Assessing the impact of COVID-19 on power plants emissions in the United States using generalized synthetic control methods

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Motivations

-Reduction of on-road vehicle emissions was one of the reasons for improved air quality in U.S. cities during COVID-lockdown period
-Emissions changes from large stationary sources influenced regional air quality has yet to be investigated in full

Objective

Investigating electric facilities emissions across the United States using generalized synthetic control (GSYNTH) causal inference model
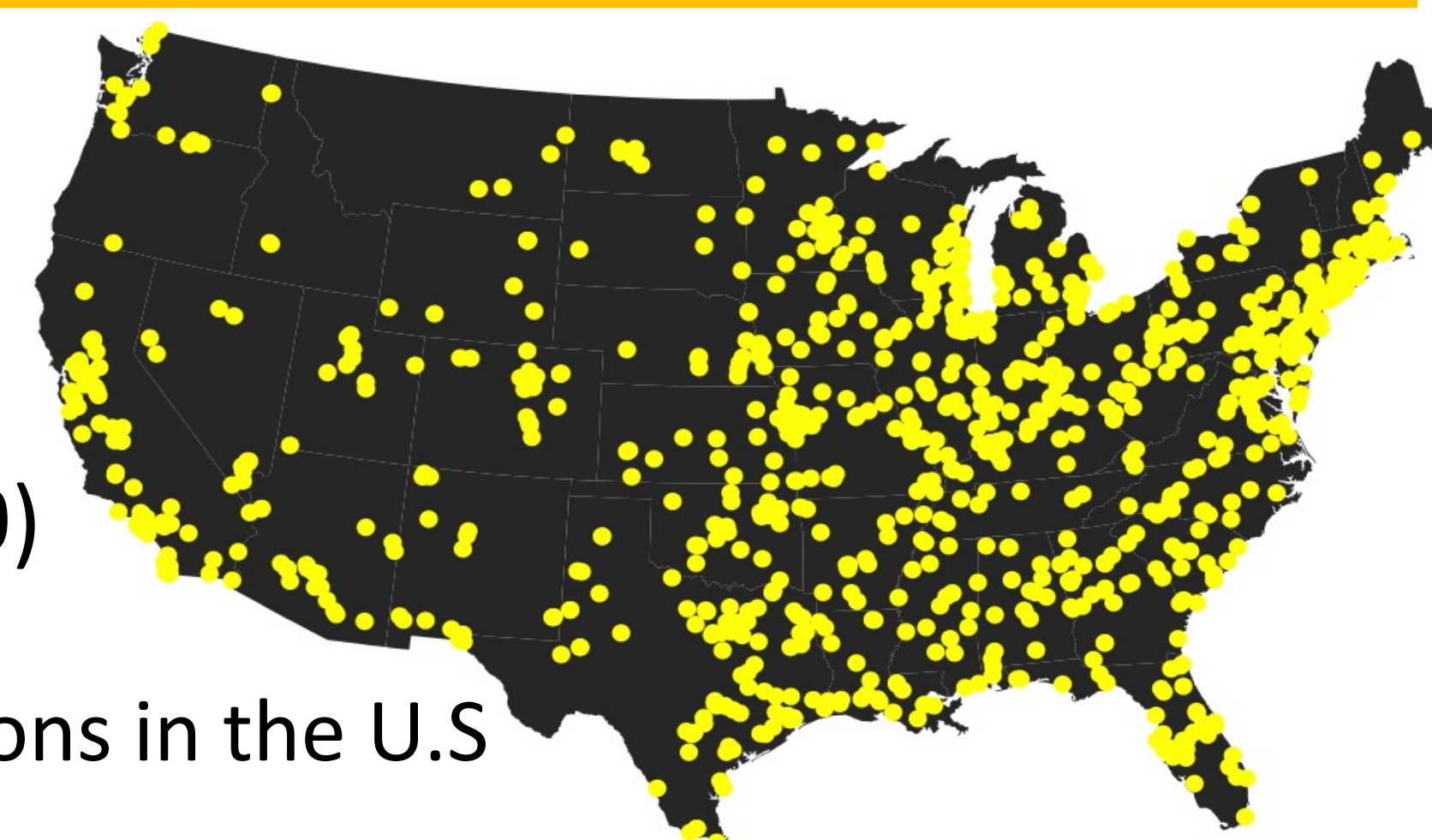
Methodology

Study Area
Contiguous U.S.

Study Period
Jan-Apr (2010-2020)

Electric Facility Locations in the U.S

Data collection
Emission dataset : Air Market Program Dataset
Meteorological data: Google Earth Engine
Modeling Equation
$E_{so2} = Dit + Mit + Wit$;
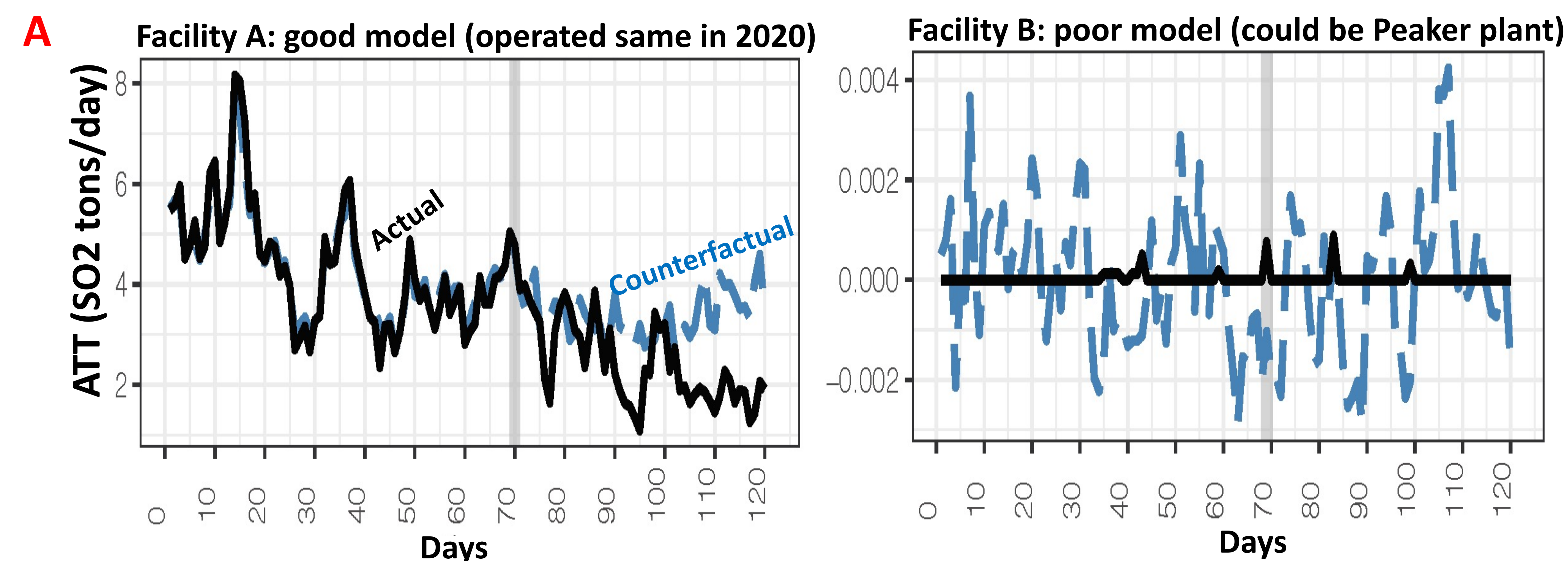D: Treatment indicator, M: Meteorology, W: Day of week, i:facility, t=time, E: SO_2 Emissions
Modeling Evaluation tools
Mean Bias, Normalized Mean Bias, Mean Error, Normalized Mean Error, Index of Agreement, RMSE, Pearson R
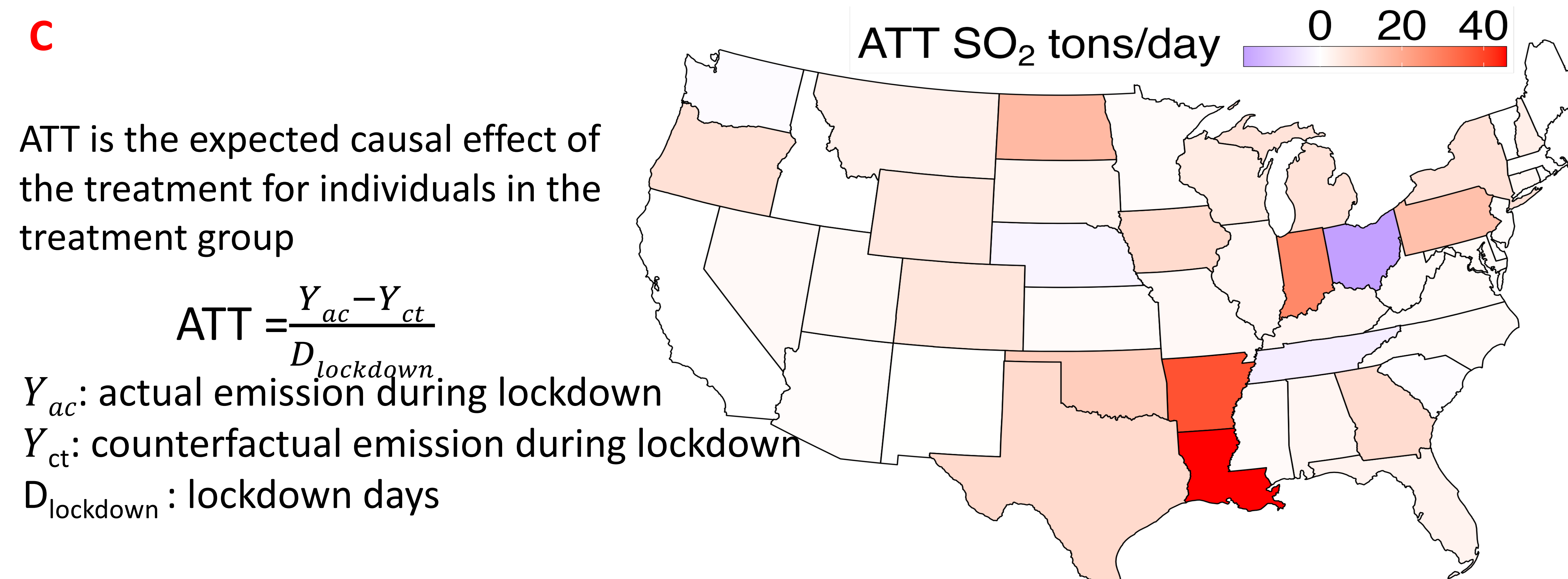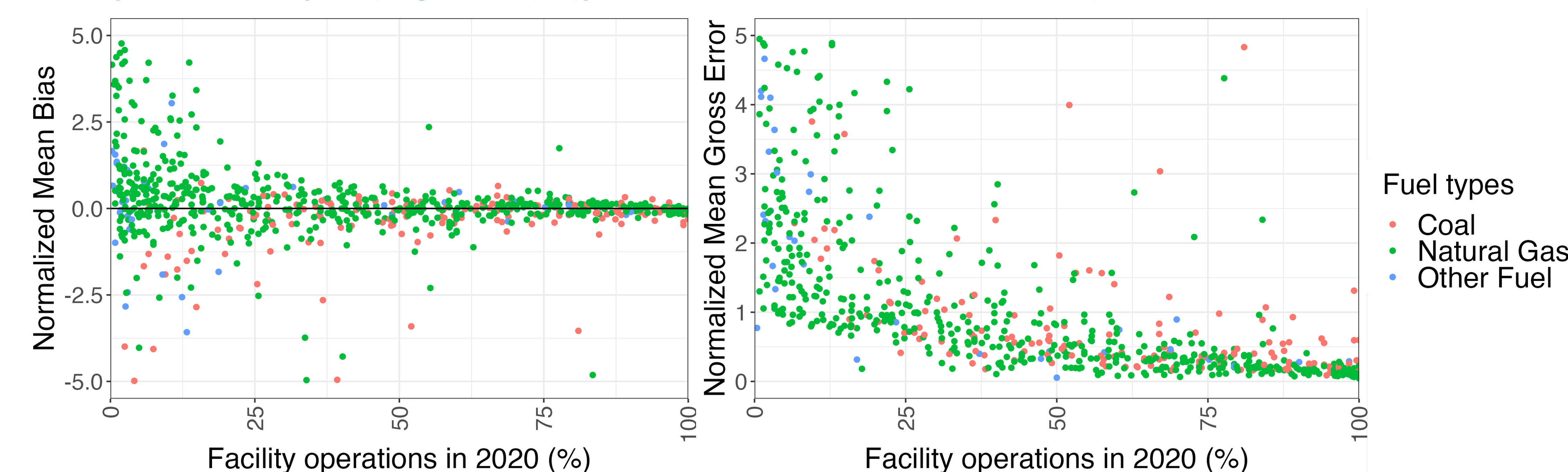### Generalized Synthetic Control method to estimate causal effect
Helps to estimate effect of an intervention (COVID-19) on a specific outcome (emissions) using historical information
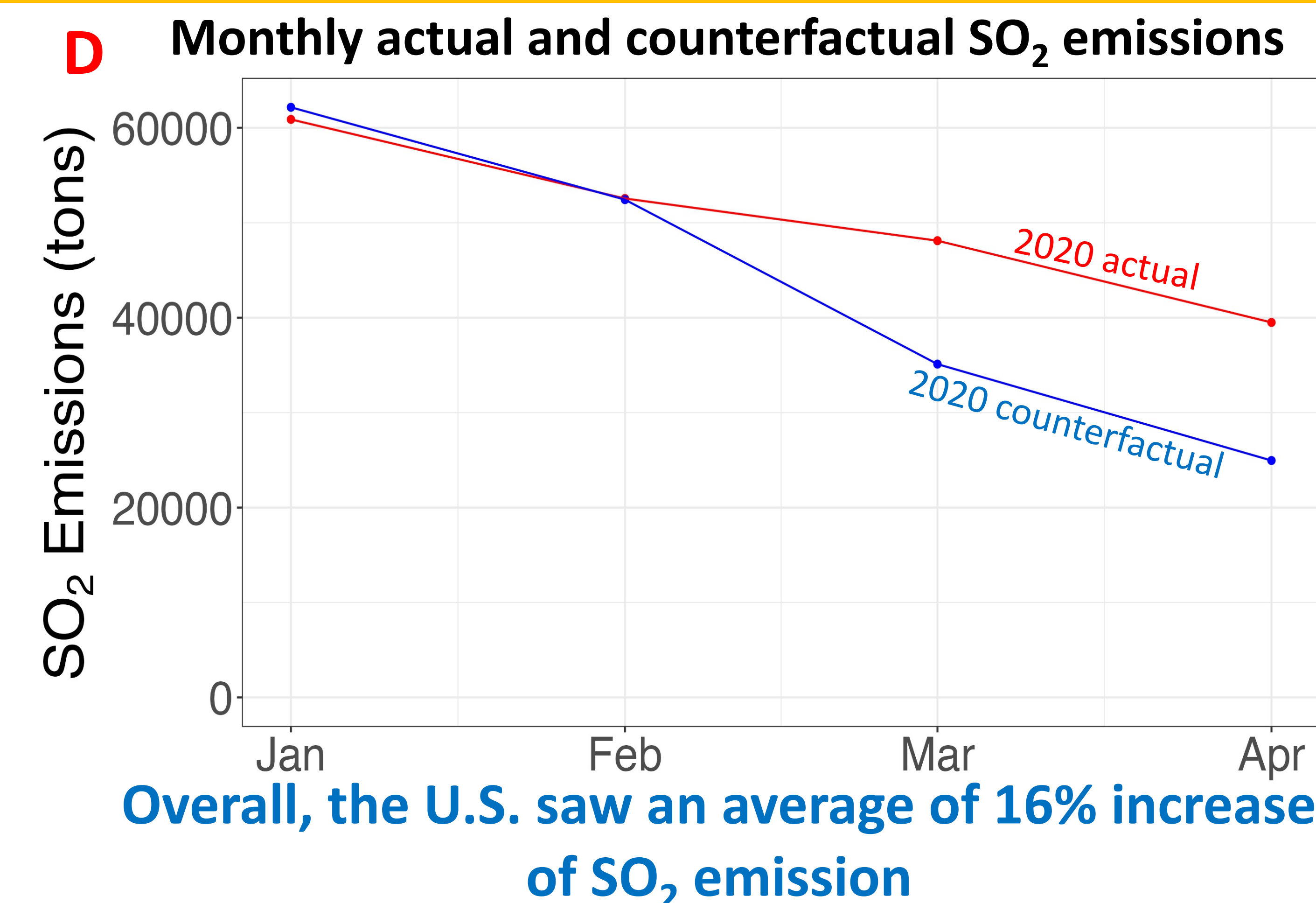ATT: Average Treatment on Treated

Results & Discussions

A

Facility A: good model (operated same in 2020)

Facility B: poor model (could be Peaker plant)

B Facilities with same operations in 2020 performed well in the model and vice versa.
Example: Facility A (Figure A), (pearson r= 0.85, NMB=11%)

Fuel types
Coal
Natural Gas
Other Fuel

C

ATT is the expected causal effect of the treatment for individuals in the treatment group

$$ATT = \frac{Y_{ac} - Y_{ct}}{D_{lockdown}}$$

Y_{ac}: actual emission during lockdown
Y_{ct}: counterfactual emission during lockdown
$D_{lockdown}$: lockdown days

ATT SO_2 tons/day

Some states (LA, AR, IN) observed increased emissions (vice versa: state OH) compared to the expected emissions in absence of lockdown in 2020

D Monthly actual and counterfactual SO_2 emissions

2020 actual
2020 counterfactual

Overall, the U.S. saw an average of 16% increase of SO_2 emission

Conclusions

U.S. observed an average increase of 254 (16%) tons of SO_2 and 121 (12%) tons of NOx emissions (not shown here) per day during the COVID-19 lockdown period relative to expected emissions in the absence of lockdown.

Future Work

HyADS (a reduced complexity model) and CMAQ-DDM will be used to quantify contributions of PM from stationary sources by using both actual and counterfactual emissions

Acknowledgement

References

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-Chen, K. L., Henneman, L. R., & Nethery, R. C. (2021). Differential Impacts of COVID-19 Lockdowns on PM2. 5 across the United States. medRxiv.
-Yiqing Xu and Licheng Liu (2021). gsynth: Generalized Synthetic Control Method. R package version 1.2.1. https://CRAN.R-project.org/package=gsynth