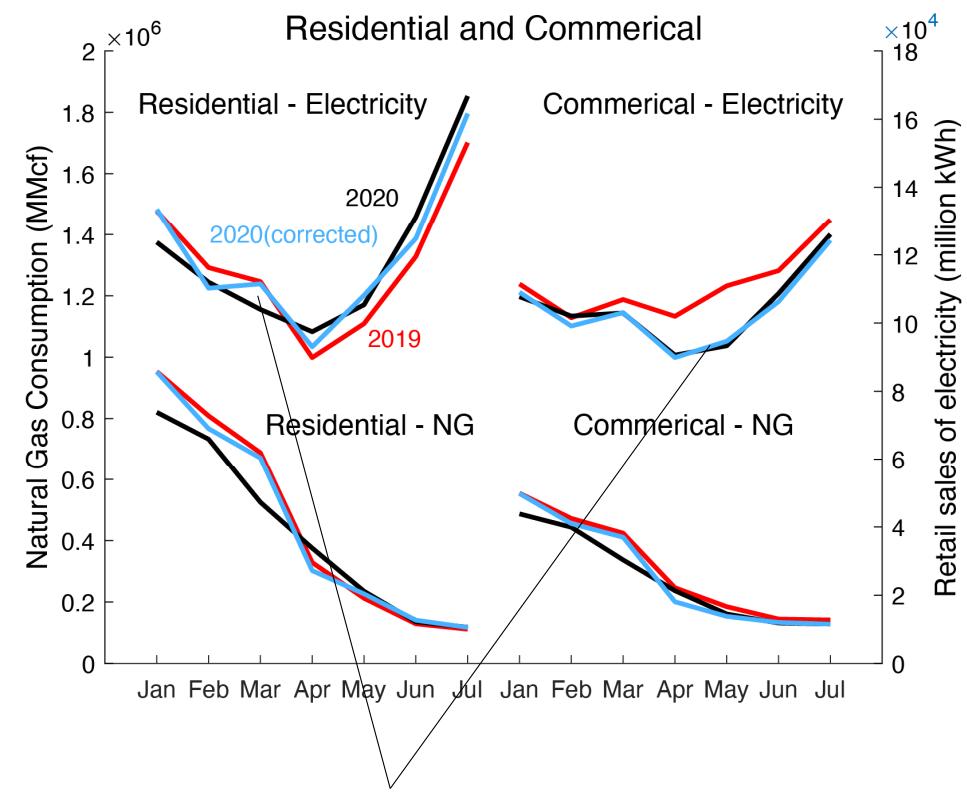
Biggest absolute decreases in largest states



Sector-specific changes



Gasoline sales dipped much more than **diesel** in 2020.



Residential electricity spiked a bit early in 2020, while commercial electricity dipped.

Hong et al., *in prep*

Take-aways

- The pandemic has given us an opportunity to observe how large-scale changes in human activity and mobility affect energy use and CO₂ emissions at planetary scales.
- Although a 9% decrease in global emissions is the largest on record, it's remarkably small considering the disruption in our daily lives. Deep decarbonization requires not only behavioral changes by systemic changes in energy structure.
- Going forward, near-real time estimates of CO₂ emissions at country- and state-level can help monitor the effects of technology and policy changes, enabling more adaptive management.

**nature
human behaviour**

ARTICLES
<https://doi.org/10.1038/s41562-020-0096-0>



Global supply-chain effects of COVID-19 control measures

Dabo Guan^{1,2,3,4}, Daoping Wang^{1,3,5}, Stephane Hallegratte⁶, Steven J. Davis^{1,3}, Jingwen Huo³, Shuping Li¹, Yangchun Bai¹, Tianyang Lei¹, Qianyu Xue¹, D'Maris Coffman¹, Danyang Cheng¹, Peipei Chen^{1,6}, Xi Liang^{1,6}, Bing Xu^{1,6}, Xiaosheng Lu^{1,6}, Shouyang Wang^{1,6}, Klaus Hubacek^{1,6}

Countries have sought to stop the spread of coronavirus disease 2019 (COVID-19) by severely restricting travel and in-person commercial activities. Here, we analyse the supply-chain effects of a set of idealized lockdown scenarios, using the latest global trade modelling framework. We find that supply-chain losses that are related to initial COVID-19 lockdowns are largely dependent on the degree of interconnectedness between countries. The degree of interconnectedness is higher than its strictness. However, a longer containment that can eradicate the disease imposes a smaller loss than shorter ones. Earlier, strict lockdowns can reduce overall losses. A 'go-slow' approach to lifting restrictions may reduce overall damages if it avoids the need for further lockdowns. Regardless of the strategy, the complexity of global supply chains will impose losses beyond the direct effects of COVID-19. Thus, pandemic control is a public good that requires collective efforts and support to lower-capacity countries.

 COVID-19, which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged in late 2019, steps using the latest available global input-output data, and taking

PERSPECTIVES

The COVID-19 lockdowns: a window into the Earth System

Noah S. Diffenbaugh¹, Christopher B. Field², Eric A. Appel³, Ires L. Avendaño⁴, Dennis D. Baldocchi⁵, Marshall Burke⁶, Jennifer A. Burney⁷, Philippe Ciais⁸, Steven J. Davis^{1,3}, Ariane M. Flor⁹, Sarah M. Fetter¹⁰, Thomas W. Hertel¹¹, Daniel P. Hoornik¹², Sotiris Ierodiaconou¹³, Brian Jackson¹⁴, Xuesong Jin¹⁵, Meryem Kadi¹⁶, Daniel R. Lashof¹⁷, Corinne A. MacLachlan¹⁸, Francis M. Montenegro¹⁹, Anastasia Montagnini²⁰, Kori C. Niedzwiedz²¹, Diane F. Petrelli²², James T. Randerson²³, Markus Reichstein²⁴, Jordan L. Schell²⁵, Sonia I. Seneviratne²⁶, Deepak Singh²⁷, Allison L. Steiner²⁸ and Gabrielle Wong-Parodi²⁹

Abstract | Restrictions to reduce human interaction have helped to avoid greater suffering and death from the COVID-19 pandemic. Here we analyse the effects of the disruption on the Earth System. This disruption has unprecedented in the modern era of global observing networks, pervasive sensing and large-scale tracking of human mobility and behaviour, creating a unique test bed for understanding the Earth System. In

questions, such as the processes linking heterogeneous local pollutant emissions and regional atmospheric chemistry and air quality, the impacts of social isolation and economic integration and poverty-driven environmental degradation. The uniquely comprehensive dataset of human activity used to reveal questions about the Earth System that have not previously been addressed is also a resource that is already underway to learn from this inadvertent experiment.

In this Perspective, we examine the impacts of COVID-19-related social distancing on the Earth System through pathways: energy, emissions, climate and air quality; and poverty, globalization, food and water security. We also explore what we know about how the COVID-19 disruption could influence the Earth system along these pathways and then explore the potential for rapid advances in understanding if

**nature
COMMUNICATIONS**

ARTICLE
<https://doi.org/10.1038/s41467-020-18922-z> OPEN



Near-real-time monitoring of global CO₂ emissions reveals the effects of the COVID-19 pandemic

Zhu Liu¹ et al.^{1,2}

The COVID-19 pandemic is impacting human activities, and in turn energy use and carbon dioxide (CO₂) emissions. Here we present daily estimates of country-level CO₂ emissions for different countries based on a machine-learning model. The key finding is an average 8.8% decrease in global CO₂ emissions (~1551 Mt CO₂) in the first half of 2020 compared to the same period in 2019. The magnitude of this decrease is larger than during previous economic downturns or World War II. The timing of emissions decreases corresponds to lockdown measures in each country. By July 1st, the pandemic's effects on global emissions diminished

www.nature.com/scientificdata/

SCIENTIFIC DATA

OPEN **Carbon Monitor, a near-real-time daily dataset of global CO₂ emission from fossil fuel and cement production**

Zhu Liu^{1,2,3,4}, Philippe Ciais^{1,2,3,4,5}, Zhuo Deng^{1,3,4,5}, Steven J. Davis^{1,3,5}, Bo Zheng^{1,2,3,4}, Yilong Wang¹, Duo Cui¹, Beijing Zhu¹, Xinyi Dong¹, Peng Ke¹, Taichun Sun¹, Rui Gao^{1,2}, Haiwang Zhang¹, Olivier Boucher¹, François-Marie Bréon^{1,6}, Chenxi Lu¹, Runtao Guo¹, Jinjun Xue^{1,2,3,4}, Eulalie Boucher¹, Katsuhiro Tanaka^{1,2,3,4} & Frédéric Chevallier¹

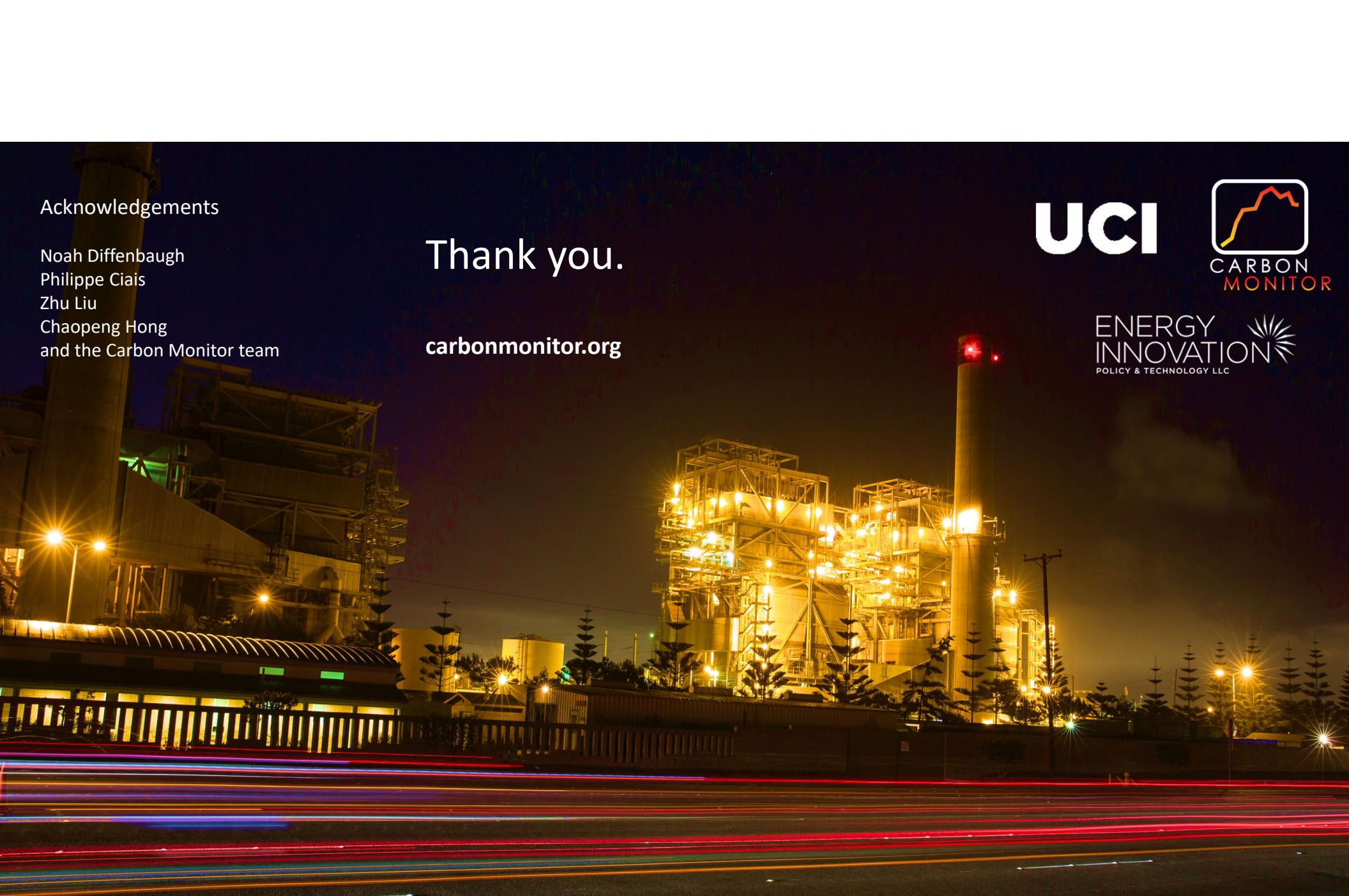
We constructed a near-real-time daily CO₂ emission dataset, the Carbon Monitor, to monitor the variations in CO₂ emissions from fossil fuel combustion and cement production since January 1, 2015, at the national level, with near-global coverage on a daily basis and the potential to be frequently updated. <https://doi.org/10.1038/s41551-020-0480-0>

Guan et al., *Nature Human Behavior*, 2020

Diffenbaugh et al., *Nature Reviews Earth & Environment*, 2020

Liu et al., *Nature Communications*, 2020

Liu et al., *Scientific Data*, 2020



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Thank you.

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