A Spatiotemporal Covid-19 Rapid Response

Taking the pulse of COVID-19: a spatiotemporal perspective

https://covid-19.stcenter.net/

Chaowei Phil Yang

Hai Lan, Yun Li, Qian Liu, Dexuan Sha, Yifei Tian, Zifu Wang, Anusha, etc., George Mason University

Wendy Guan, Tao Hu, etc. , Harvard University

Yanfang Su, Univ. of Washington

&

CVT Members from every time zone of the world

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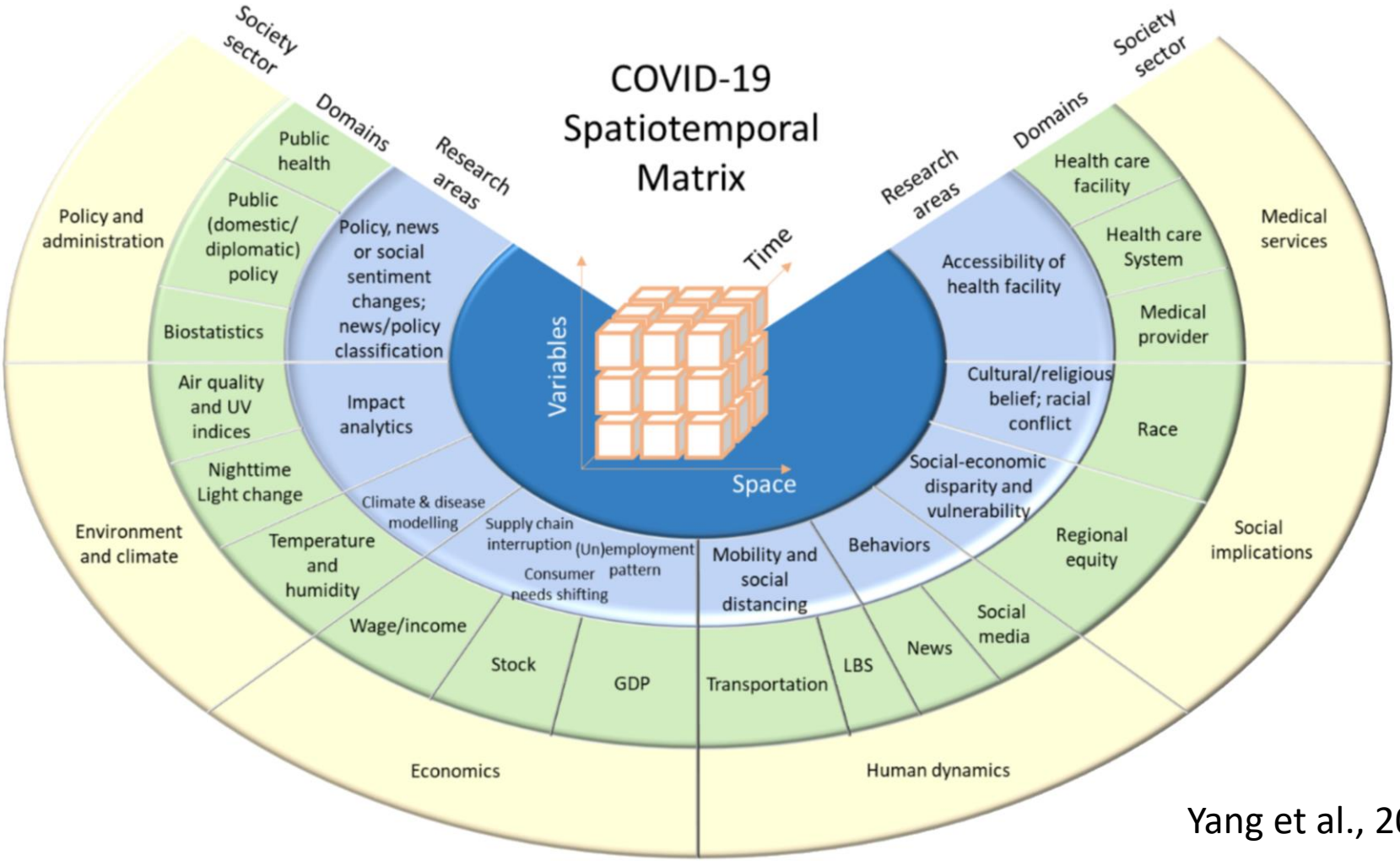
The spatiotemporal rapid response to The Global Pandemic Health Crisis



Yang et al., 2020

An integrative effort for combating COVID-19

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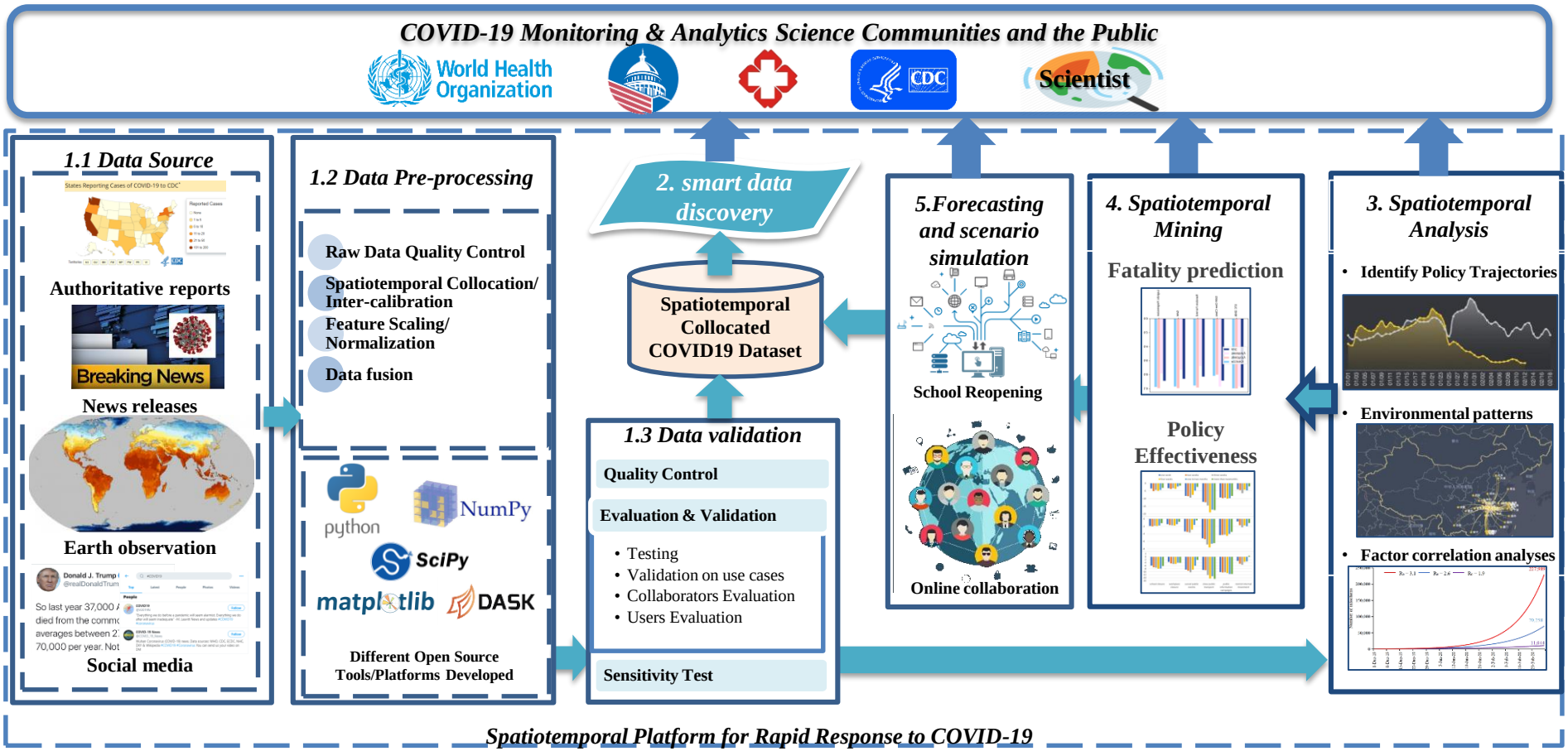

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Spatiotemporal Analytics: Outline

1) How the viral diseases evolved in the U.S.?
2) How the citizens responded to the lockdown policies?
3) How the government and authoritative agencies responded?
4) How the regional climate and environment have been impacted?
5) How were the medical resources pressed?
6) How individuals may be impacted if confirmed?
7) Could we and how to reopen the campus under the global pandemic?
8) Where to obtain data, source code, and report of the research?

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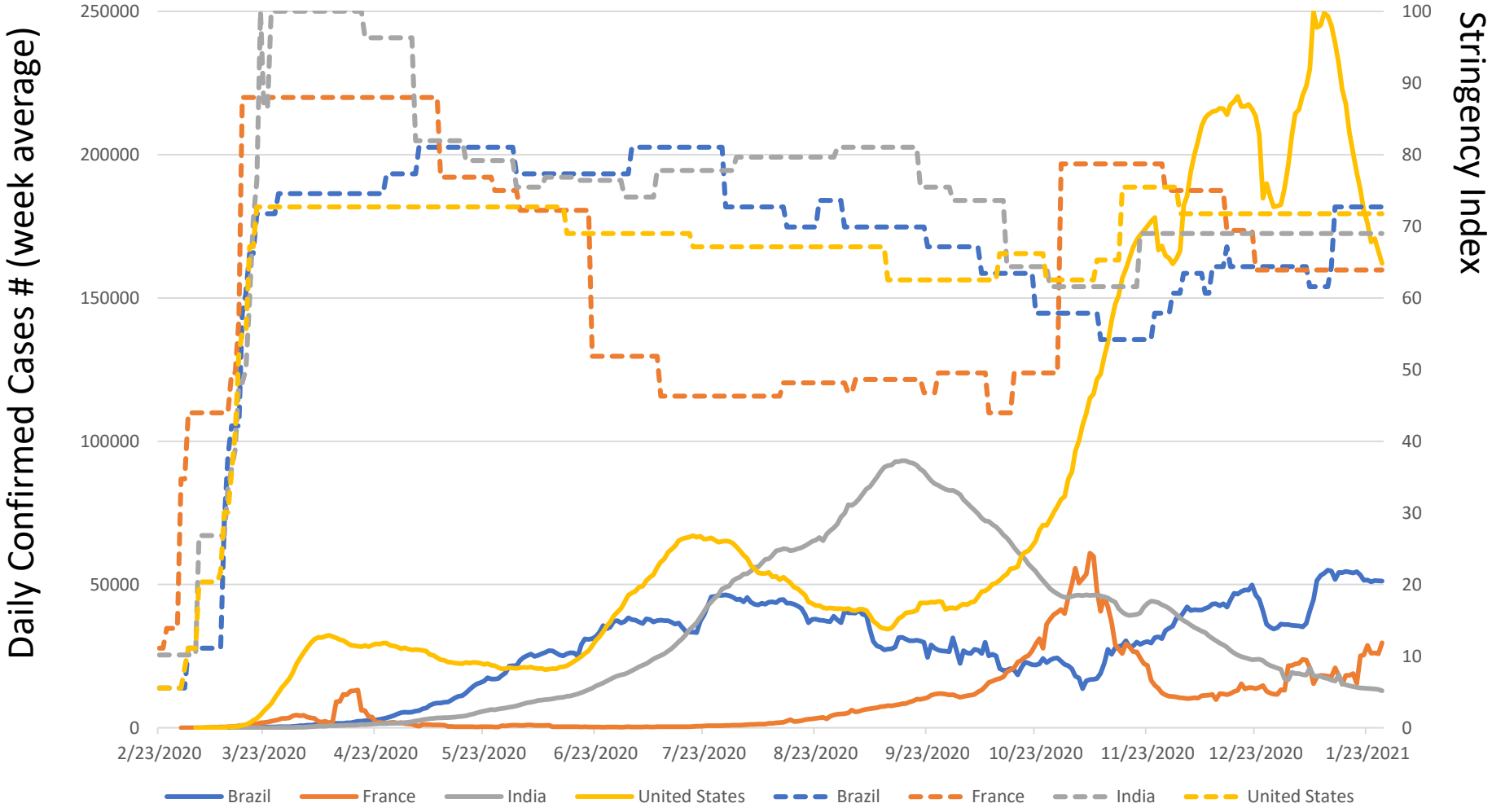
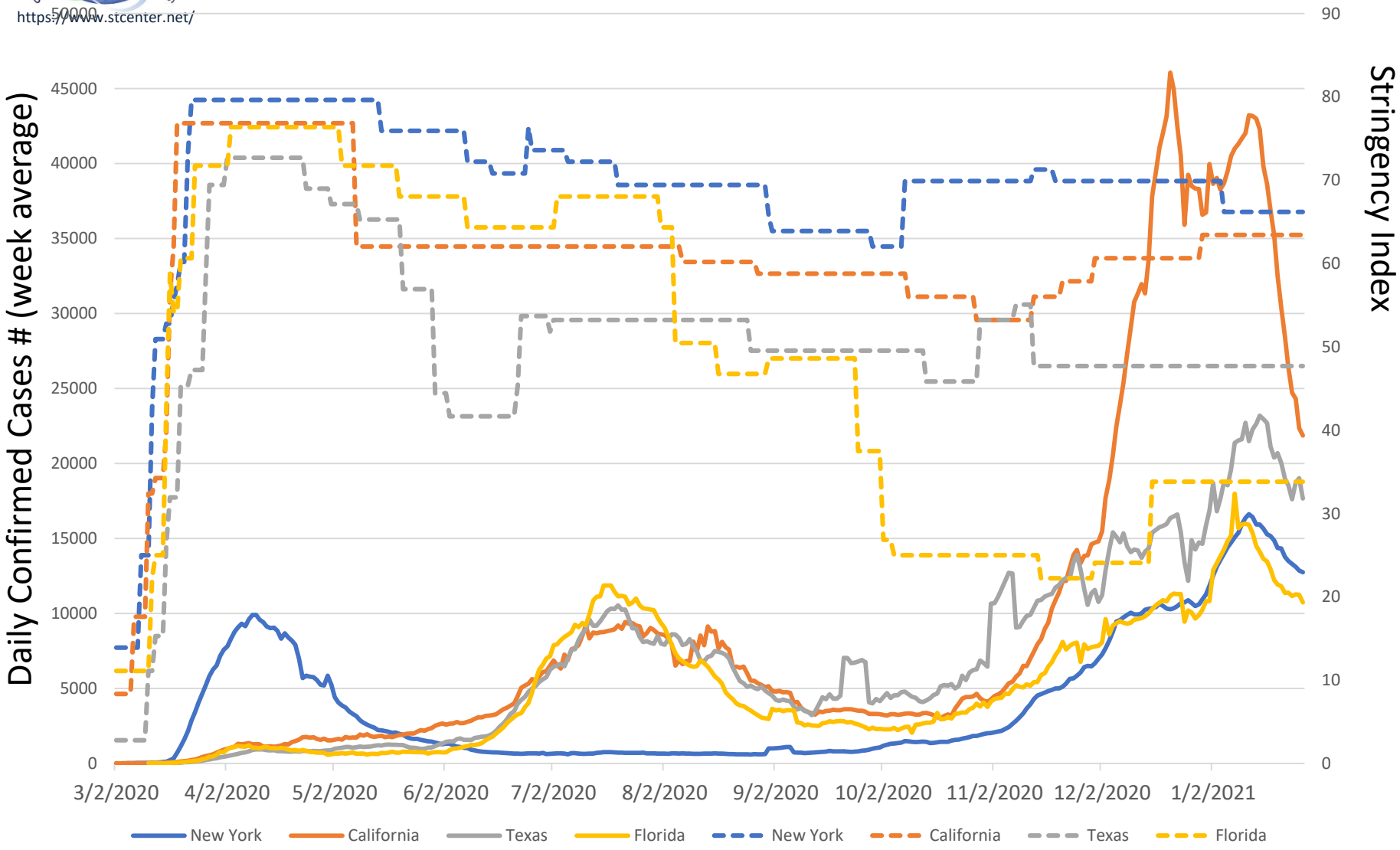
1. How has the global outbreak evolved?



1. How has the US outbreak evolved?



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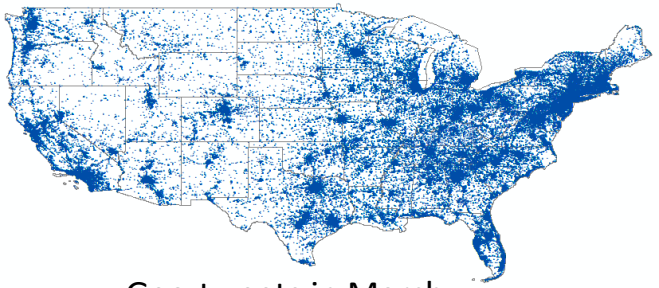
2. How the citizens responded to the policies?

Human movement is an important driver of the dispersion of infectious diseases.

- **Social media Data**: Geotagged tweets

  Collected from Twitter, which provides Rest API to scrape tweets with GPS-based geolocations.



Geo-tweets in March

- **Mobile Phone data**: Community mobility reports

  Collected and aggregated by Google, which records movement trends over time across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential.

https://opensky-network.org/community/blog/item/6-opensky-covid-19-flight-dataset

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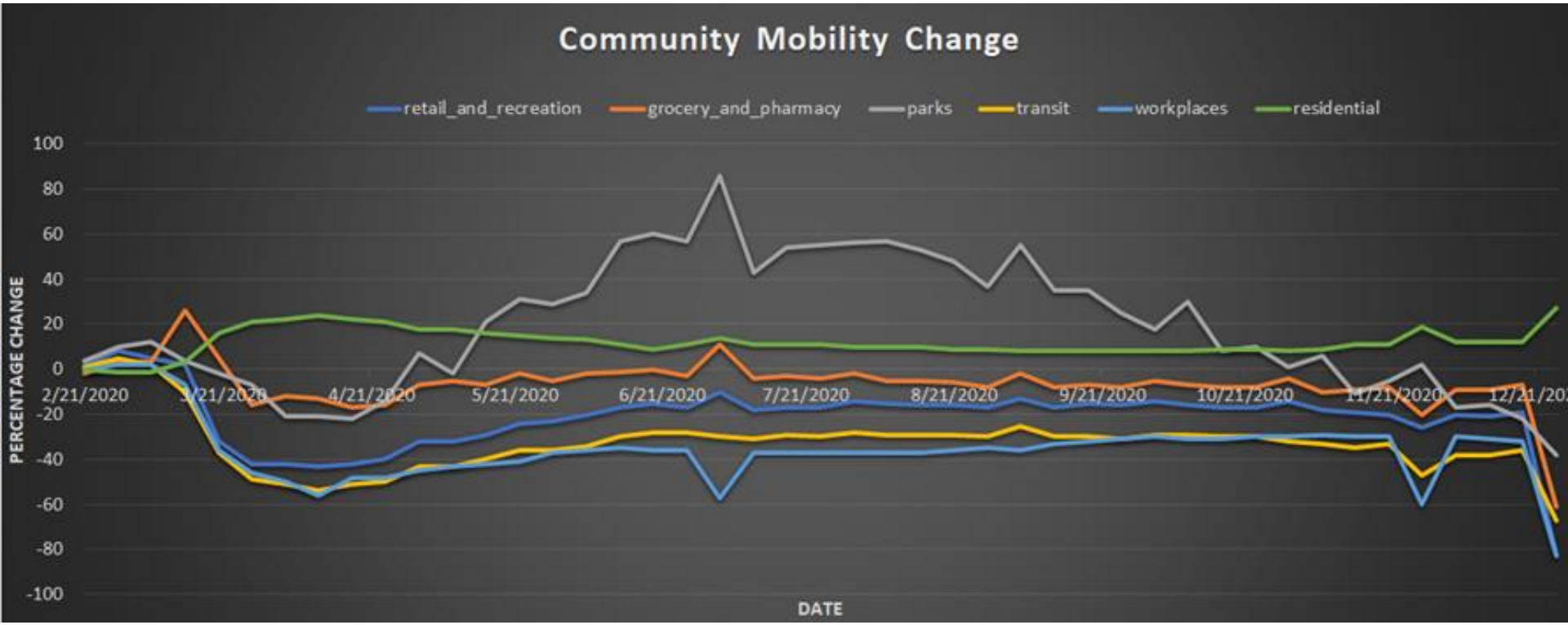
2. How are community activities changed?



3. How the government and authoritative agencies responded?

An effective method to combat covid-19: Social distancing

- A series of policies are announced, e.g., stay at home orders, school closure, cancellation of public events
- Affect normal life
- Economic loss

The United States is caught in a double bind

- take the risk of outbreak by allowing people to return to work
- suffer economic losses by maintaining social distancing orders

To support the reopen process, it is important to

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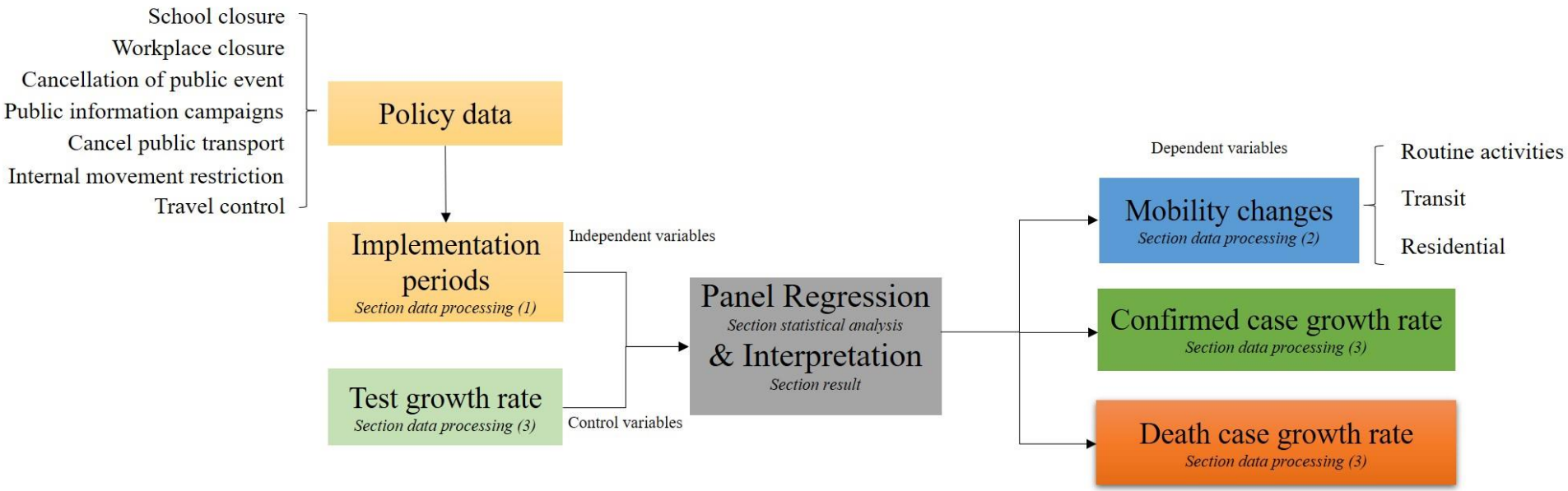
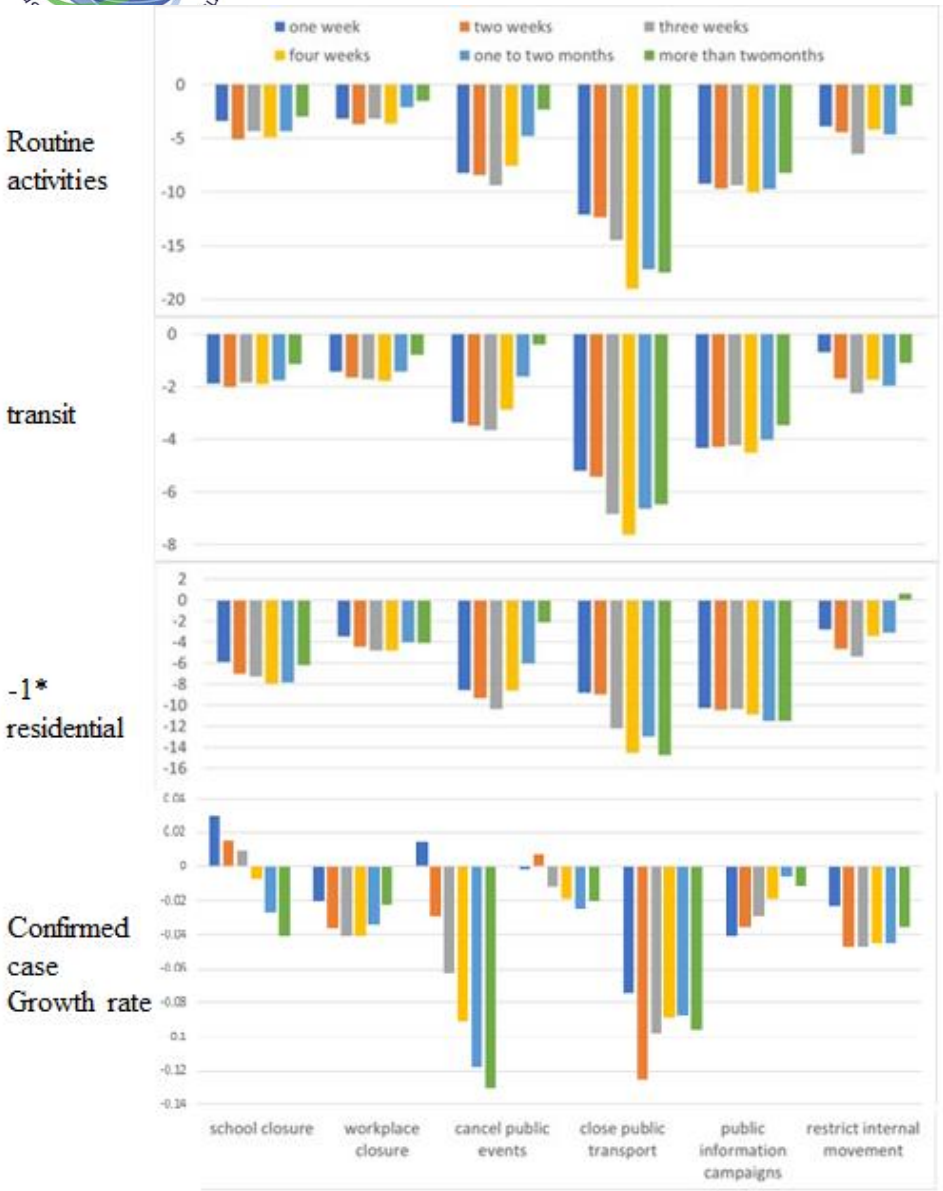
3. Solution with the Data/Resources



https://www.mdpi.com/1660-4601/18/3/996

3. Results



Internal movement restriction(Stay-at-home orders):

- significantly decrease in mobility in the first three weeks
- the impacts on the confirmed case growth rate were significant

Workplace closures:

- significantly decrease in mobility
- changes in mobility were not persistent

Public event cancellations:

- saw significant changes in mobility
- saw significant results in the confirmed case growth rate after one month

Public transport closures

- saw significant changes in mobility
- no significant impacts were observed for this policy

School closures and international/national travel

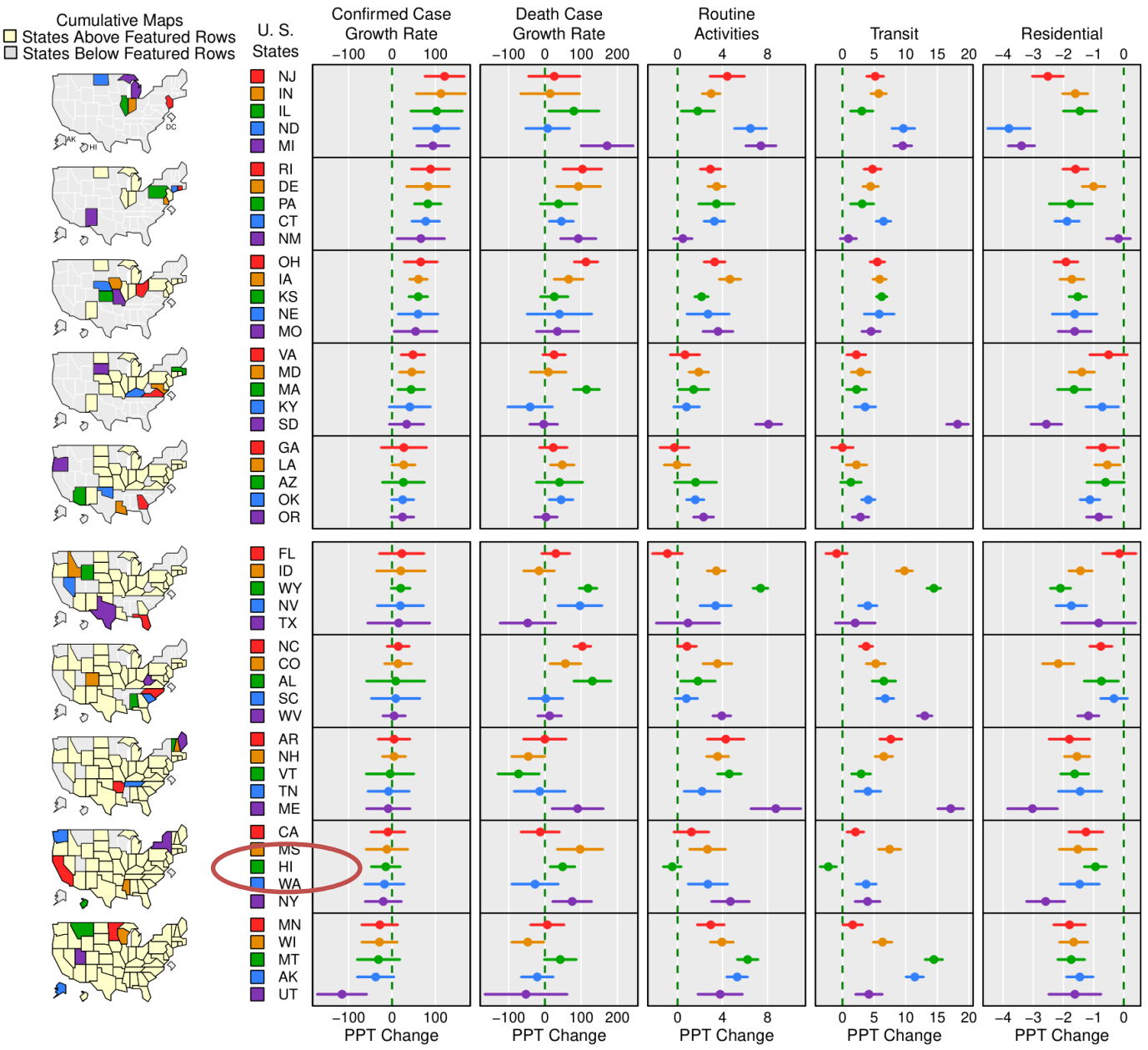
- impact on mobility were not significant
- estimates on confirmed case growth rate were not statistically significant

Public information campaigns:

- had little to no effect on the mobility subgroups
- effectively reduce the COVID-19 confirmed case growth rate
- policy can significantly impact COVID-19 trends through channels other than changes in mobility

3. Counterfactual state-specific time trends

- It displays the time trends in absence of seven social distancing policies.
- Spatial heterogeneity bet ween state-specific trends.



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3. Counterfactual analysis: state-specific time trends for the confirmed case growth rate

- Good fits between the predicted confirmed case growth rate and the observations.
- Large gaps between the predicted curves with and without policies

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3. How did governments and organizations respond?

-
-
-

4. How the regional climate and environment have been impacted?

- Challenges:
- How different environmental factors are changed by COVID-19?
- Do they have similar responses in different regions?
- How to explain the changes?
- Motivation:

➢ The factors are essential indicators of industrial production and global economic;

➢ Results can offer vital and practical basis for loss assessment and economic reopening and planning.

4. Solution with the Data/Resources

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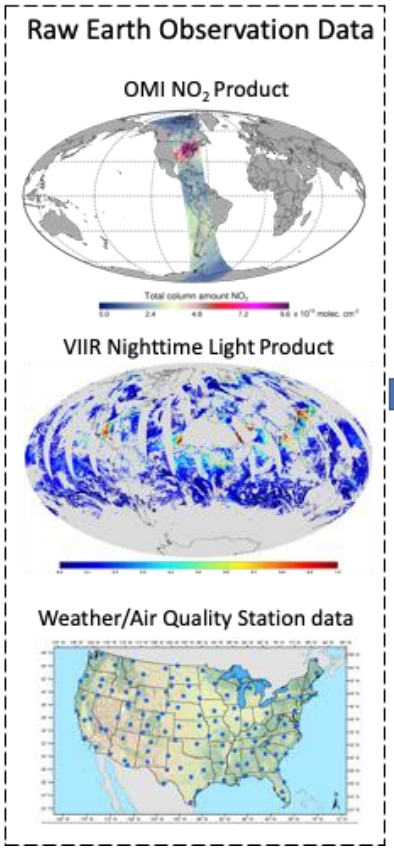
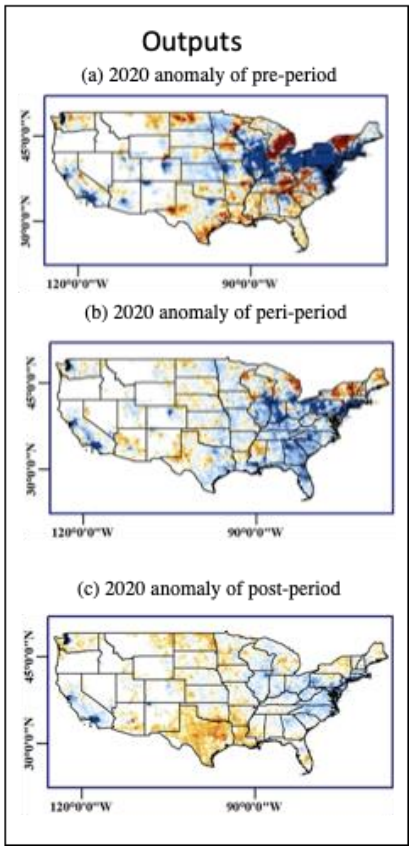


Spatiotemporal Environmental Data Analytical Tool

python data analysis and processing packages: numpy, netCDF4, math, scipy

Daily/Monthly/ Periodically Average, Season cycles

Visualization

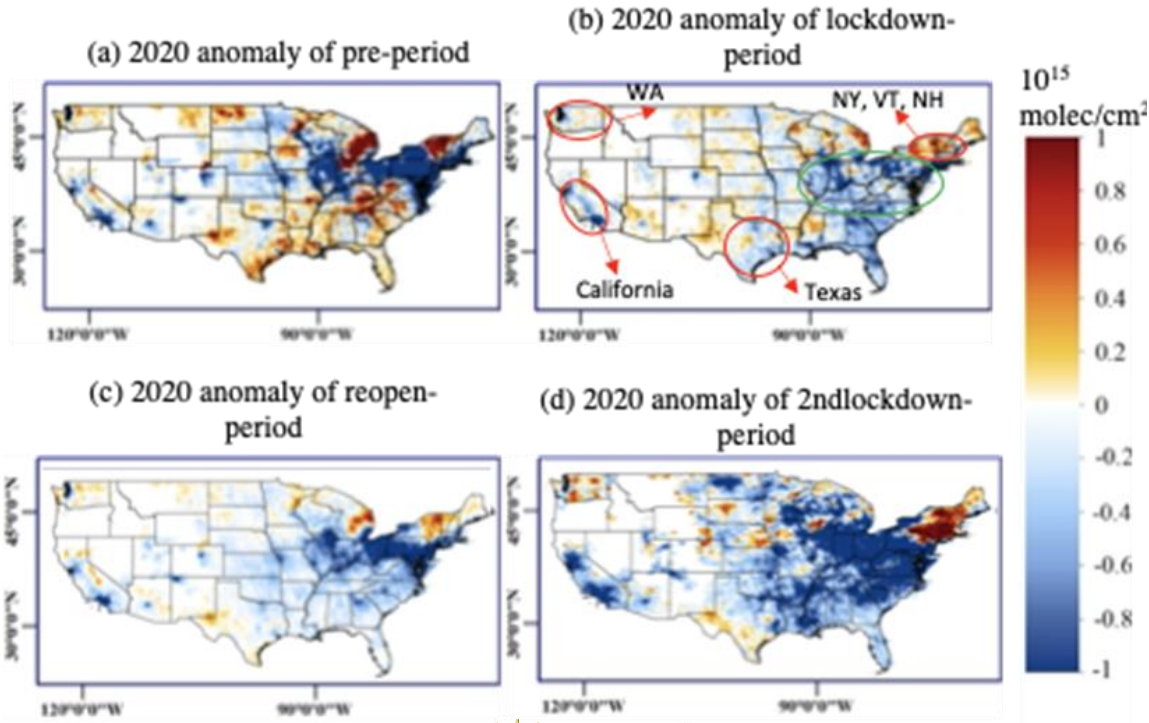


1. Liu, Q., Sha, D., Liu, W., Houser, P., Zhang, L., Hou, R., Lan, H., Flynn, C., Lu, M., Hu, T. and Yang, C., 2020a. Spatiotemporal Patterns of COVID-19 Impact on Human Activities and Environment in Mainland China Using Nighttime Light and Air Quality Data.
2. Liu, Q., Liu, W., Sha, D., Kumar, S., Chang, E., Arora, V., Lan, H., Li, Y., Wang, Z., Zhang, Y. and Zhang, Z., 2020b. An Environmental Data Collection for COVID-19 Pandemic Research. Data, 5(3), p.68.
3. Liu, Q., Harris, J.T., Chiu, L.S., Sun, D., Houser, P.R., Yu, M., Duffy, D.Q., Little, M.M. and Yang, C., 2020c. Spatiotemporal impacts of COVID-19 on air pollution in California, USA. Science of The Total Environment, p.141592.

4. The regional NO2 change in the U.S.?

Relative difference between peri- and pre-period (%)		Relative difference between post- and pre-period (%)		Relative difference between post- and 2nd-peri-period (%)	
2020	2010-2019	2020	2010-2019	2020	2010-2019
-43%	-44%	-48%	-52%	-32	-28

- 1. The NO2 columns didn't change much during the first lockdown period over the US, but decreased by 4% in relative difference with before-pendemic period during the second lockdown;
- 2. Significant declines can be observed over major road, industrial regions and transportation hubs;
- 3. The NO2 level bounced back in some decreasing areas.

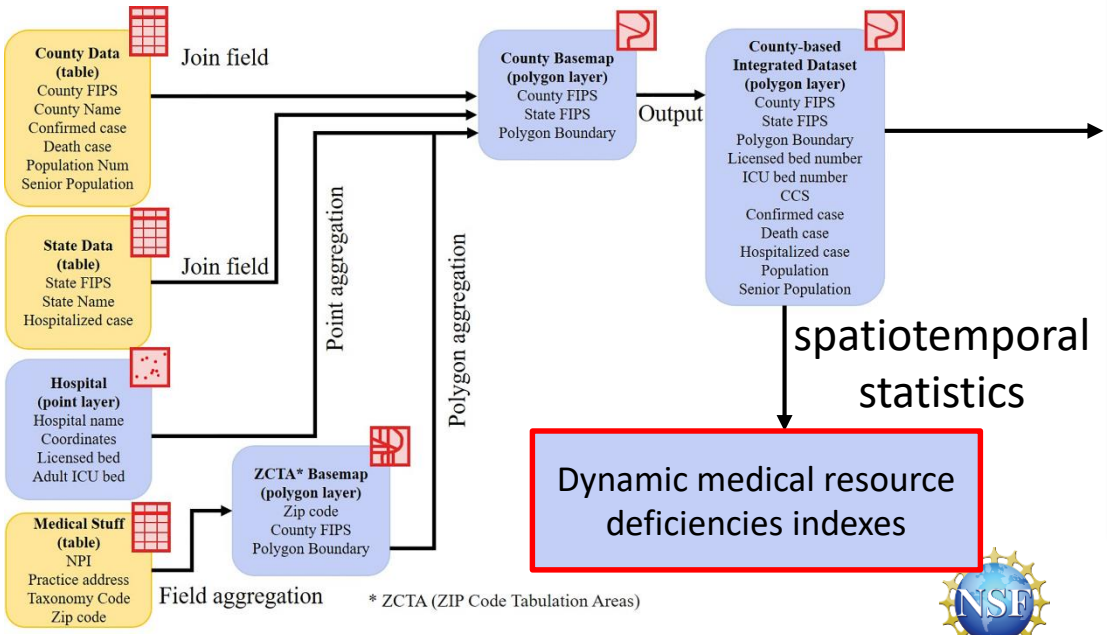


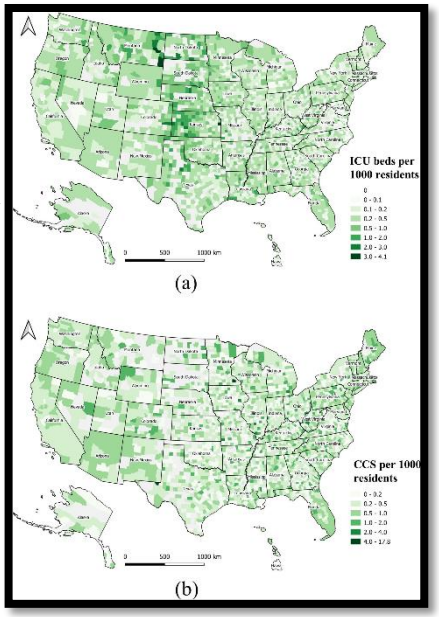
5. Do we have enough medical resources?

- Overview problem

Are U.S. medical resources enough to handle the worst scenario during this crisis?

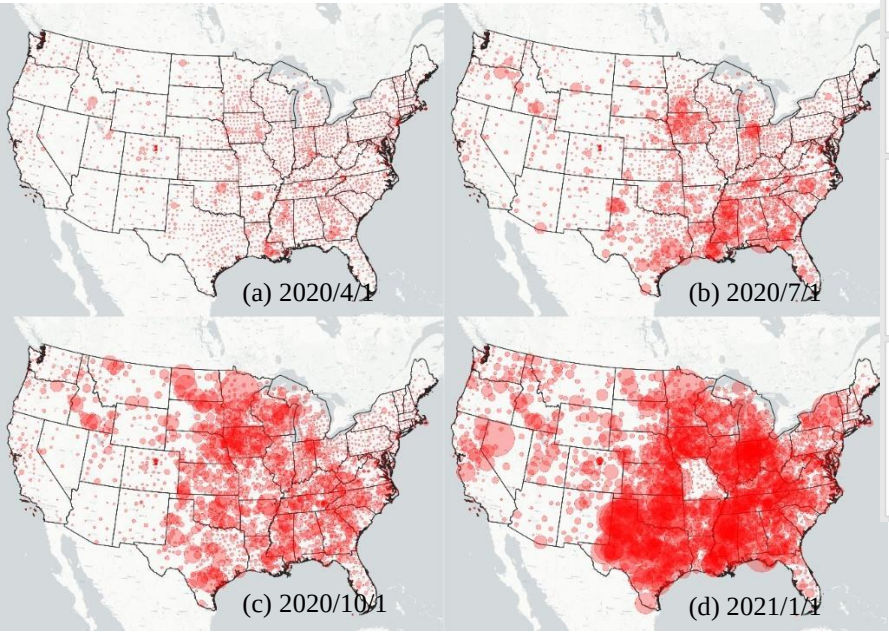
- Objectives
  1. evaluate the spatial distribution of medical resource features (hospital beds, ICU beds, and Critical Care Staff) at county level;
  2. measure the local medical burden by developing Medical Resource Deficiency Indices of COVID-19;
  3. visualize and analyze the dynamic trend of derived index.
- Workflow diagram

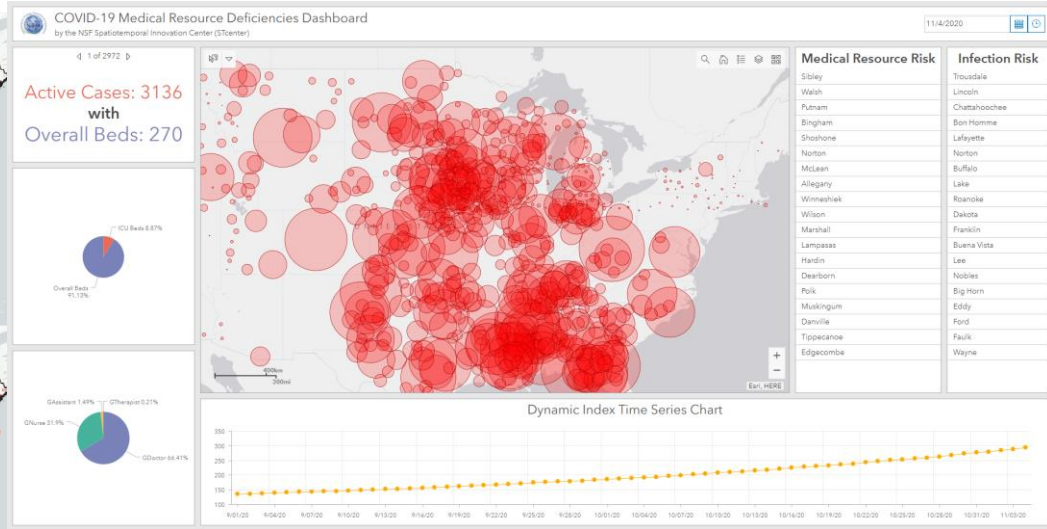




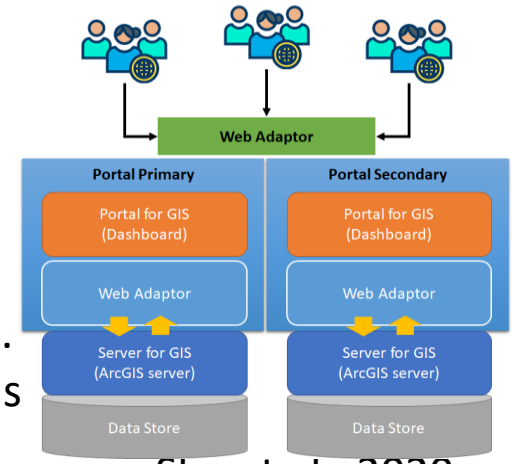
5. Do we have enough medical resources?

http://mrd-dashboard.stcenter.net





$$MRDI = \frac{N_c - N_{death}}{N_{licbed} \cdot N_{CCS}}$$



- The medical resource deficiency index is increasing in last half years.
- The spatial distribution of medical resources is highly heterogeneous across the U.S.

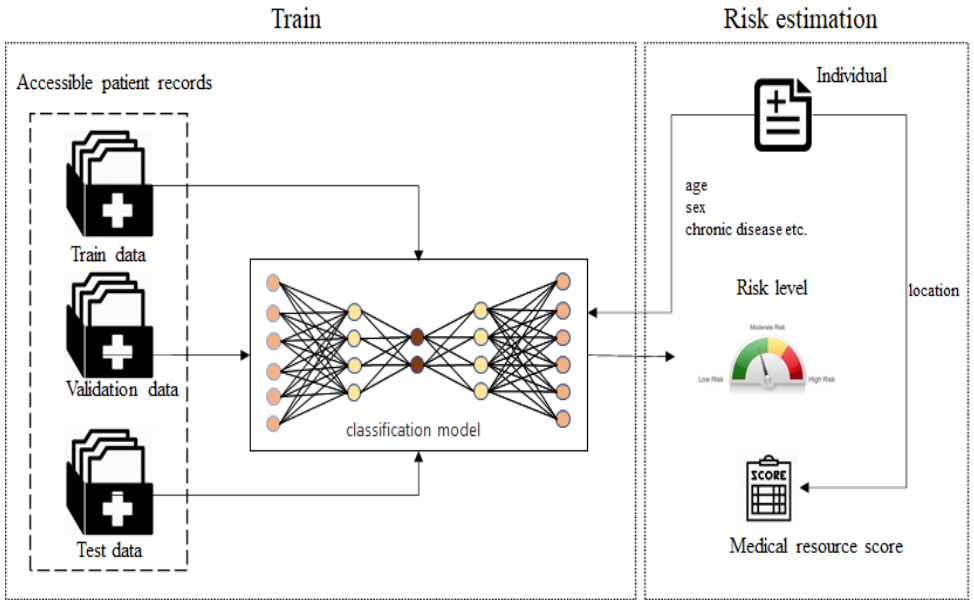
Spatiotemporal analysis of medical resource deficiencies in the U.S. under COVID-19 pandemic (plos.org)

Sha et al., 2020

https://www.stcenter.net/

6. How to determine the health risk?

- To help prioritize medical resources, such as vaccine and hospital space
- Adopting deep learning algorithms and spatiotemporal statistical information to predict health risk of individuals by using people's underlying health conditions, age, sex, chronic diseases and other factors.
- The risk adjusted calculator computed a score from socioeconomic status, county level infection and medical resource risks based on the person's location



System:
https://riskprediction.stcenter.net/index.php

Publication:
https://www.frontiersin.org/articles/10.3389/fpubh.2020.587937/full

https://www.stcenter.net/

7. Could we reopen campus?

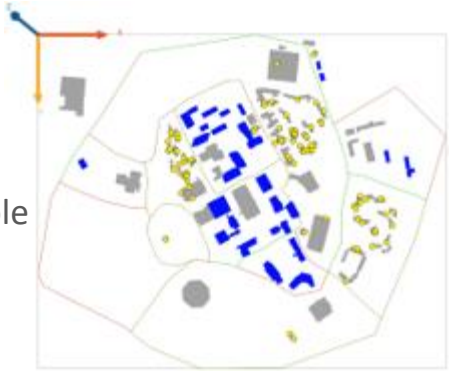
To support decision making of campus/schools reopening by evaluating and assessing multi-scenario reopen strategies based on traditional epidemiologic model integrated with agent-based simulation

1. Impact factors identification

Identify and collect possible factors that may affect on COVID-19 spreading on campus after reopening

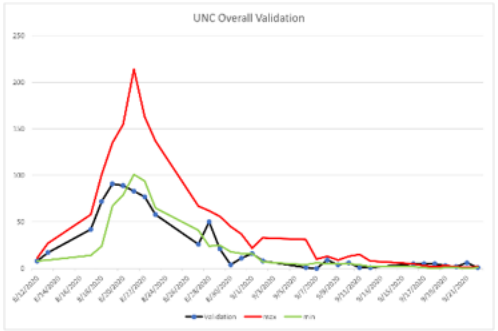
2. SEIR-ABM modeling

Traditional model integrated with ABM to simulate near-real scenario of campus activities. Predict possible COVID transmission.



3. Model Calibration & Validation

Calibrate model to reduce randomness and tune better parameter settings. Comparing predicted results with real confirmed cases record for accuracy assessment



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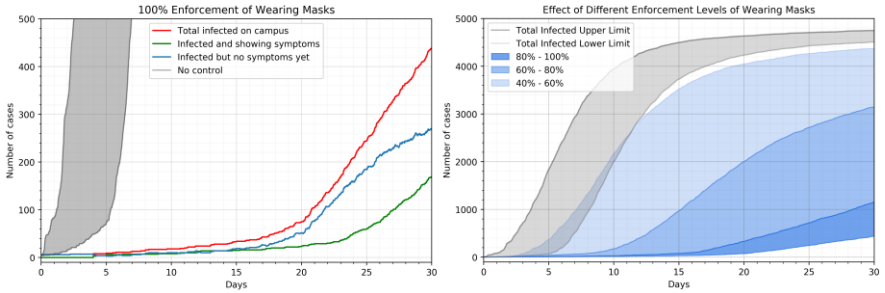
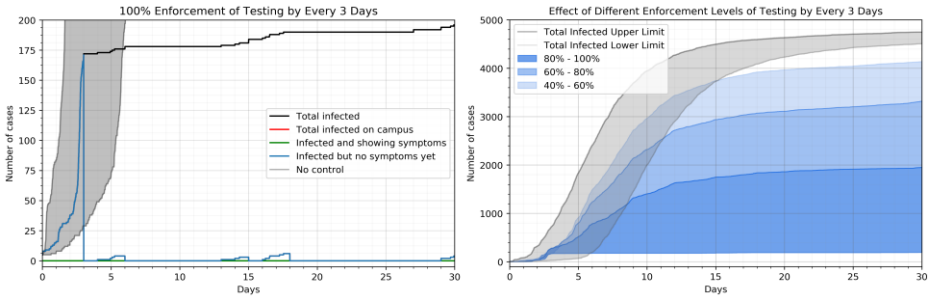
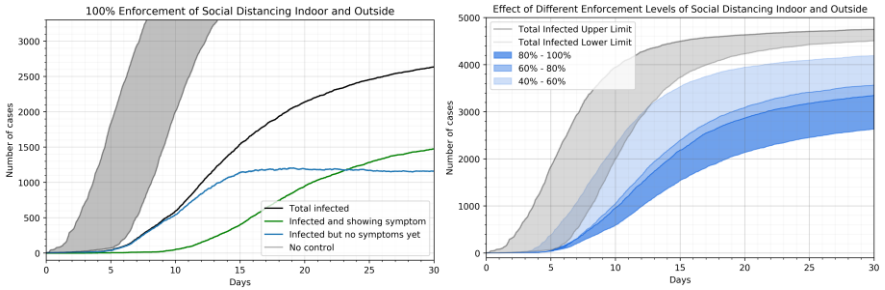
7. Controlling Results



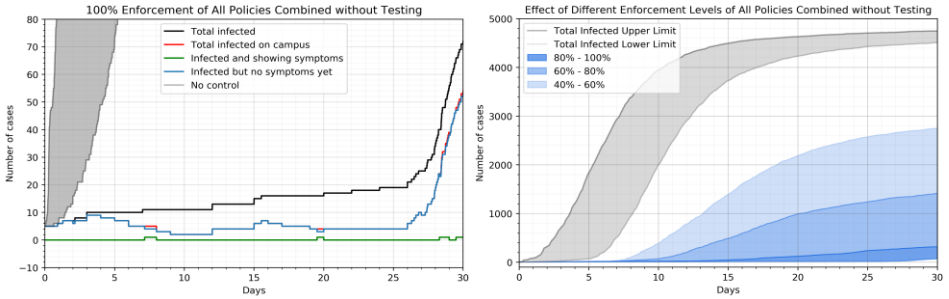
Masks Only



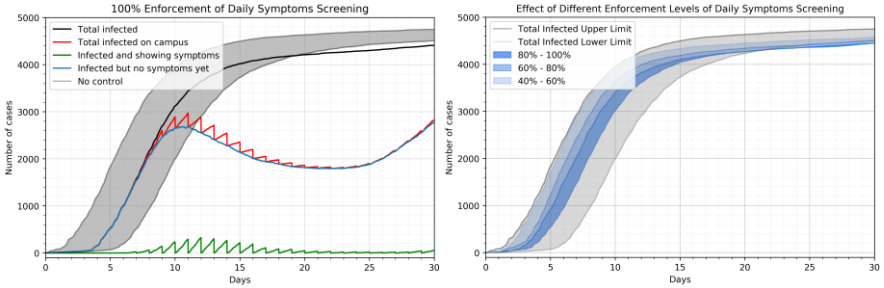
Viral Testing Only



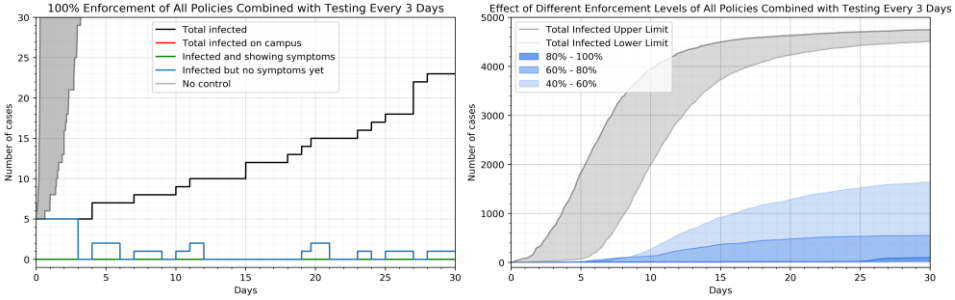
Social Distancing Only



All combined without testing



Symptoms Screening Only



All combined

System: https://smartgateway.stcenter.net/

https://www.stcenter.net/

8. Could I use the data and code for my research?

- What is available ?
  - Covid-19 global case data
    - Admin0-1
    - Confirmed, death, recovered
  - Covid-19 related research
    - CA - Air pollution
    - China - NTL AQI
  - Environmental data
    - Humidity
    - NO2
    - Precipitation
    - Temperature
  - Socioeconomic data
    - Dynamic data
      - GDP, Personal Income, policy, etc.
    - Static data
      - Population, poverty rate, etc.

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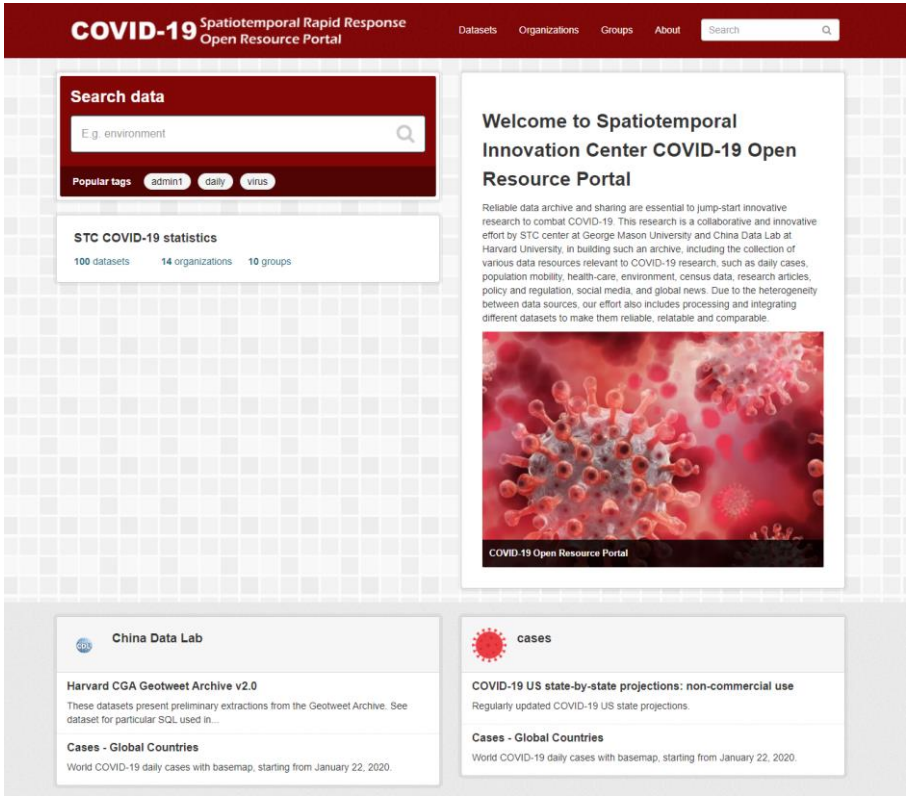
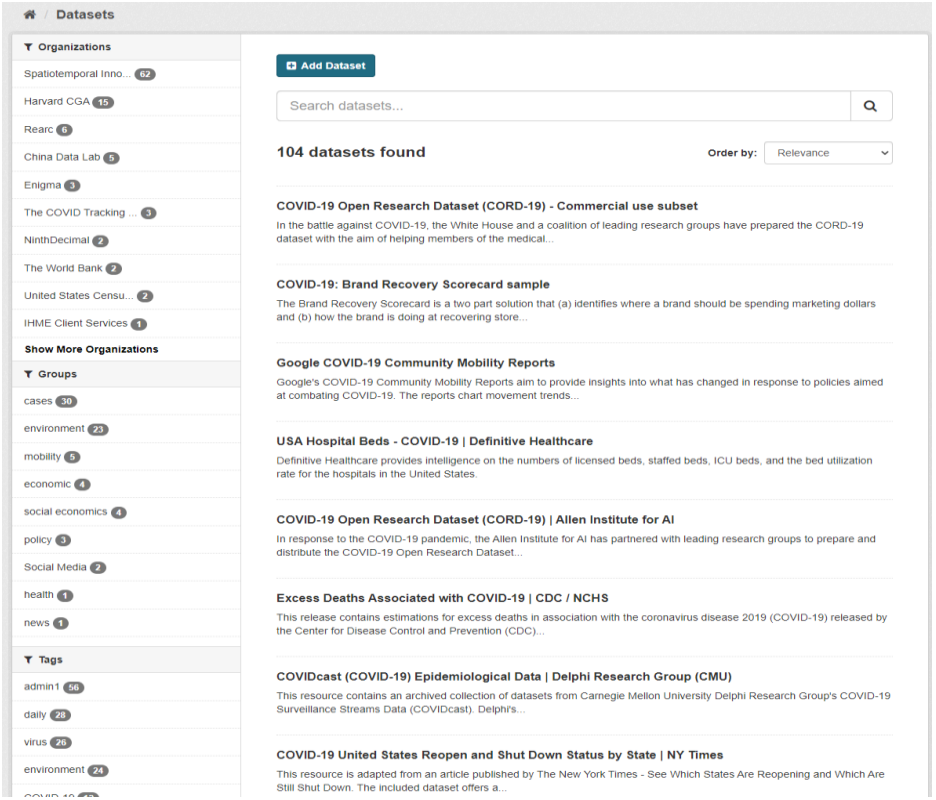
8. Open Source and Data Discovery Portal

https://covid19datadiscovery.stcenter.net/





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8. Open Data

https://github.com/stccenter/COVID-19-Data

master · 1 branch · 0 tags · Go to file · Add file · Code

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Albania	auto push at 2020-11-07 19:41:17	22 hours ago
Australia	auto push at 2020-11-07 19:41:17	22 hours ago
Austria	auto push at 2020-11-07 19:41:17	22 hours ago
Bolivia	auto push at 2020-07-30 22:23:24	3 months ago
Brazil	auto push at 2020-11-07 19:41:17	22 hours ago
Bulgaria	auto push at 2020-08-21 00:37:17	3 months ago
Canada	auto push at 2020-11-07 19:41:17	22 hours ago
Chile	auto push at 2020-11-07 19:41:17	22 hours ago
China	auto push at 2020-11-07 19:41:17	22 hours ago
Croatia	auto push at 2020-11-07 19:41:17	22 hours ago
Denmark	auto push at 2020-11-07 19:41:17	22 hours ago
El Salvador	auto push at 2020-08-21 00:37:17	3 months ago
Environmental factors	auto push at 2020-10-27 16:32:52	12 days ago
Germany	auto push at 2020-11-07 19:41:17	22 hours ago
Global	auto push at 2020-11-07 19:41:17	22 hours ago
Guatemala	auto push at 2020-08-15 00:45:13	3 months ago
Haiti	auto push at 2020-11-07 19:41:17	22 hours ago
Hungary	auto push at 2020-11-07 19:41:17	22 hours ago
India	auto push at 2020-11-07 19:41:17	22 hours ago
Italy	auto push at 2020-11-07 19:41:17	22 hours ago
Japan	auto push at 2020-11-07 19:41:17	22 hours ago
Latvia	auto push at 2020-11-07 19:41:17	22 hours ago
Mexico	auto push at 2020-11-07 19:41:17	22 hours ago
Nigeria	auto push at 2020-11-07 19:41:17	22 hours ago
Pakistan	auto push at 2020-11-07 19:41:17	22 hours ago
Policy/US_Policy	auto push at 2020-10-30 01:06:27	10 days ago
Romania	auto push at 2020-11-07 19:41:17	22 hours ago
Russia	auto push at 2020-11-07 19:41:17	22 hours ago

About

COVID-19 related virus data, environmental data and policy data

Readme

Releases

No releases published
Create a new release

Packages

No packages published
Publish your first package

Contributors 2

Leontian36
quintinali

Environments 1

github-pages Active

Languages

Python 100.0%

Legend for data source and operation status

source data source · source validaiton source · status passing · status pause

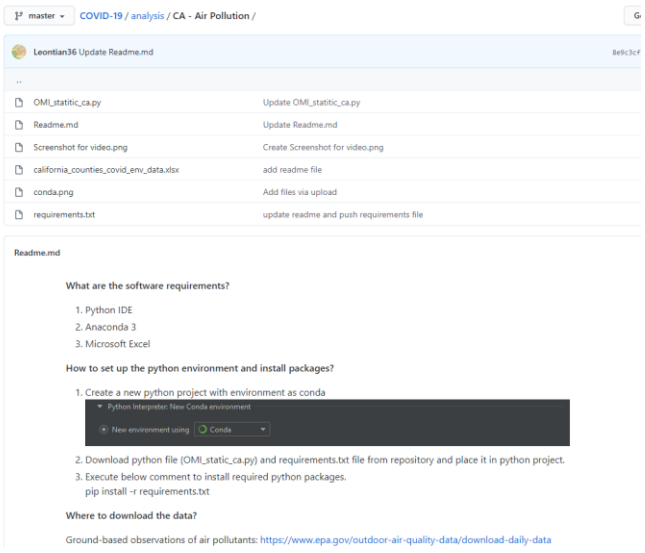
Country / Region	Continent	Admin level	Data Source	Temporal Coverage	Operation Status
Global	Global	0	source Johns Hopkins CSSE; source WHO	2020/1/22 to current	status passing
United States	North America	1 , 2	source Johns Hopkins CSSE; source USAFACTS; source CDC.gov	admin0: 2020/1/22 to current, admin1: 2020/1/27 to current	status passing
China	Asia	1 , 2	source Ding Xiang Yuan; source NHC	admin0: 2020/1/22 to current, admin1: 2020/1/24 to current	status passing
Canada	North America	1	source Johns Hopkins CSSE; source canada.ca	2020/1/26 to current	status passing
Australia	Oceania	1	source Johns Hopkins CSSE; source health.gov.au	2020/1/27 to current	status passing
Italy	Europe	1 , 2	source protezionecivile.it; source worldometers	2020/2/24 to current	status passing
Germany	Europe	1	source covid19-eu-data; source rki.de	2020/2/29 to current	status passing
Austria	Europe	1	source sozialministerium.at; source sozialministerium.at	2020/3/4 to current	status passing
Brazil	South America	1	source covid.saude.gov.br; source covid.saude.gov.br	2020/2/26 to current	status passing
Chile	South America	1	source Covid-19 Latinoamérica; source minsal.cl	2020/3/2 to current	status passing
Japan	Asia	1	source covid-2019.live; source stopcovid.jp	2020/1/15 to current	status passing
Russia	Europe	1	source yandex.ru; source стопкоронавирус.рф	2020/3/22 to current	status passing
South Africa	Africa	1	source NICD; source health.gov.za; source statssa.gov.za	2020/3/5 to current	status passing
Croatia	Europe	1	source koronavirus.hr; source koronavirus.hr	2020/3/21 to current	status passing
Sweden	Europe	1	source folkhalsomyndigheten.se; source Folkhalsomyndigheten	2020/3/16 to current	status passing
India	Asia	1	source api.rootnet.in/; source mohfw.gov.in/	2020/3/10 to current	status passing
Hungary	Europe	1	source koronavirus.gov.hu/; source koronavirus.gov.hu/	2020/3/31 to current	status passing

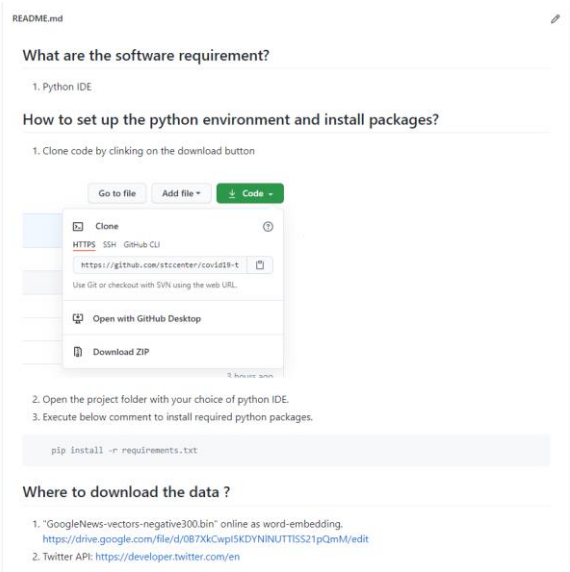
https://www.stcenter.net/

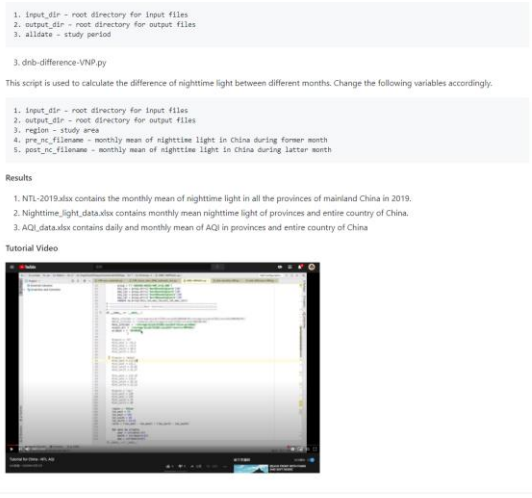
8. Open Source Code

https://github.com/stccenter/COVID-19/tree/master/analysis/CA%20-%20Air%20Pollution

How to duplicate the research?



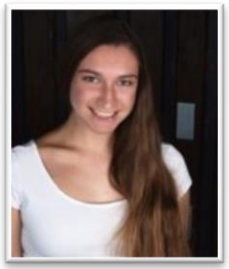




9. Engaging STEM Undergraduates

Jackson T. Harris
Dartmouth College
Cloud Classification/ AQ Impact
Co-Author of Data and STOTEN paper

Nadine Meister
Harvard University
COVID-19 ABM campus reopening simulation

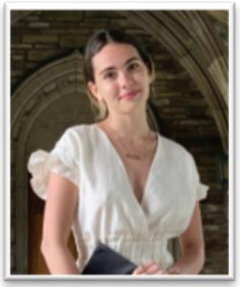


Melanie Alfonzo
Johns Hopkins University
Fatality Prediction & Social Media Analytics

Megan A. Rice
Carnegie Mellon
COVID-19 variable correlation

Samantha Carr
McGill University
GPU-based multi-million level Analytics

Erin Abbott
University of Chicago
Spatiotemporal Patterns Analytics



Sophia O'Neill
Cornell University
COVID-19 data clean/ ArcCI prototype design

Oliver Chartock
Dartmouth College
Computing Infrastructure/ COVID-19 Visualization

Alma Topete
UCSB
Data Search, Collection, & Twitter Data Analyses

9. Global Engagement in Collaboration with CVT

https://www.stcenter.net/

Lucas Chu
Harvard University
CVT Founder

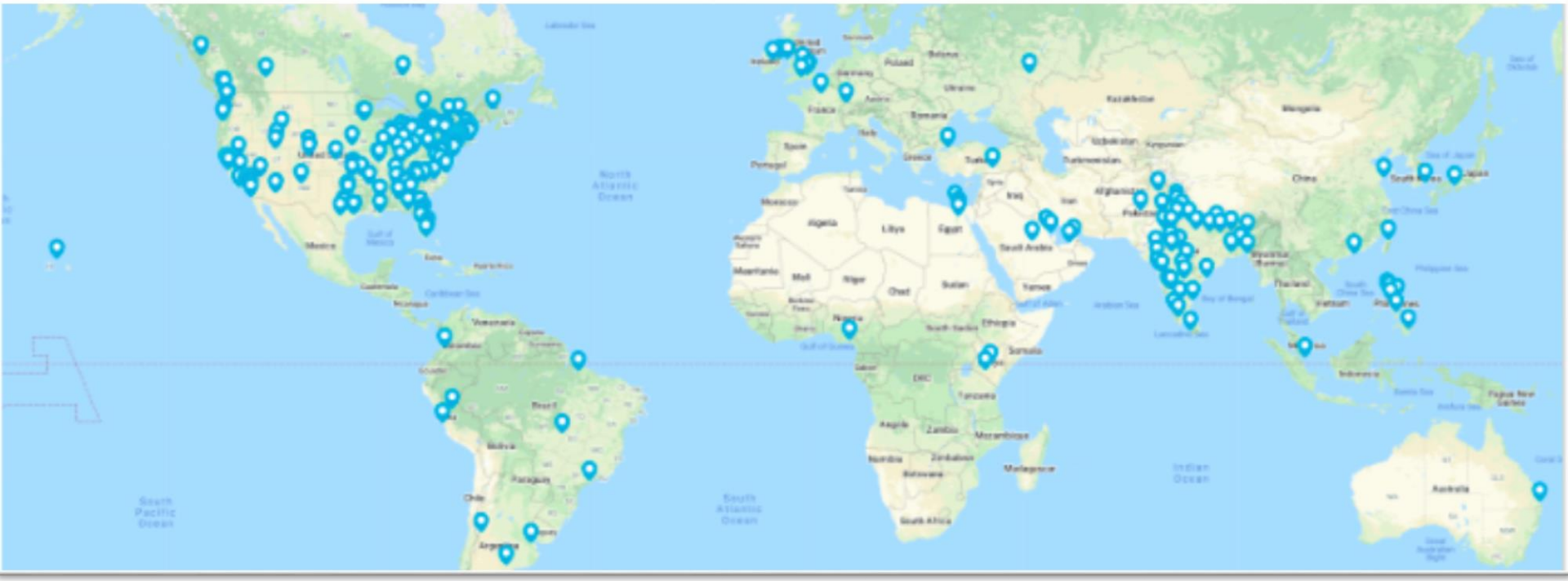
Scott Blender
Temple University
Social Media Data Viz

Viraj Kacker
Georgia Institute of Technology
Global News Analysis

Regina Liu
Mercer University
Literature Review

Kelly Ly
University of MA Lowell
Media Data Analysis

Akhil Kumar
Turner Fenton Secondary School
Data Visualization



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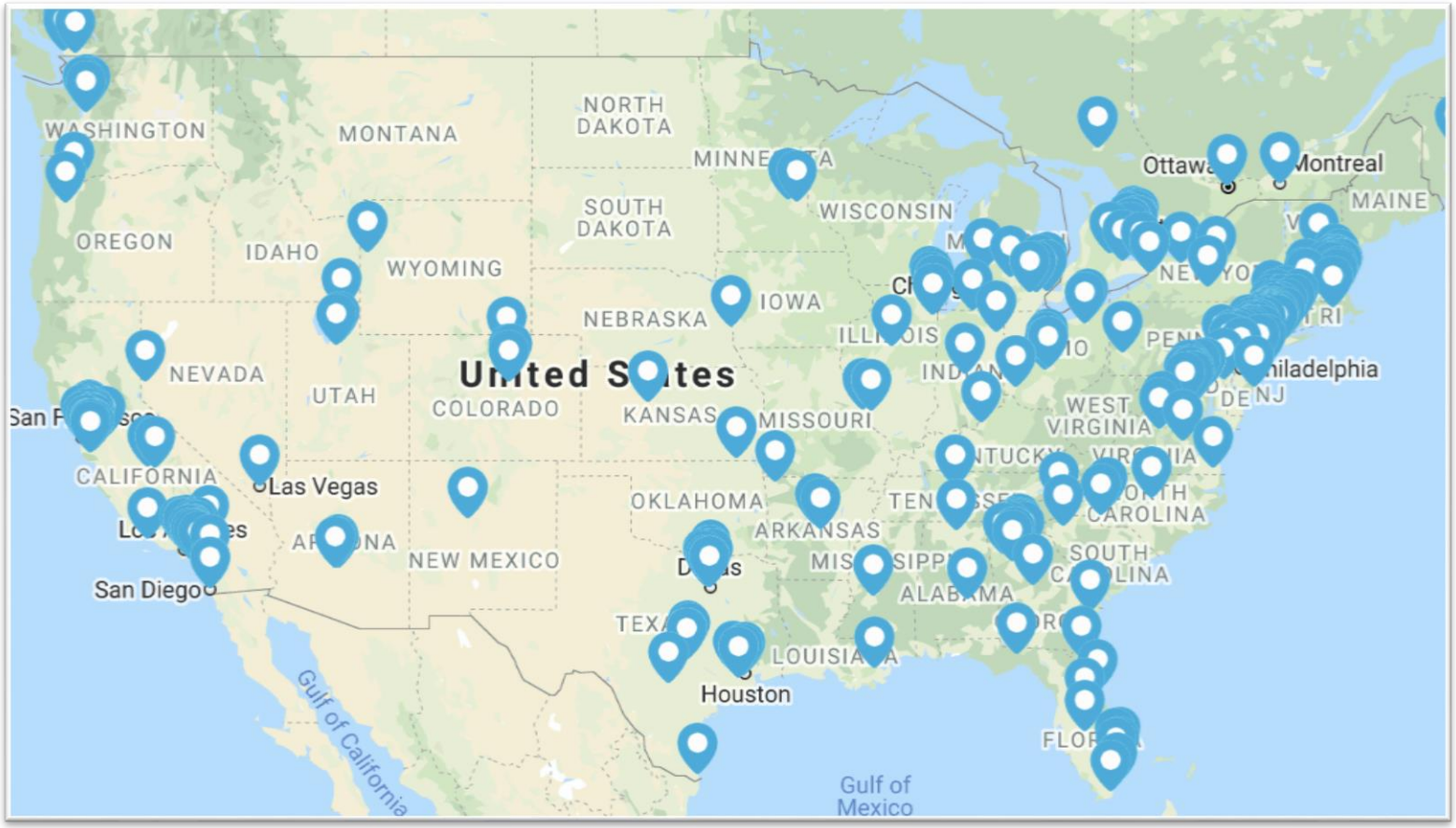
9. US Members in CVT



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10. Next Steps

- How the vaccine is helping control the spreading?
- What other data are needed to reveal the spatiotemporal evolution patterns?
- What new spatiotemporal tools are needed?
- How COVID-19 impact regional climate and how climate change may trigger future public health disasters?
- What are the economic and social resilience indications in both short-term and long-term perspective?
- How will COVID-19 shape the future of emergency surveillance systems?
- Etc.

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- We give our special thanks to our NSF program project directors, Rita Rodriguez, Dmitri Perkins, Behrooz Shirazi, our evaluators Donald Price & David Meyer, IAB chairs Lynn Usery and Myra Bambacus (past chairs), and Daniel Duffy
- All our partners

Thank you!

Questions?

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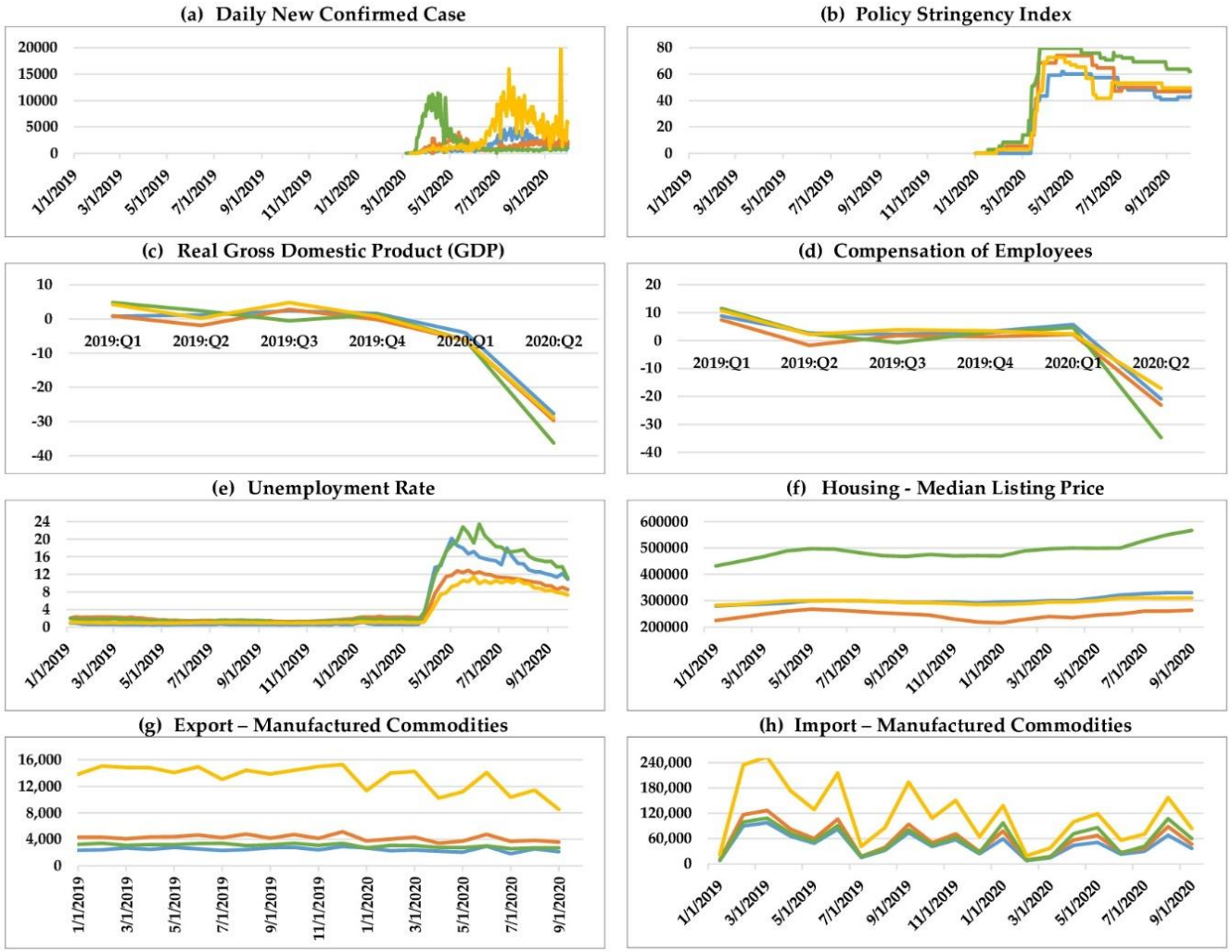
The economy



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https://www.mdpi.com/2306-5729/5/4/118