Spatiotemporal Patterns and Simulations for Fighting COVID-19

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

Chaowei Yang

Dexuan Sha, Hai Lan, Qian Liu, Yun Li, Zifu Wang, Fayez Beani, Kyla Carte, Yifei Tian, Joy Zhou, and a ~60 expert task force, as well as 200+ Harvard CVT members in every time zone

NSF Spatiotemporal Innovation Center

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Fairfax, VA, 22030-4444

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Outline

1. The Covid-19 Dilemma and Challenges
2. How is the Pandemic spreading?
3. Can climate control infection speed?
4. Is the Pandemic biased?
5. Are policy and administrative measures working?
6. Do we have enough medical resources?
7. Are we ready to reopen?
8. Could we have an in-person Fall semester?
9. Geospatial needs towards a solution

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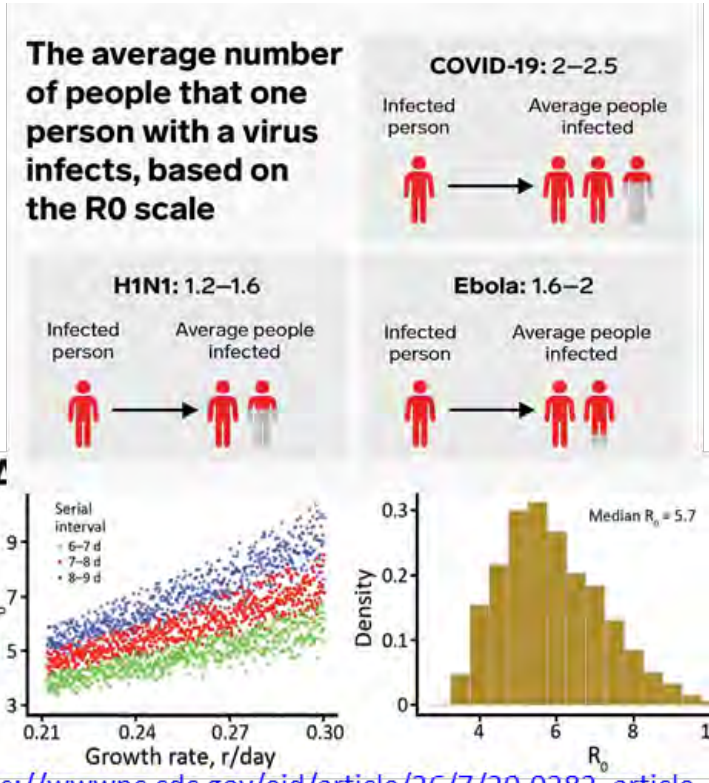
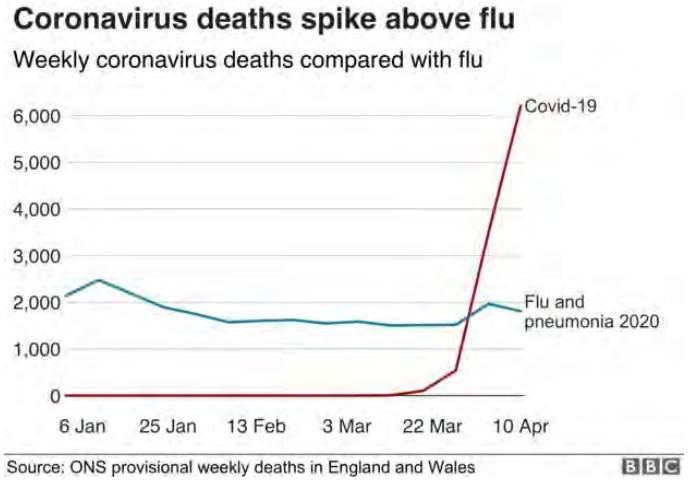
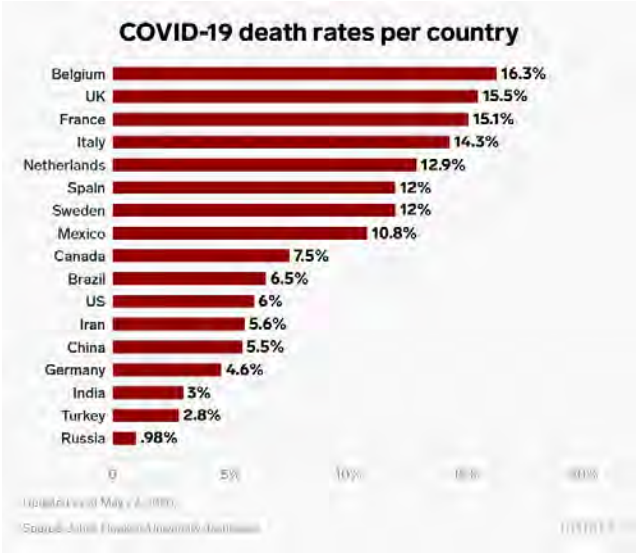
COVID-19 Dilemma and Challenges



https://wwwnc.cdc.gov/eid/article/26/7/20-0282_article



https://www.bbc.com/news/health-52361519



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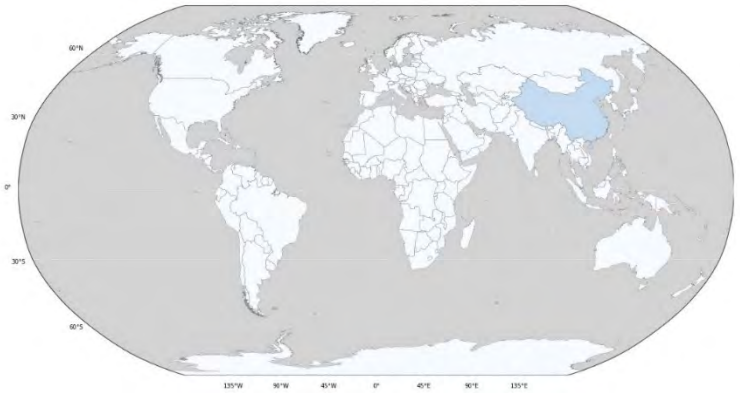
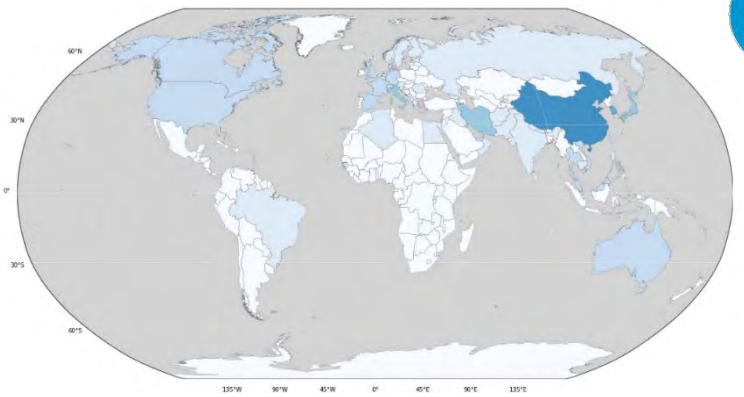
How was the Pandemic spreading?

01/17/2020



02/27/2020



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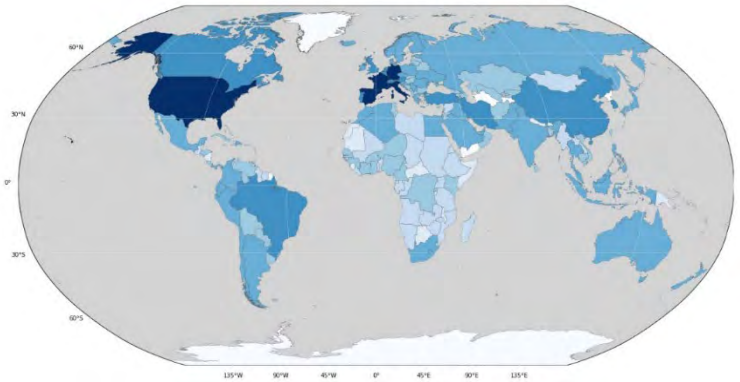
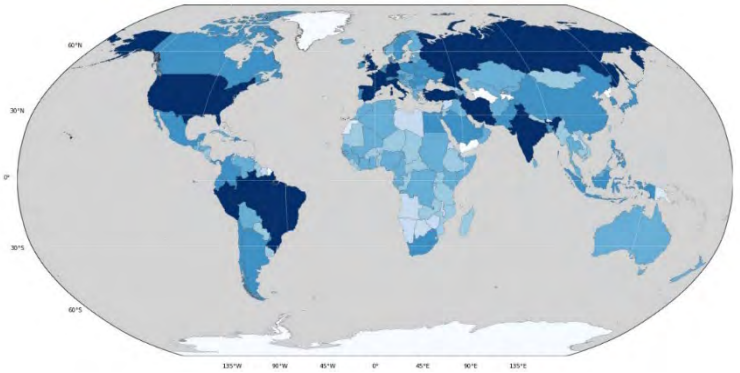
04/07/2020



05/23/2020

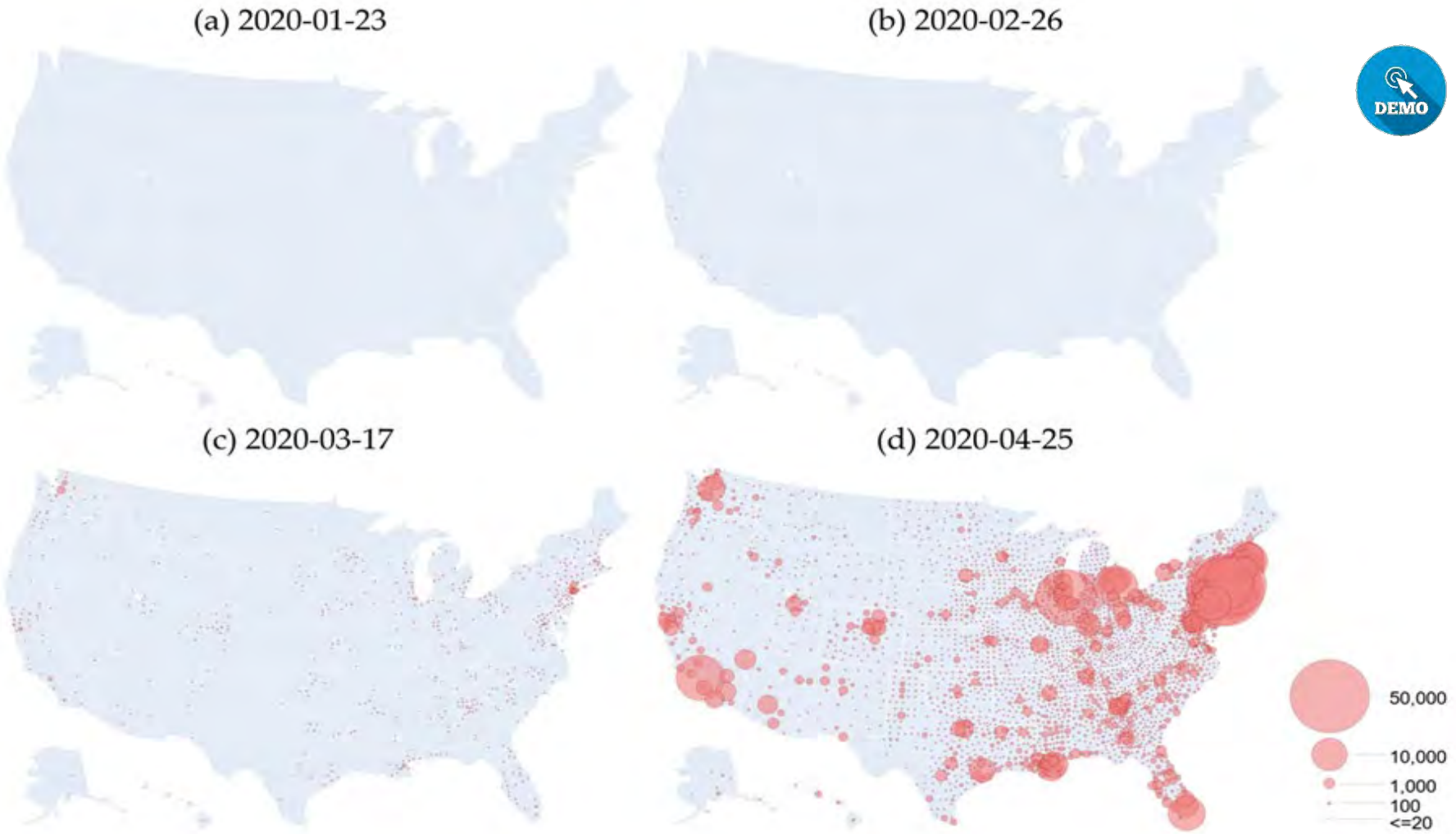


Data Source: https://github.com/stccenter/COVID-19-Data/tree/master/Global

Yang et al., 2020; Sha et al., 2020

https://www.stcenter.net/

How was the Pandemic spreading?



DEMO

Data Source: https://github.com/stccenter/COVID-19-Data/tree/master/Global

Yang et al., 2020; Sha et al., 2020

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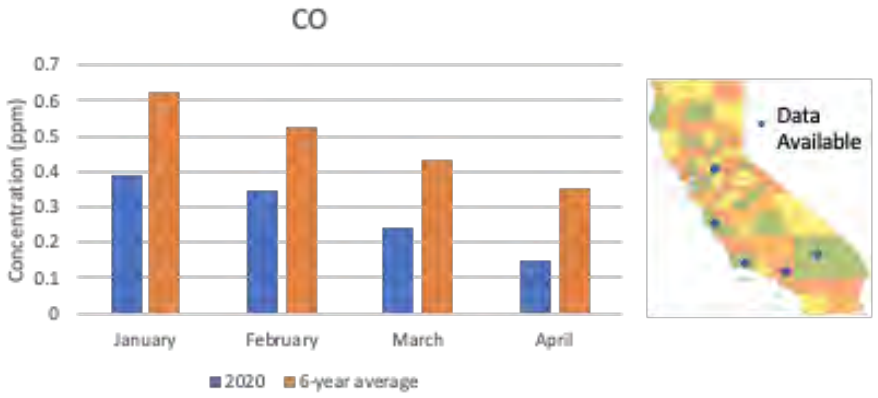
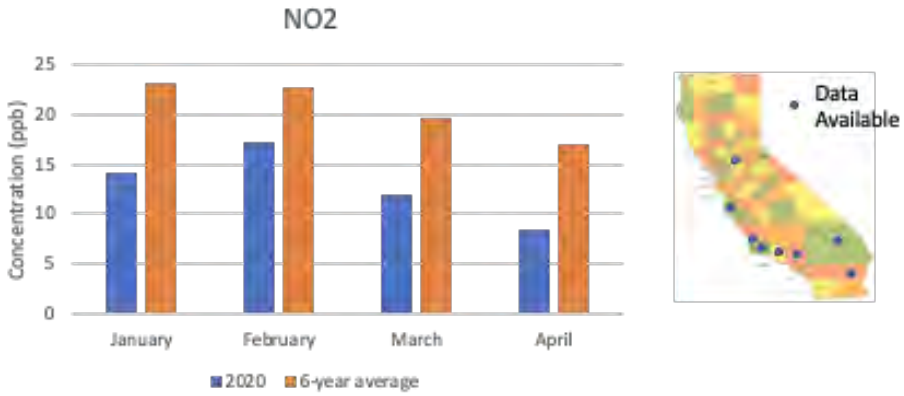
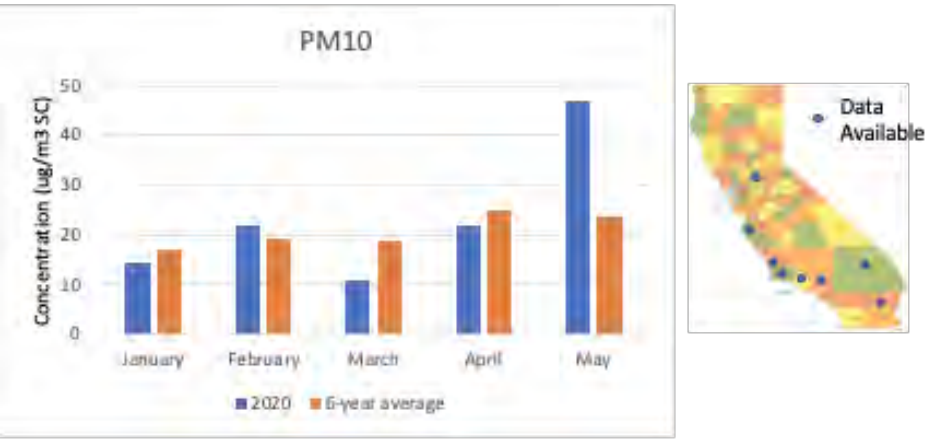
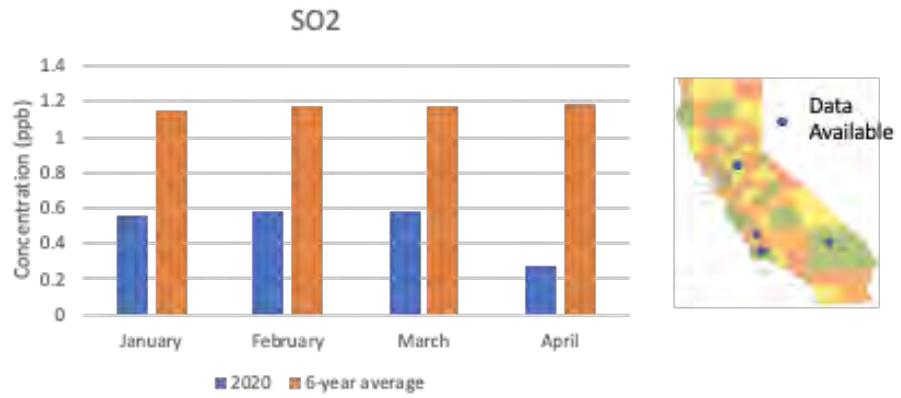
How has the air quality changed?



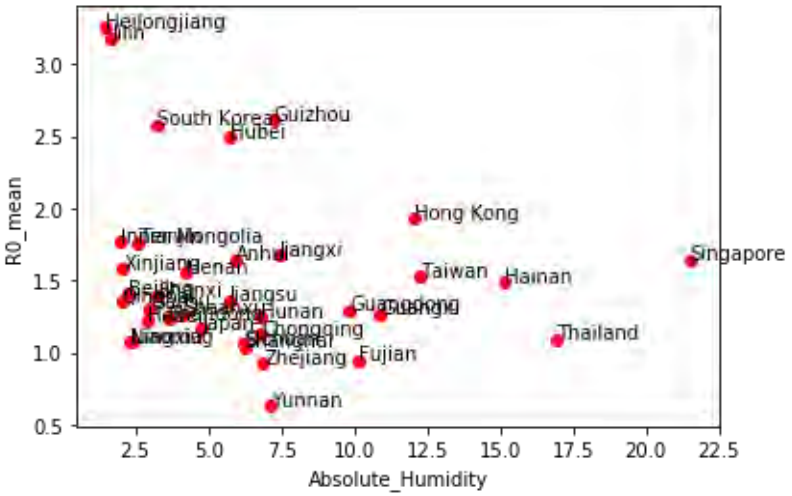


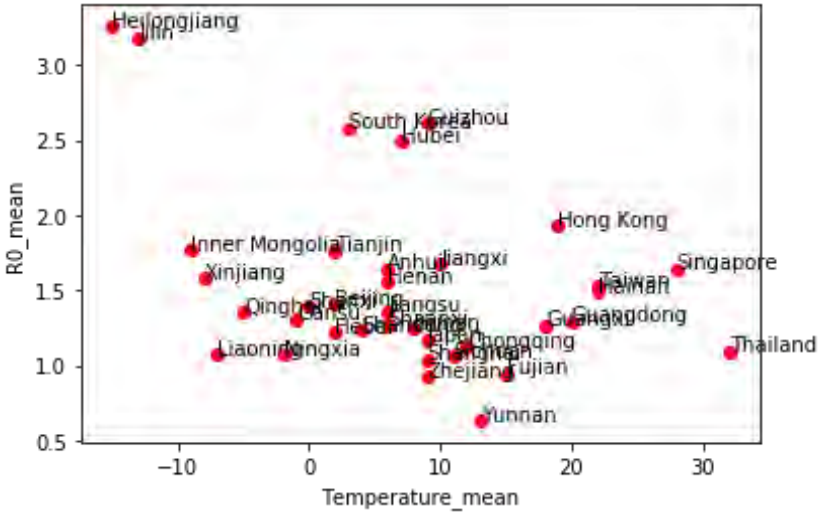


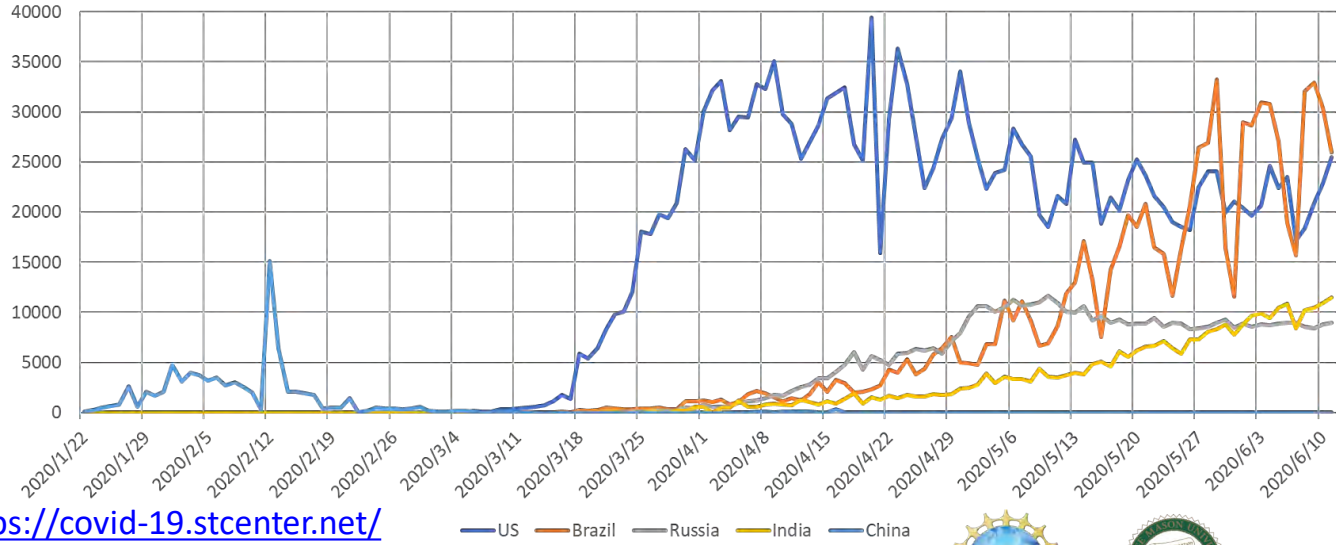


Liu et al., 2020

Could climate control the spreading?





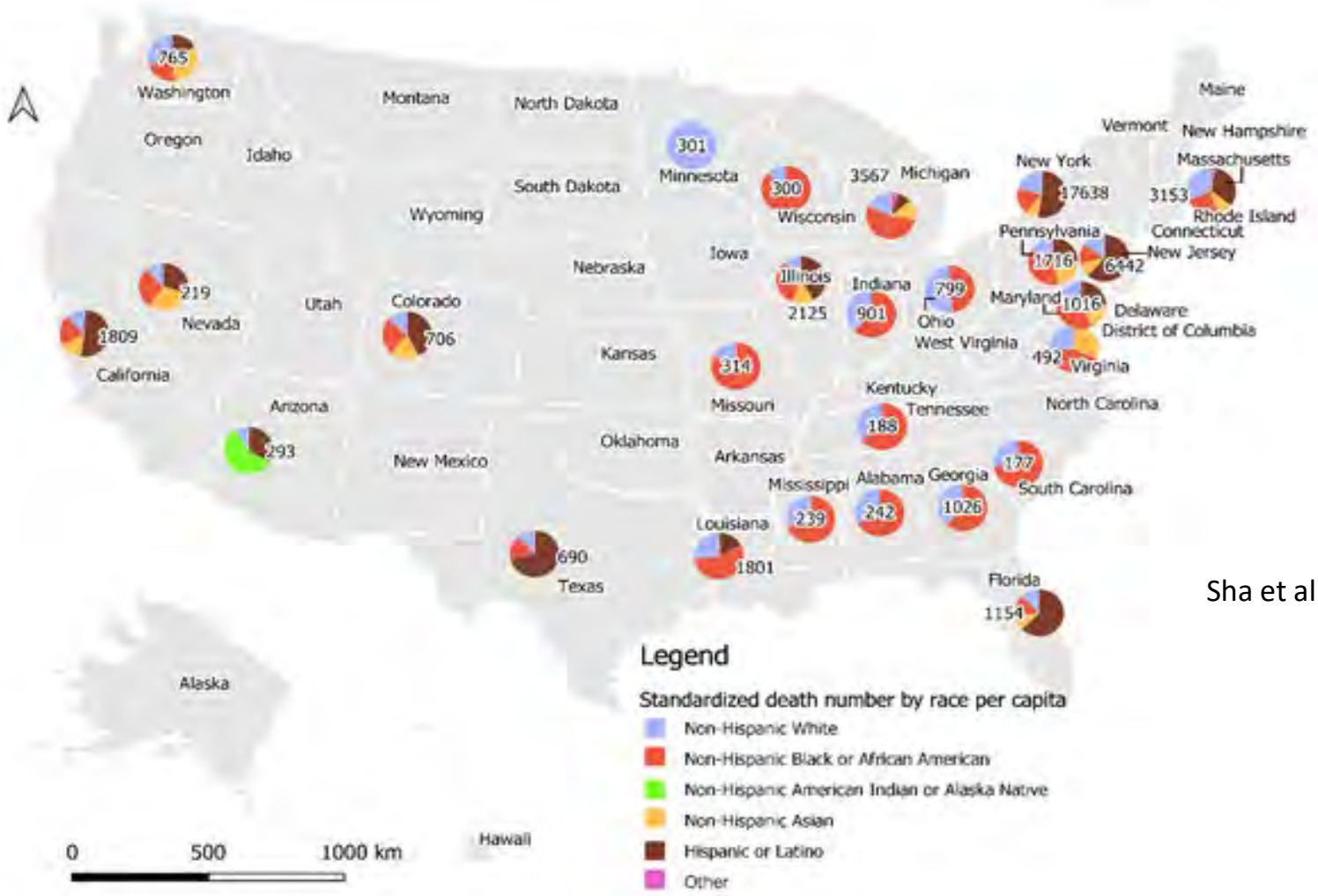


Data Source: https://covid-19.stcenter.net/

Yang et al., 2020; Sha et al., 2020

https://www.stcenter.net/

Is the Pandemic Biased?

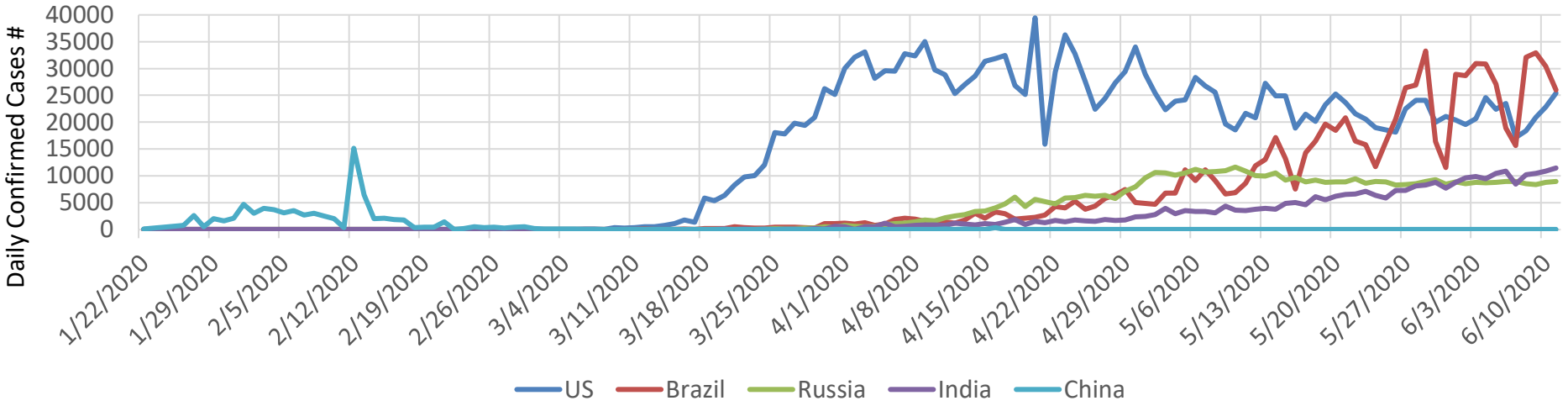


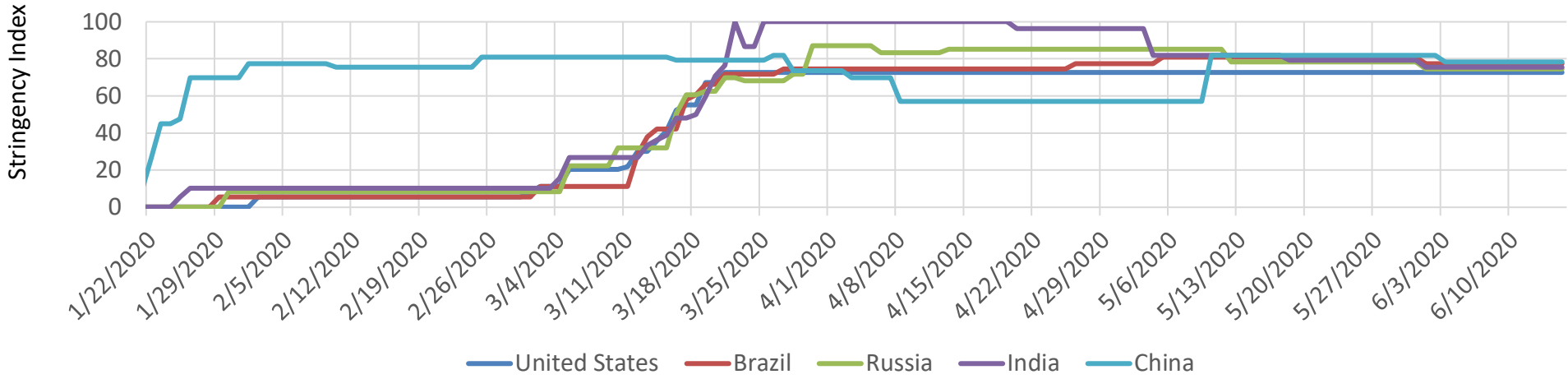
Sha et al., 2020

Sha et al., 2020

https://www.stcenter.net/

Did the policy help and is it safe to reopen?





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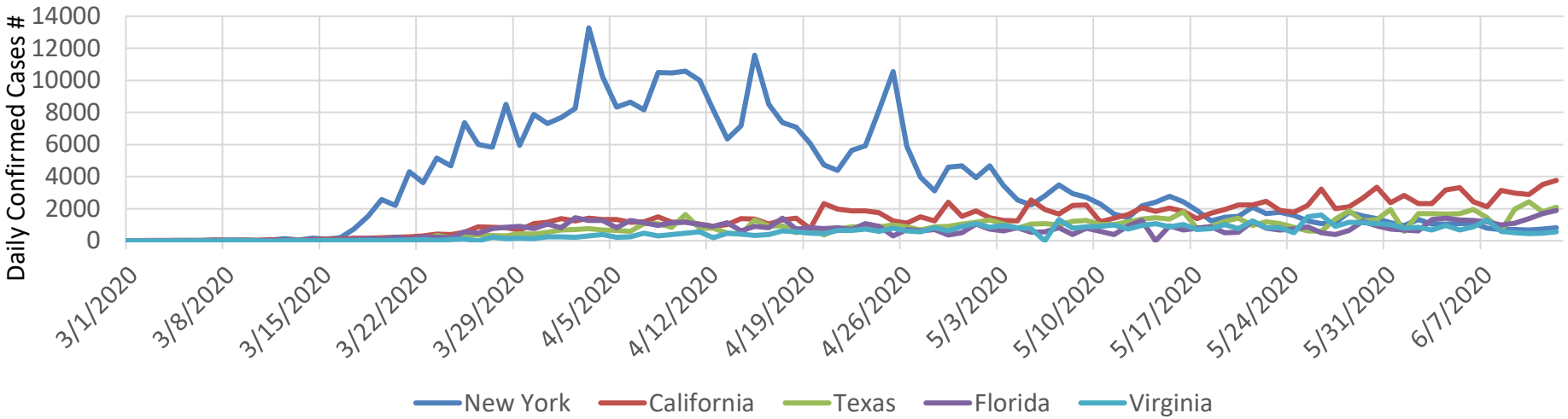

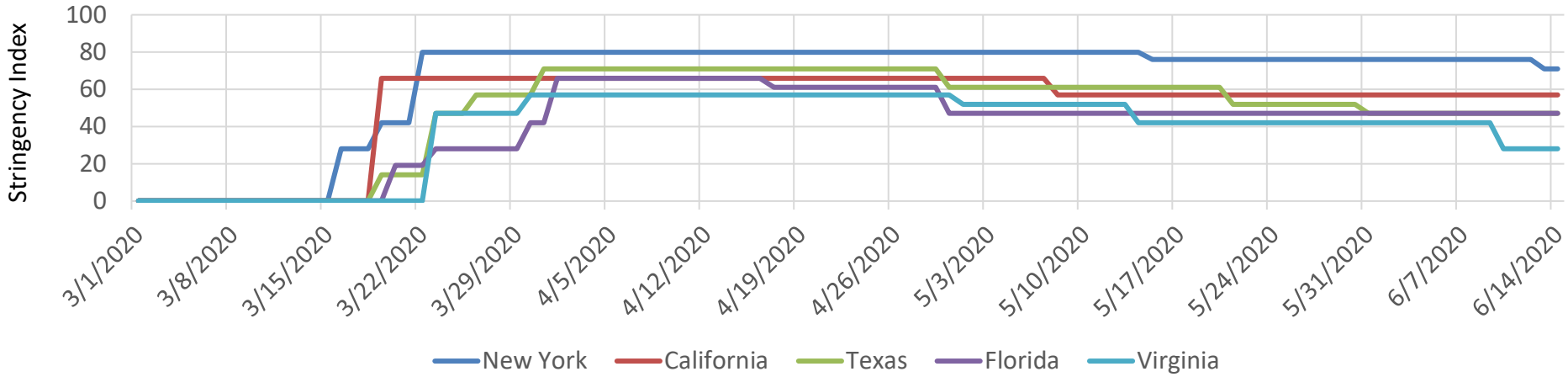

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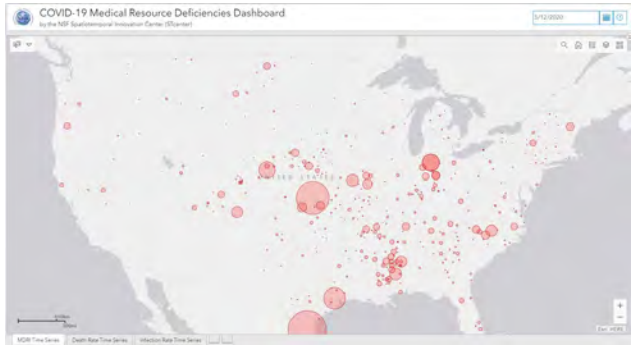
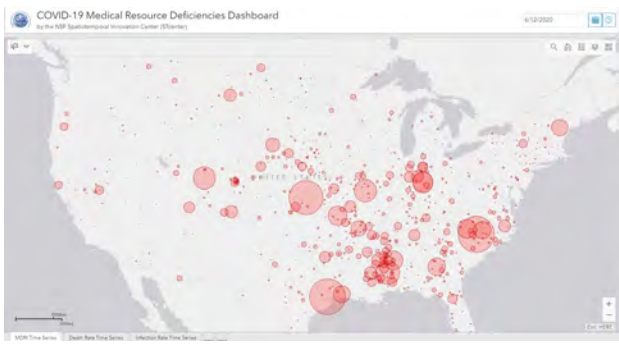
Do we have enough medical resources?

(a) April 12, 2020

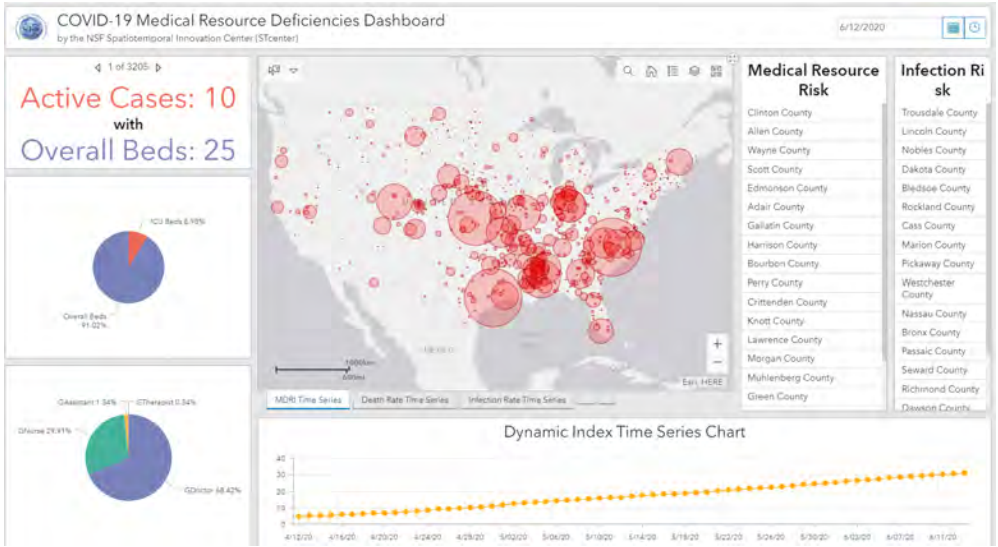


(b) May 12, 2020



(c) June 12, 2020

General MRDI trend.



http://mrd-dashboard.stcenter.net/ Spatiotemporal Dashboards

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

Sha et al., 2020

Could we have an in-person Fall semester?

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Could we have in-person Fall classes?

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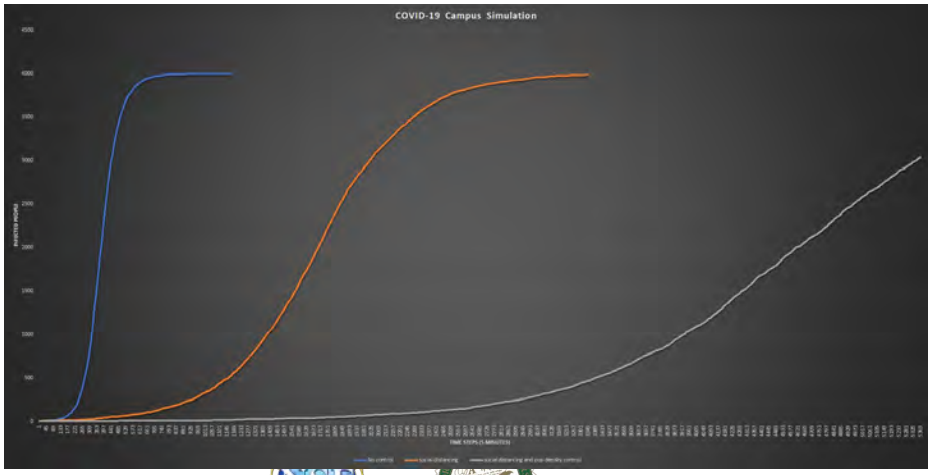
Scenario 1 Infection Curve (free)

Scenario 2 Infection Curve (6 ft)

Scenario 3 Infection Curve (6ft &36 ft^2)



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Geospatial CI Needs

1. **Transparency**: A community/person reachable mechanism
2. **Quality**: A reliable global distributed data collection and validation physical/social system
3. **Mindset**: Geographical and spatiotemporal thinking and scientific & factual-based reasoning
4. **Cross-domain**: An interdisciplinary integration/fusion framework
5. **Diversity**: A diversity workforce cross all time zones, gender, races, and culture backgrounds
6. **Collaborative**: A collaborative spirit cross domains, states, countries, etc.

https://www.stcenter.net/

References

1. Yang, C., Sha, D., Liu, Q., Li, Y., Lan, H., Guan, W.W., Hu, T., Li, Z., Zhang, Z., Thompson, J.H. and Wang, Z., etc. 2020. Taking the pulse of COVID-19: A spatiotemporal perspective. arXiv preprint arXiv:2005.04224.
2. Liu, Q., Sha, D., Liu, W., Houser, P., Zhang, L., Hou, R., Lan, H., Flynn, C., Lu, M., Hu, T. and Yang, C., 2020. Spatiotemporal Patterns of COVID-19 Impact on Human Activities and Environment in Mainland China Using Nighttime Light and Air Quality Data. Remote Sensing, 12(10), p.1576.
3. Sha, D., Miao, X., Lan, H., Stewart, K., Ruan, S., Tian, Y., Tian, Y., Yang, C., 2020. Spatiotemporal Analysis of Medical Resource Deficiencies in the U.S. under COVID-19 Pandemic. DOI: 10.13140/RG.2.2.20238.38721
4. Hu, T., Guan, W.W., Zhu, X., Shao, Y., Liu, L., Du, J., Liu, H., Zhou, H., Wang, J., She, B. and Zhang, L., 2020. Building an Open Resources Repository for COVID-19 Research.
5. Yang, C.; Clarke, K.; Shekhar, S.; Tao, C.V. Big Spatiotemporal Data Analytics: a research and innovation frontier. Taylor & Francis: 2019.
6. Yang, C.; Huang, Q.; Li, Z.; Liu, K.; Hu, F. Big Data and cloud computing: innovation opportunities and challenges. International Journal of Digital Earth 2017, 10, 13-53.
7. Yu, M.; Bambacus, M.; Cervone, G.; Clarke, K.; Duffy, D.; Huang, Q.; Li, J.; Li, W.; Li, Z.; Liu, Q. Spatiotemporal event detection: a review. International Journal of Digital Earth 2020, 1-27.
8. Yang, C.; Wu, H.; Huang, Q.; Li, Z.; Li, J. Using spatial principles to optimize distributed computing for enabling the physical science discoveries. Proceedings of the National Academy of Sciences 2011, 108, 5498-5503.

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Acknowledgements

- NSF I/UCRC Rapid Response Projects
- Jianjun Xu and Kyle Hawkins from Amazon Cloud Team
- Wendy Guan and Tao Hu from Harvard, Shuming Bao from CDI.
- Our current and past members provides foundational support, NASA Goddard, NCCS, USGS, NASG, NGCC, Harris, Northrop Grumman, Microsoft, USDA, NOAA, UN, State Dept., Eastview Geospatial, OminiSci, RMDS Inc., CDI and the institutional support from GMU, Harvard, UCSB.
- 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 (past chair) and Myra Bambacus, and Daniel Duffy
- All our partners

Thank you!

Questions?

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Backup Slides

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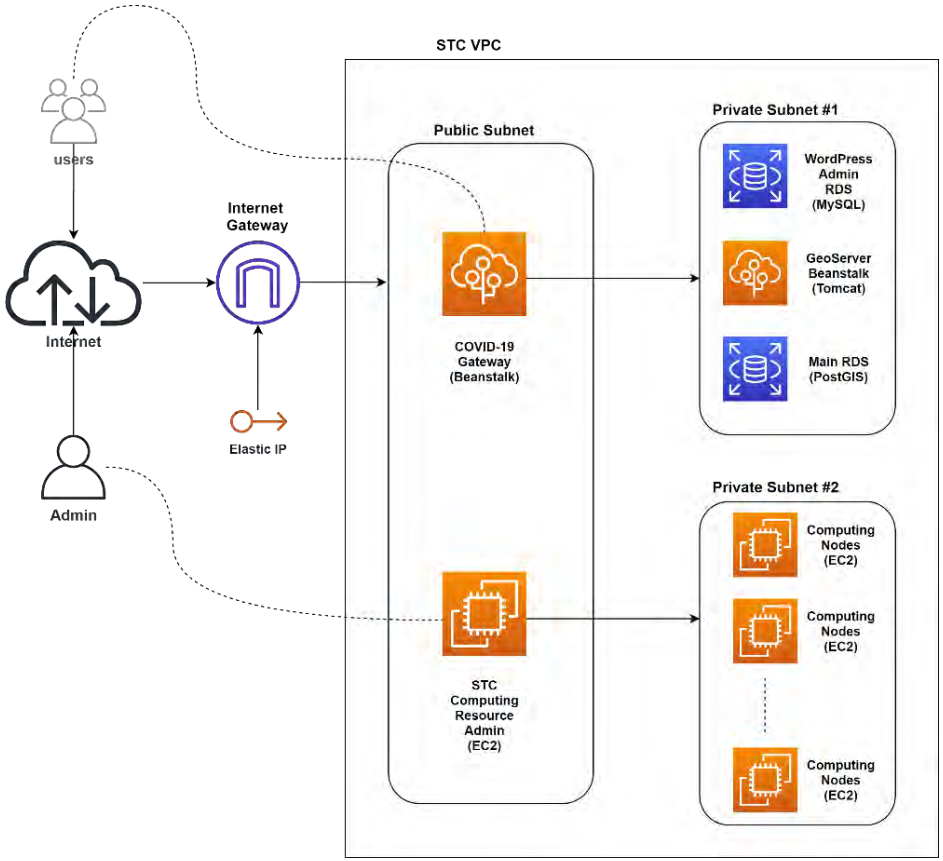
High Available Amazon Cloud Zones

- Gateway based on Beanstalk and RDS on Amazon Cloud
- Elastic computing for supporting computing intensive research, such as Earth and in-situ observations
- Big Data storage and processing using **HDFS and YARN** could environment



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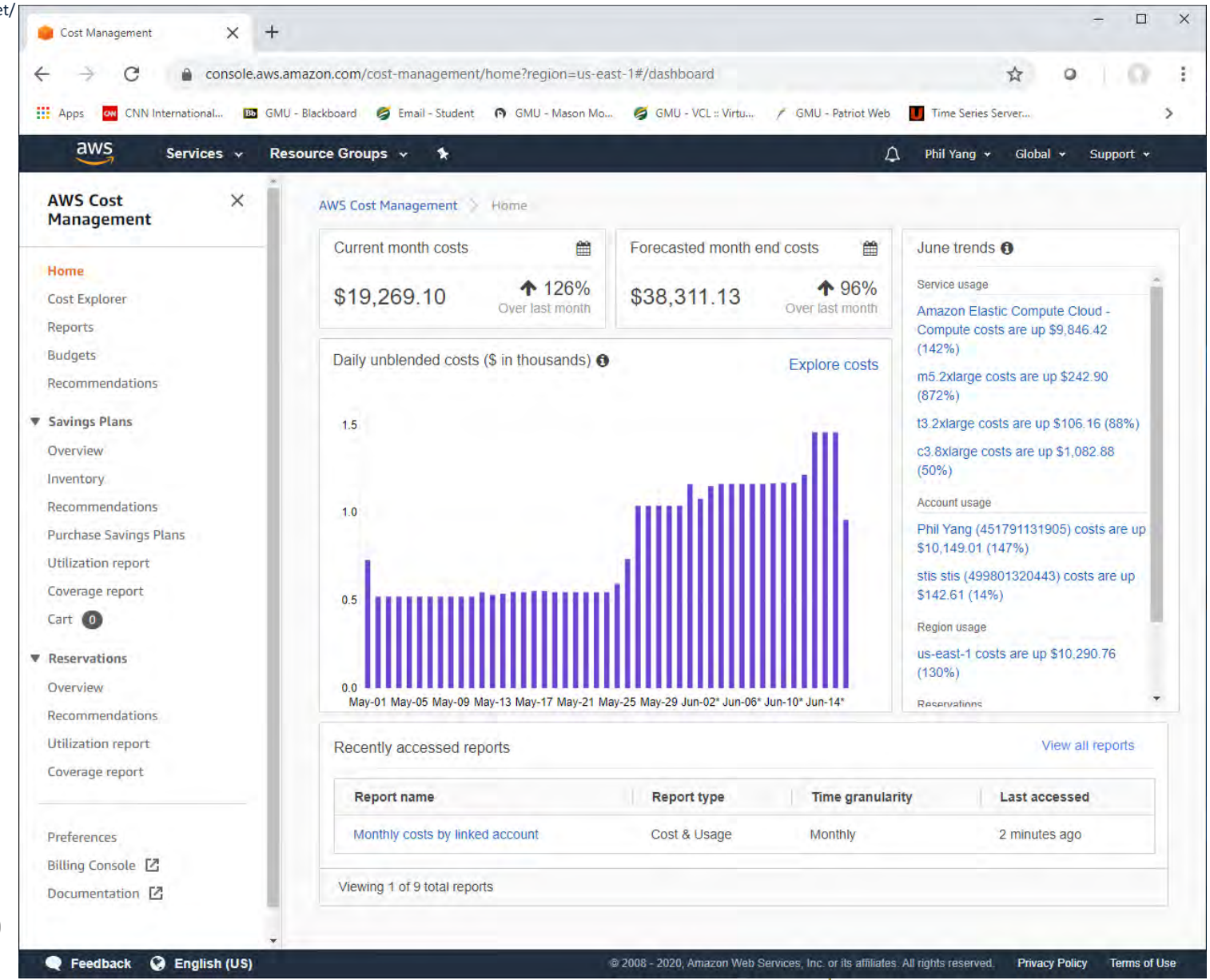
The Usage of Amazon Cloud



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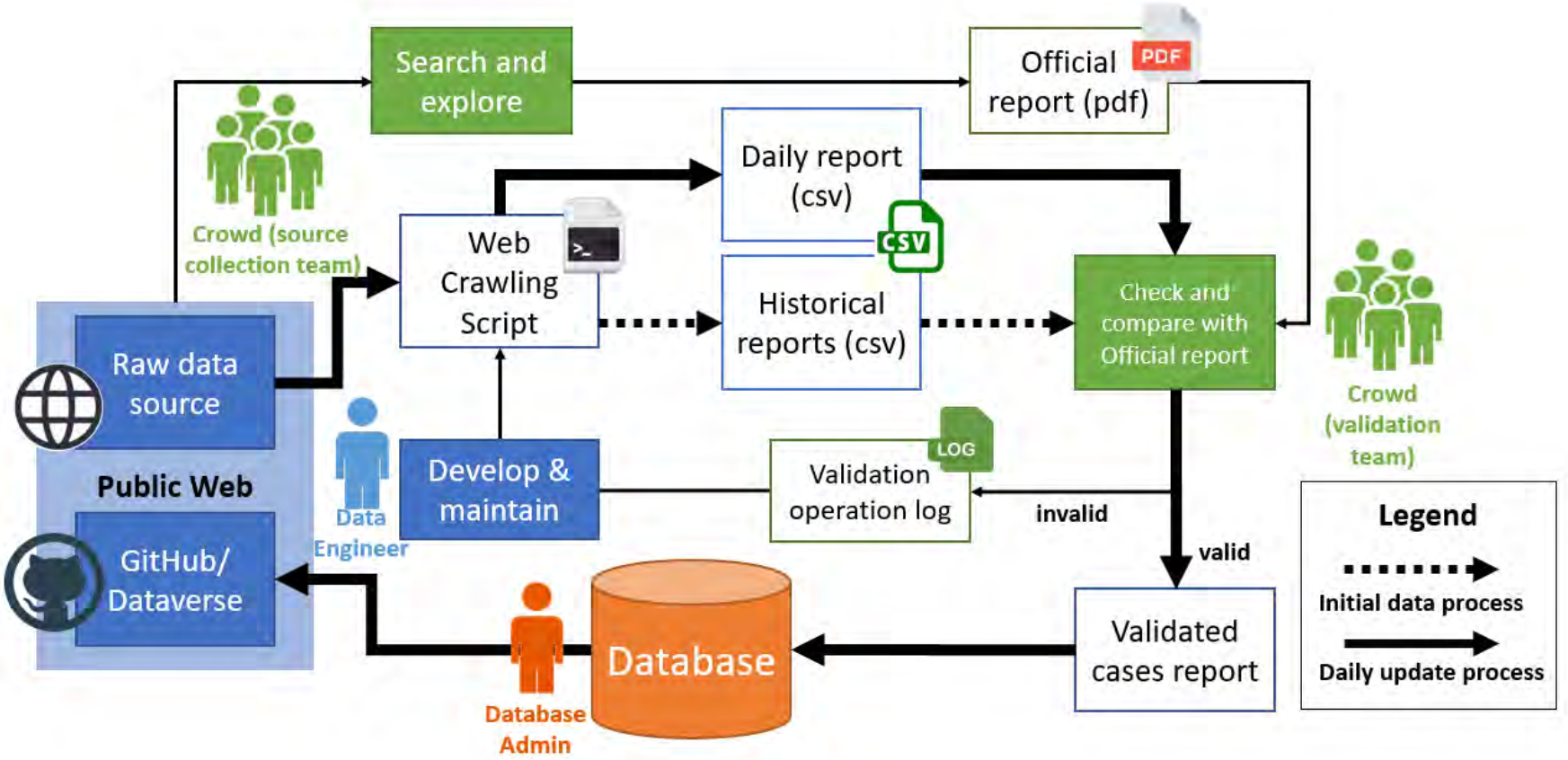
Collecting and Validating Data



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Data Sharing through GitHub

- **GitHub sharing address:** https://github.com/stccenter/COVID-19-Data
  - Organized by Country
  - Each country：provide daily and time series data

Overall data sources by Country

source data source source validaiton source

Country / Region	Continent	Admin level	DataSource
Global	Global	0	source Johns Hopkins CSSE source WHO
United States	North America	1 , 2	source Johns Hopkins CSSE source USAFACTS source CDC.gov
China	Asia	1	source Ding Xiang Yuan source NHC
Canada	North America	1	source Johns Hopkins CSSE source canada.ca
Australia	Oceania	1	source Johns Hopkins CSSE source health.gov.au
Italy	Europe	1	source protezionecivile.it source world0meters
Germany	Europe	1	source covid19-eu-data source rki.de
Austria	Europe	1	source sozialministerium.at source sozialministerium.at
Brazil	South America	1	source covid.saude.gov.br source covid.saude.gov.br
Chile	South America	1	source Covid-19 Latinoamérica source minsal.cl
Japan	Asia	1	source covid-2019.live source stopcovid.jp
Russia	Europe	1	source yandex.ru source стопкоронавирус.рф
South Africa	Africa	1	source NICD source health.gov.za source statssa.gov.za
Malaysia	Asia	1	source covid-19-malaysia source covid-19-infosihat.gov.my
Denmark	Europe	1	source covid-19-sa.dk source coronatracker.com
Finland	Europe	1	source arcgis.com source thl.fi
Greece	Europe	1	source covid19.gov.gr source eody.gov.gr
Hungary	Europe	1	source koronavirus.gov.hu source abouthungary.hu
Croatia	Europe	1	source koronavirus.hr source world0meters
Iceland	Europe	1	source wikipedia.org source covid.is
Slovakia	Europe	1	source wikipedia.org source korona.gov.sk

Daily data

Daily data provides automatically updated information of COVID-19 cases, and related attributes daily.

Attribute Name	Description	Format	Example
date	The date representing the current day in which the data represents. UTC time is used for this dataset, all values will calculated before the end of UTC time of the date	Date (YYYY/MM/DD) in UTC	2020/04/09
country_name	Name of the country	string	United States
iso3	3 digit ISO country codes	varchar(3)	USA
admin1_name	The name for admin 1 level	string	Virginia
hasc1	This will represent the Hierarchical administrative subdivision codes (HASC) for admin 1 level	string	US.VA (for Virginia, United States)
local_id1	This will represent the ID for specific admin 1 level. ID that represents the country's admin 1 level	string	VA (for Virginia, United States)
confirmed	The number of confirmed cases	integer	777
death	The number of death cases	integer	19
recovered	The number of recovered cases. (might be null for admin 2 level)	integer	null
Miscellaneous	Other data attributed to our dataset	TBD	TBD

Summary data

Summary data records the COVID-19 cases, and related attributes, to show the timeline of cases.

Attribute Name	Description	Format	Example
country_name	Name of the country.	string	"US"
iso3	3 digit ISO country codes.	varchar(3)	USA
admin1_name	The name for admin 1 level.	string	State for USA
date	The date representing the current day in which the data represents. UTC time is used for this dataset, all values will calculated before the end of UTC time of the date.	UTC	YYYY/MM/DD

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COVID-19 Data, Information and Knowledge Gateway

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

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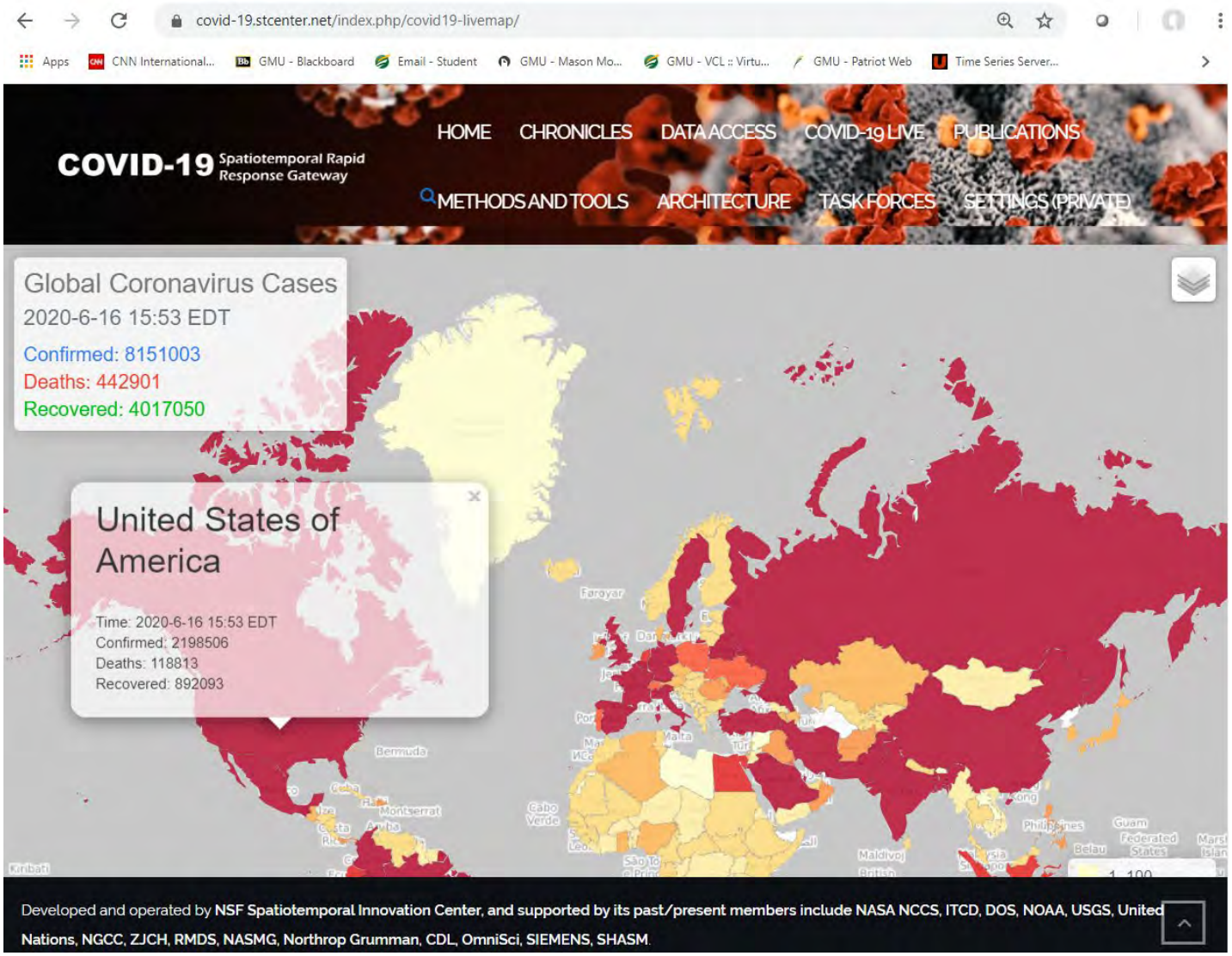
The Current Global Status

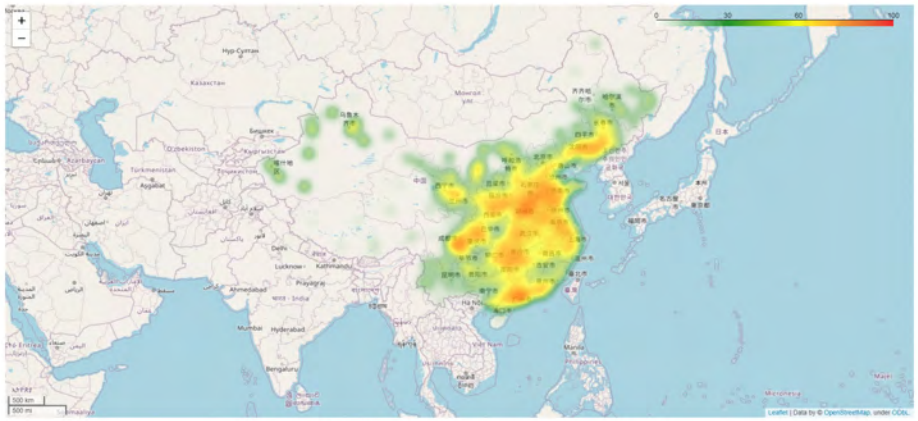


https://covid-19.stcenter.net/index.php/covid19-livemap/

https://www.stcenter.net/

The Air Quality Change

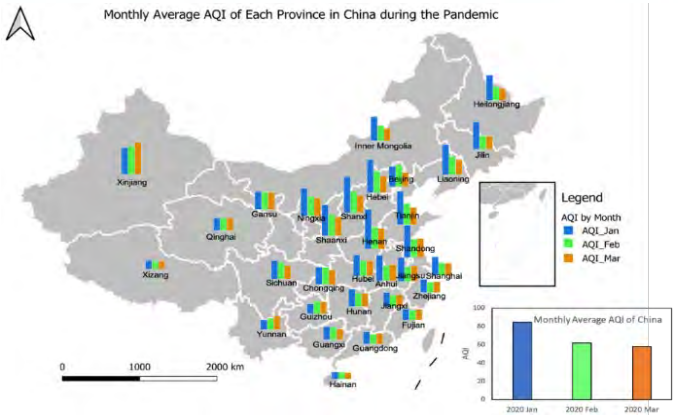
Heatmap of the Air Quality Index on Jan. 01, 2020

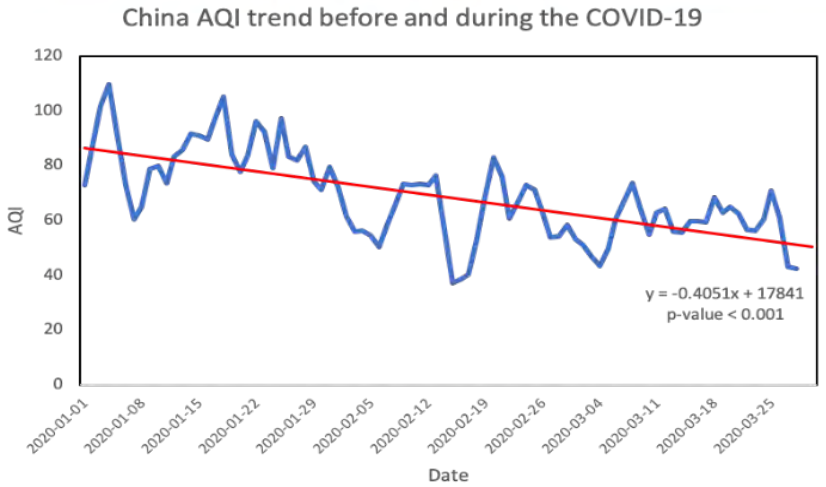


Data and visual analytics provided by Qian Liu and Zhiran Zhang, NSF Spatiotemporal Innovation Center.

Heatmap of the NO2 Emission on Jan. 01, 2020

Data and visual analytics provided by Qian Liu and Zhiran Zhang, NSF Spatiotemporal Innovation Center.





https://github.com/stccenter/COVID-19/tree/master/analysis

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How is the economy impacted?

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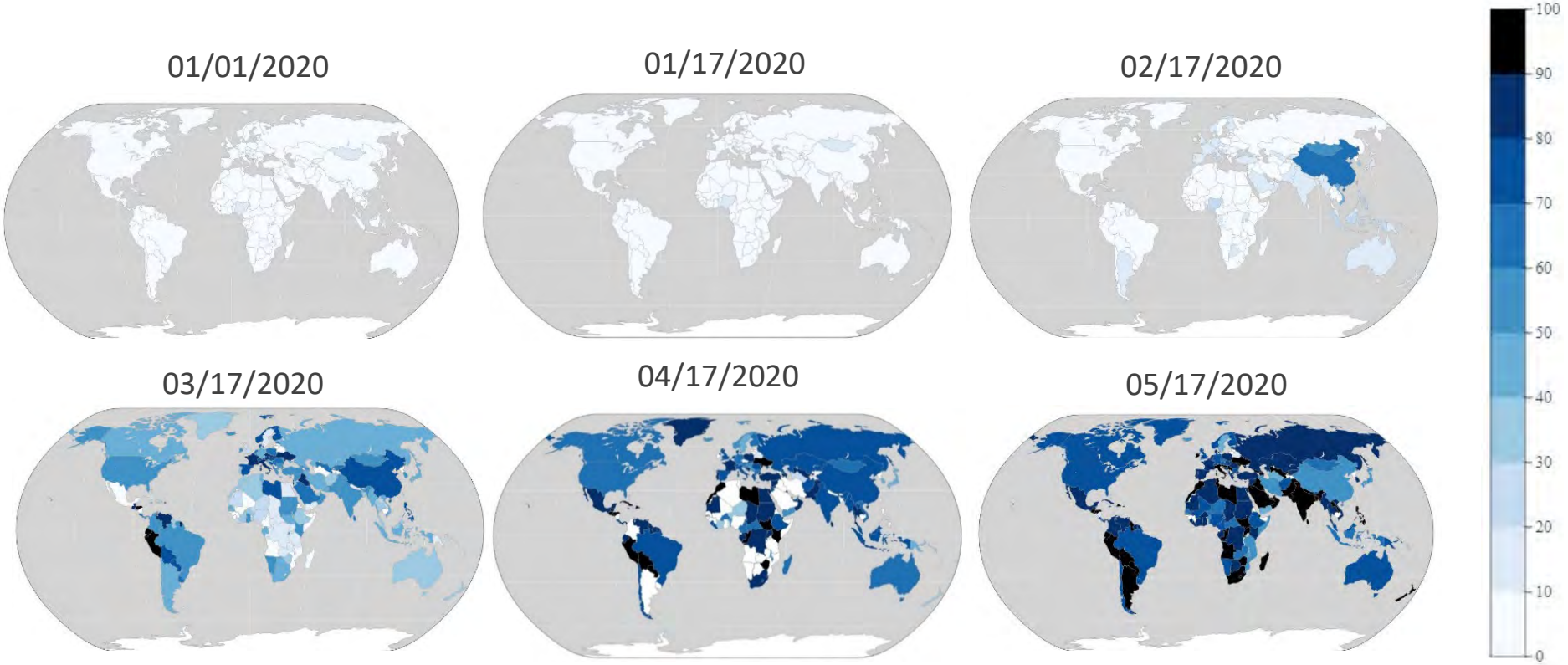
The Policy Stringency Index

DEMO



The policy stringency Index

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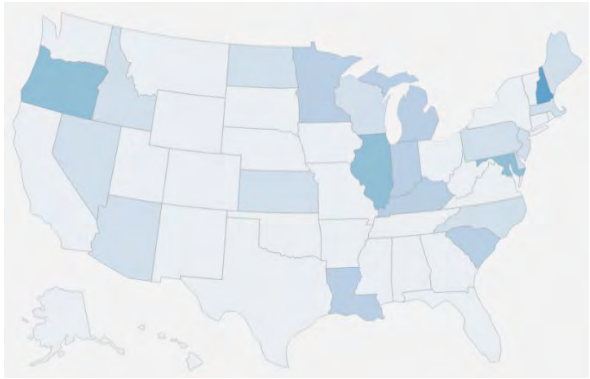
03/15/2020



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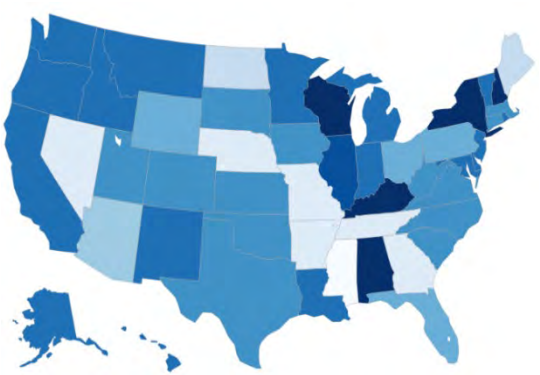
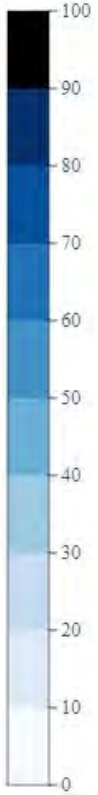
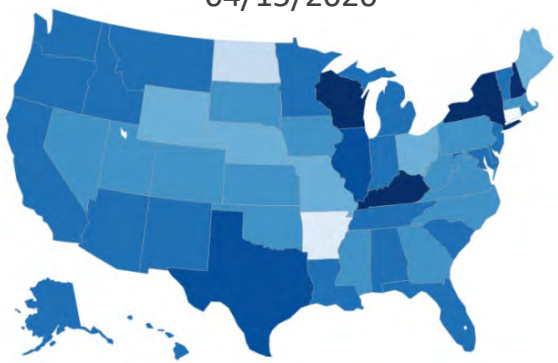




04/15/2020



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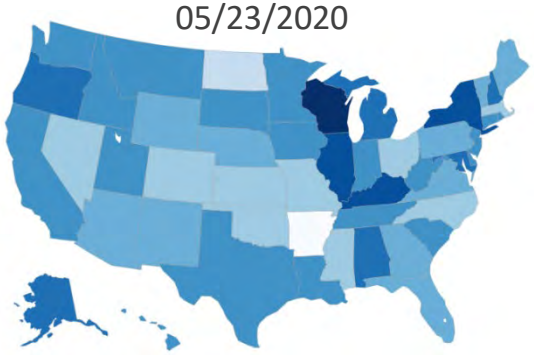

Data Source: https://github.com/stccenter/COVID-19-Data/tree/master/US