Mapping Spatial and Temporal Variability in Mobility Patterns in CA (2020-2022)

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UC Santa Barbara @ Autocarto 2022

Background

- COVID-19 < - - - > Mobility (two-way interconnectedness)
  - Coronavirus spread (Huang et al., 2021)
  - Disease-modeling (Agbehadji et al., 2020)
  - Non-pharmaceutical interventions (Askitas et al., 2021)
- COVID-19 made many mobility datasets available for researchers. Data-rich environment and data-driven geography [Miller & Goodchild, 2015])
  - Big Tech (Google Mobility Trends, Apple Mobility Reports, Facebook)
  - Smaller geospatial intelligence companies (Descartes Labs, Cuebiq, Streetlight)

Research Opportunities

- Aggregating and summarizing mobility data
  - Modifiable areal unit problem (MAUP)
  - Privacy thresholding (Ethics)
  - Data representativeness (selection bias)

- How does using certain **types of mobility data** influence our **research outcomes**?
- Can we utilize **mobility indices** to investigate human movement **before, during and after COVID**?

SAFEGRAPH

cuebiq

data for good

Descartes Labs

STREETLIGHT DATA

Big Data for Mobility

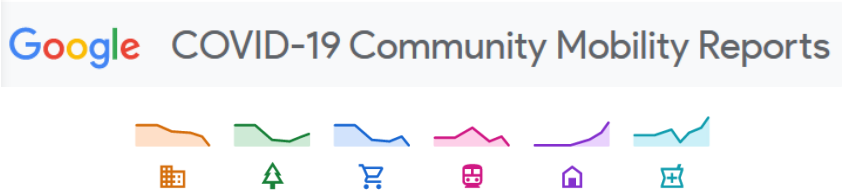
Mobility Data

Apple

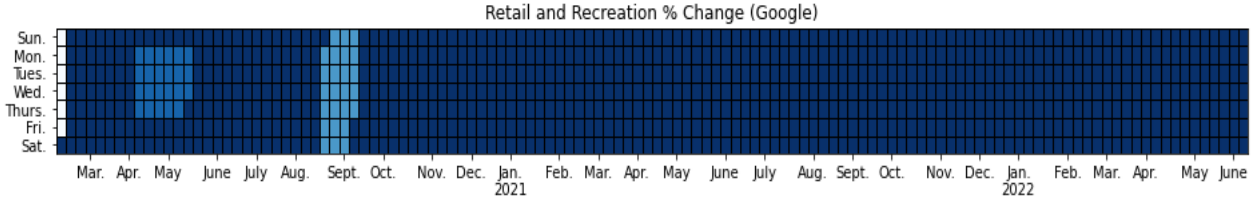
- Jan 13, 2020 - April 14, 2022
- Relative volume of **directions requests** per country/region, sub-region or city compared to a baseline volume on January 13th, 2020.

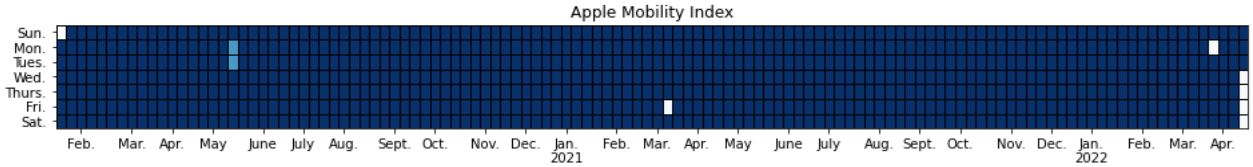
Google

- Feb 15, 2020 - Oct 15, 2022
- The data shows how **visitors** to (or time spent in) categorized places change **compared to our baseline** day (Retail & Recreation, Grocery & Pharmacy, Parks, Transit, Workplaces, Residential)

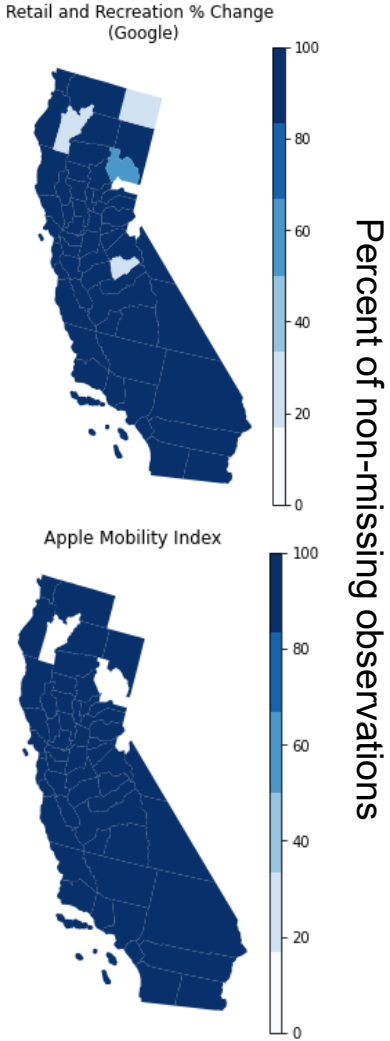


Spatial and Temporal Coverage





- The least populous counties in CA (Modoc, Trinity, Plumas, Sierra and Alpine), so the gaps in data are likely attributed to privacy-thresholding algorithms.

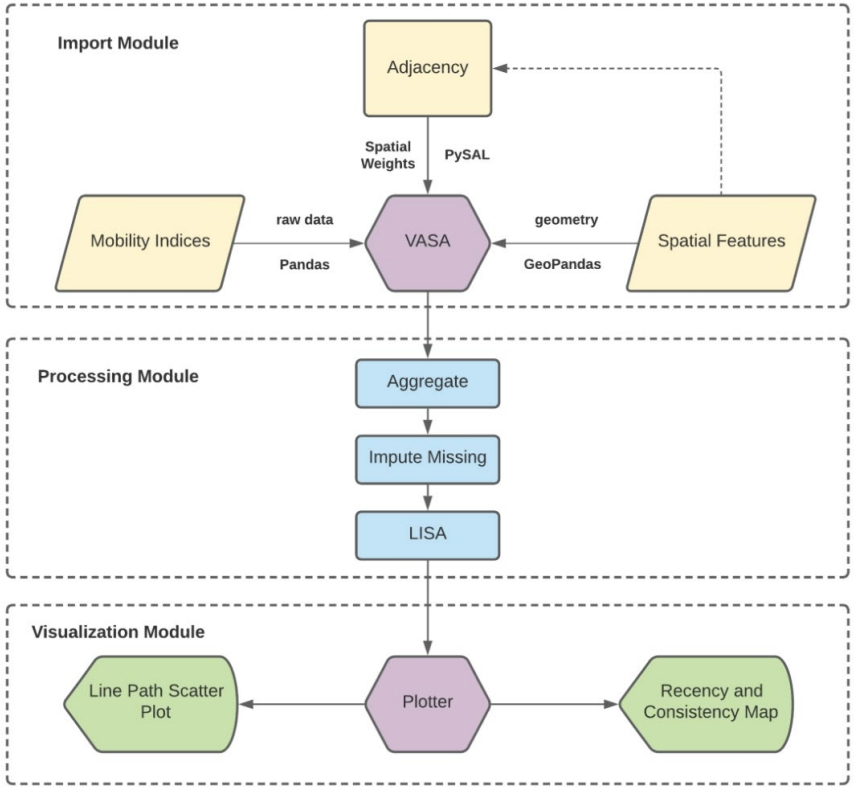


VASA - Visual Analytics for Spatial Association

Exploratory mapping tool to streamline analysis of spatio-temporal structure of data.

Free and Open Source Software (FOSS)

Amends traditional measures of spatial autocorrelation with new visual displays



GitHub

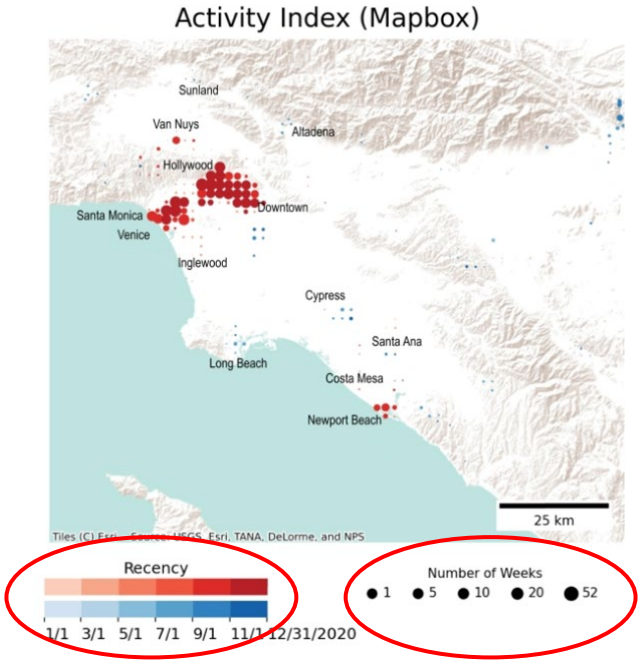
https://github.com/move-ucsb/VASA

Source: Noi, E., Rudolph, A., & Dodge, S. (2022). VASA: an exploratory tool for mapping spatio-temporal structure of mobility - a COVID-19 Case Study. Cartography and Geographic Information Science (forthcoming).

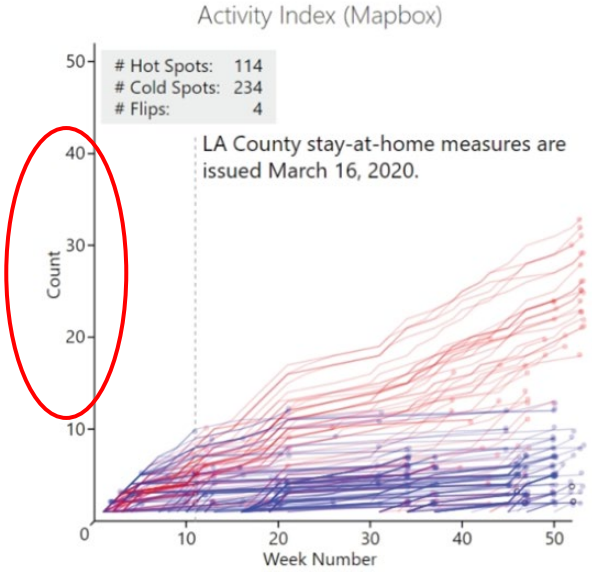
VASA visual displays

Hotspots - counties with higher than average mobility near the counties with higher than average mobility values (HH).

Coldspots - counties with lower than average mobility near the counties with lower than average mobility values (LL).



Recency and Consistency Map

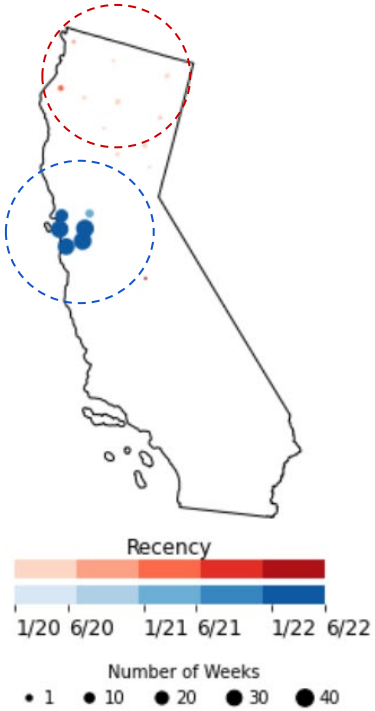


Line-path scatter plots

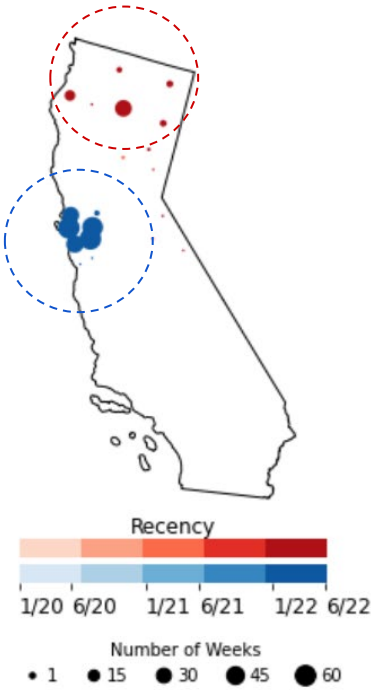
Recency and Consistency Map

Coldspots in the **Bay Area**: in Alameda, San Francisco, Contra Costa, San Mateo, and Marin county (**IT jobs**)

Apple **misses recent hotspots** in NorCal: in Shasta, Humboldt, Lassen, Modoc, and Siskiyou counties (**wineries** and **camp sites** in numerous national **forests**).



Apple

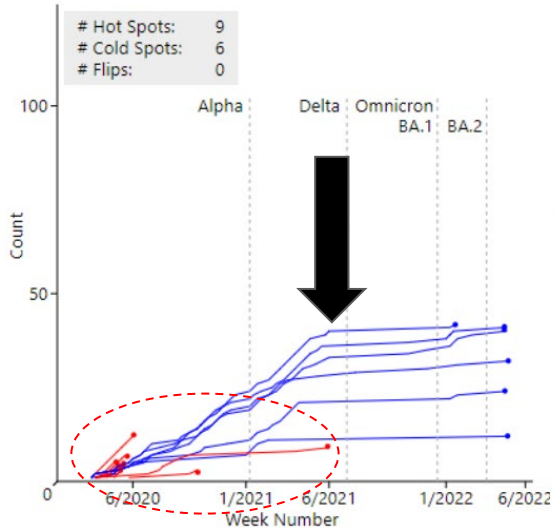


Google

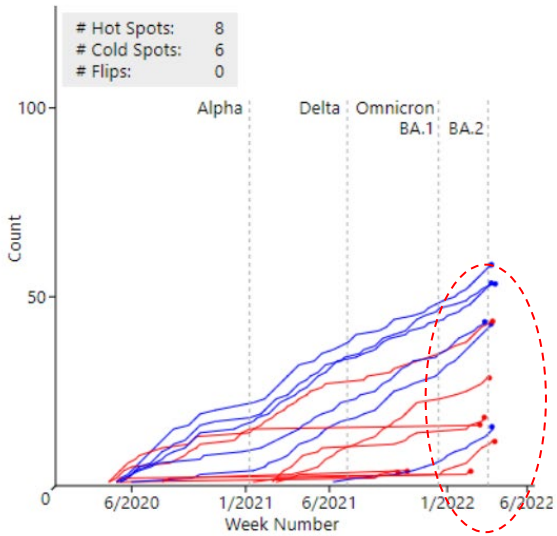
Recency and Consistency Map

Apple mobility plateaus around May 2021 (fails to capture Delta, Omicron and BA.1/2)

Hotspots are better captured in Google data.

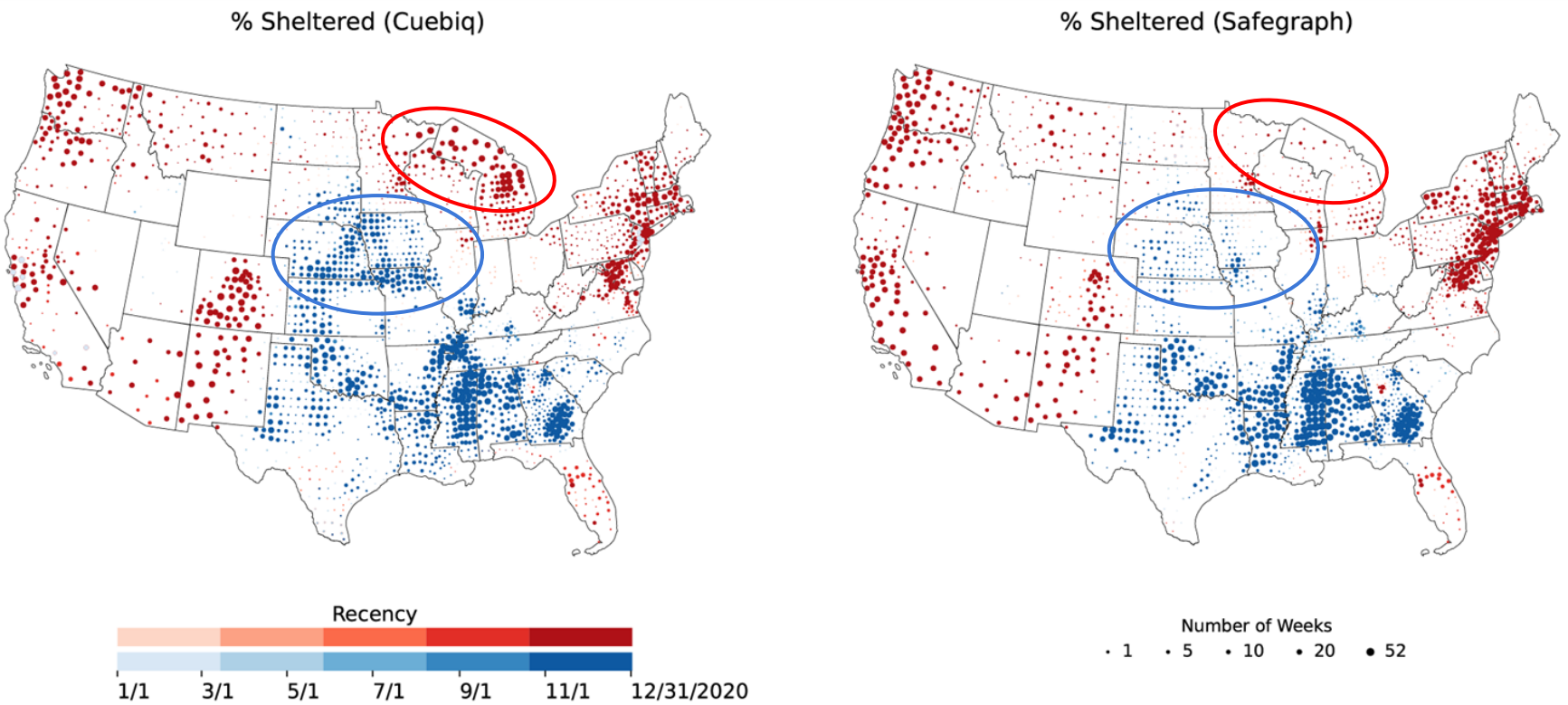


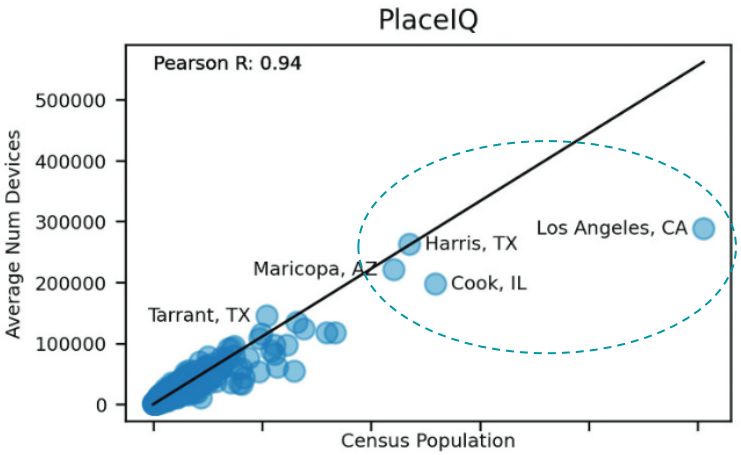
Apple

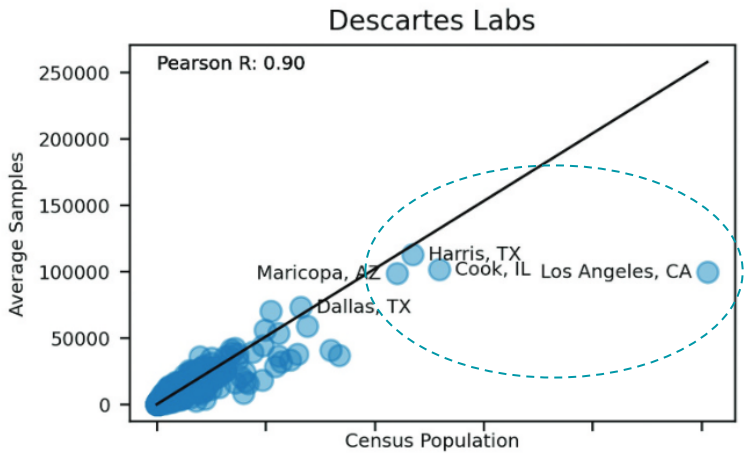


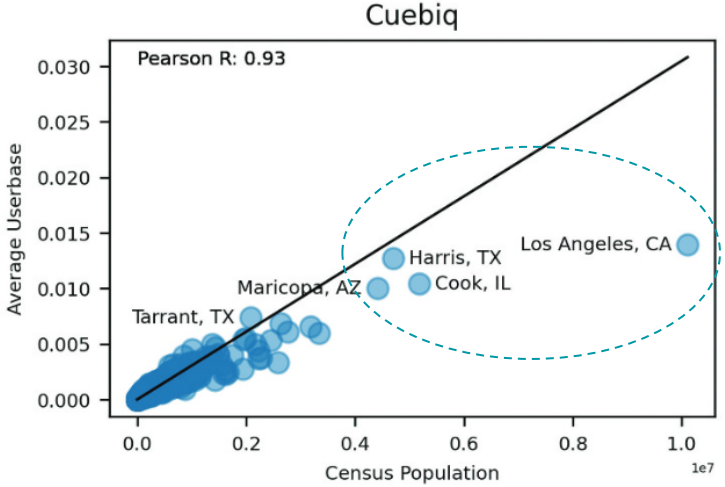
Google

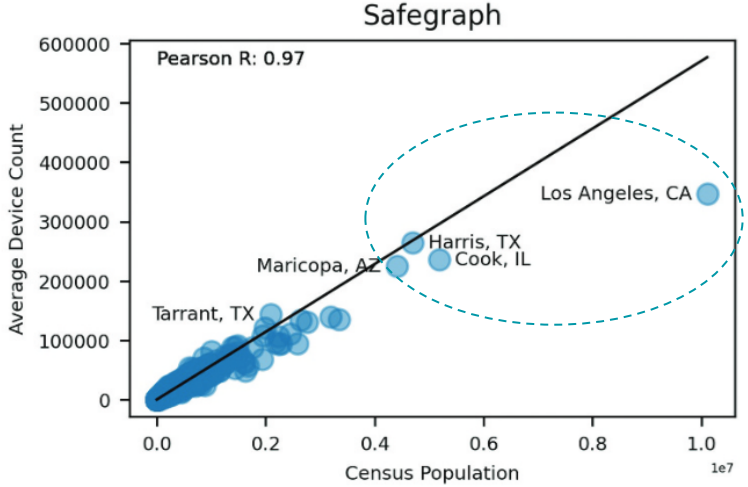
Discussion


% Sheltered (Cuebiq)
% Sheltered (Safegraph)
Recency
1/1
3/1
5/1
7/1
9/1
11/1
12/31/2020
Number of Weeks
1
5
10
20
52


PlaceIQ
Pearson R: 0.94
Average Num Devices
Census Population
Los Angeles, CA
Harris, TX
Maricopa, AZ
Cook, IL
Tarrant, TX


Descartes Labs
Pearson R: 0.90
Average Samples
Census Population
Harris, TX
Cook, IL
Los Angeles, CA
Maricopa, AZ
Dallas, TX


Cuebiq
Pearson R: 0.93
Average Userbase
Census Population
1e7
Los Angeles, CA
Harris, TX
Maricopa, AZ
Cook, IL
Tarrant, TX


Safegraph
Pearson R: 0.97
Average Device Count
Census Population
1e7
Los Angeles, CA
Harris, TX
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Maricopa, AZ
Tarrant, TX

Conclusion

- Statistical outcomes will vary depending on the biases and uncertainty in data
- There are multiple definitions of mobility (Mapbox, Google, Apple, SafeGraph, Cuebiq). There is no one perfect mobility index.
- Uncertainty will come from heterogeneity of mobility data sources.

Thank you for listening!

Questions?

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NSF

UNIV. OF CALIFORNIA SANTA BARBARA GEOGRAPHY

MOVE ucsb

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Noi, E., Rudolph, A., & Dodge, S. (2022). Assessing COVID-induced changes in spatiotemporal structure of mobility in the United States in 2020: a multi-source analytical framework. International Journal of Geographical Information Science, 36(3), 585-616.

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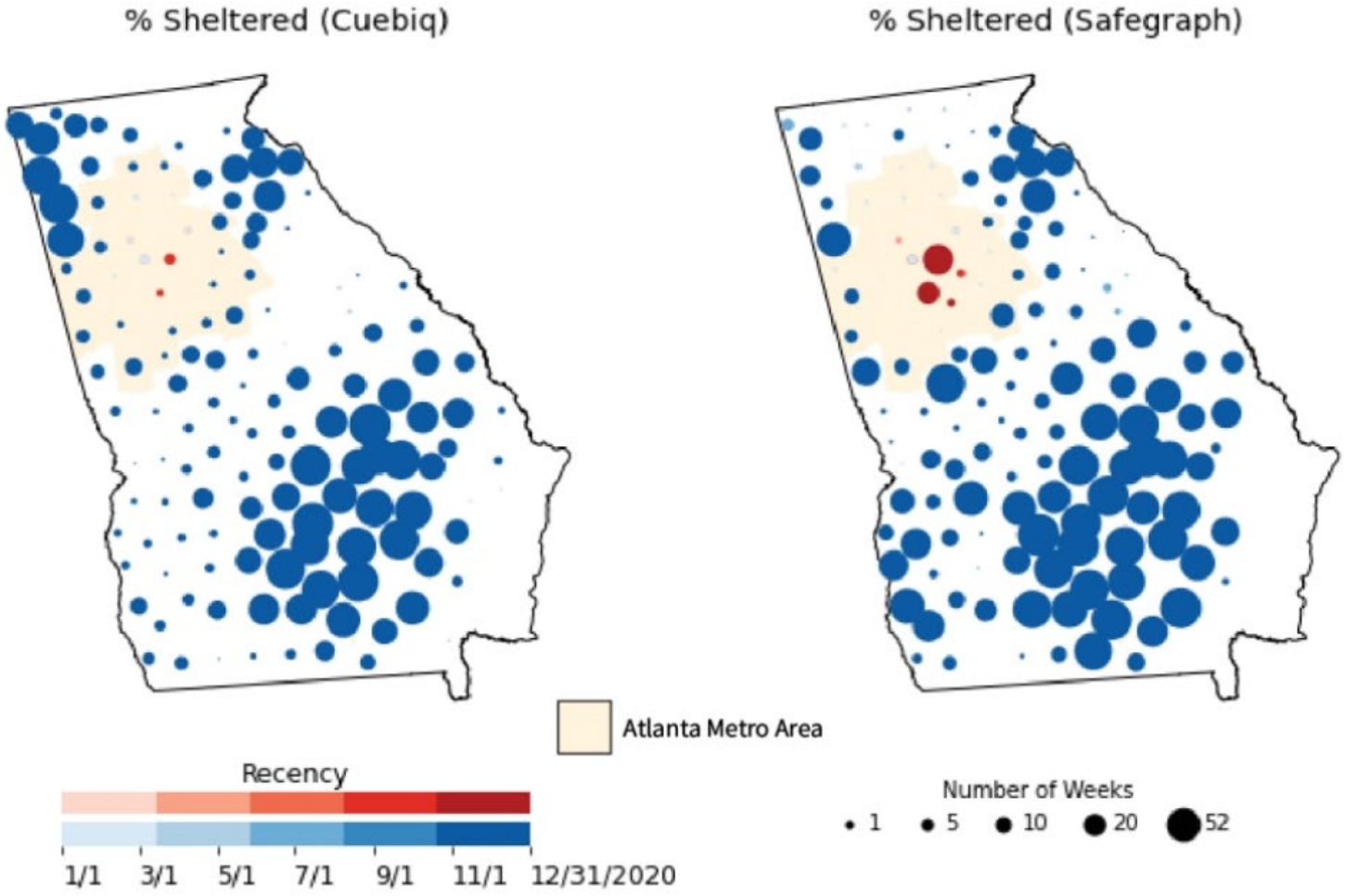
Appendix


% Sheltered (Cuebiq)
% Sheltered (Safegraph)
Atlanta Metro Area
Recency
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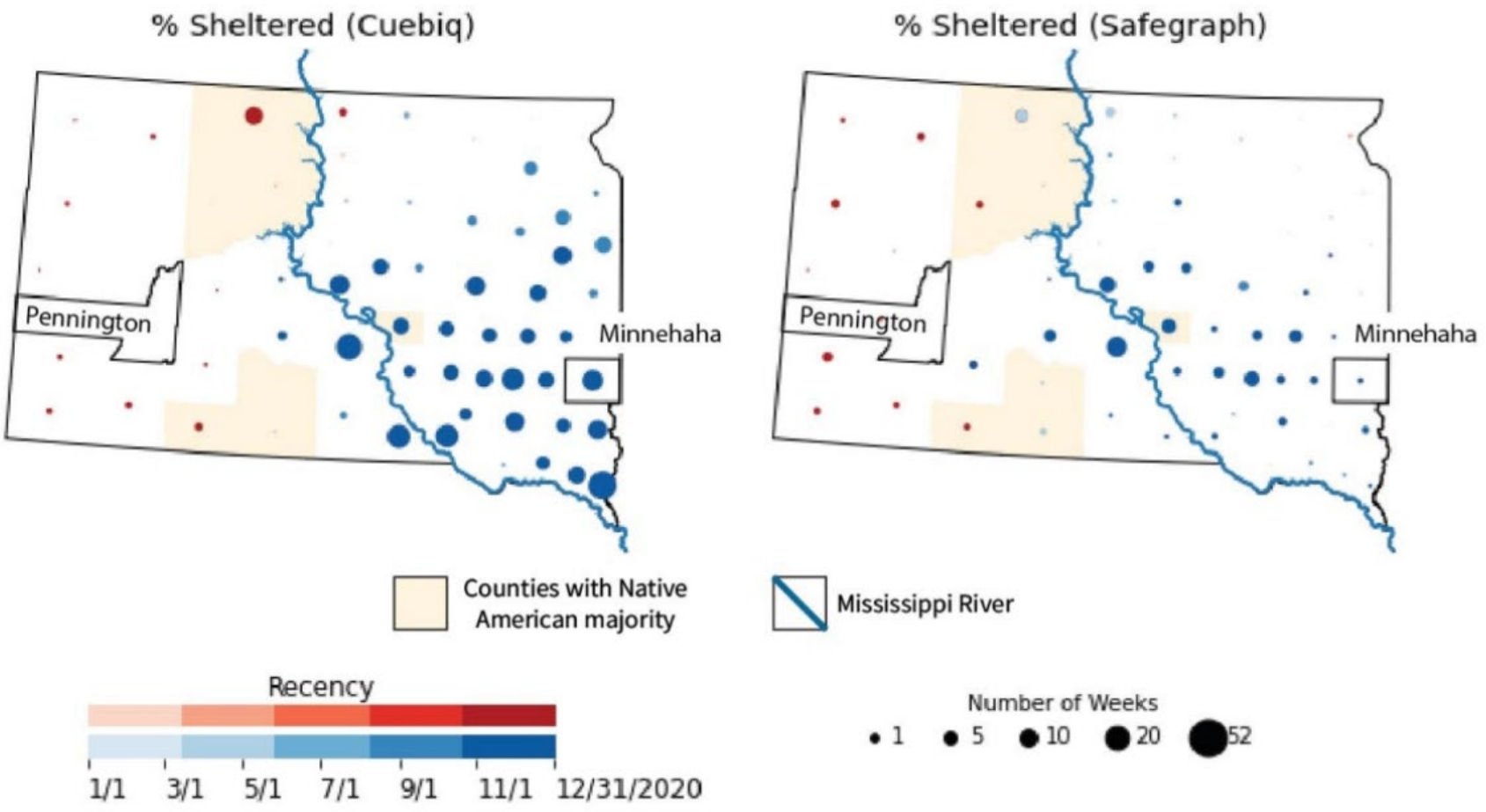
% Sheltered (Cuebiq)
% Sheltered (Safegraph)
Pennington
Minnehaha
Pennington
Minnehaha
Counties with Native American majority
Mississippi River
Recency
1/1
3/1
5/1
7/1
9/1
11/1
12/31/2020
Number of Weeks
1
5
10
20
52

Mobility Data in Geospatial Analysis of COVID

Table 1. Major mobility data providers in COVID-19 studies for the United States, listed alphabetically.

	Data source	Access	Availability (since)	# of metrics	Coverage[b] (%)
1	Apple	Open	1 3 January 2020	1	42.7
2	Cuebiq	Commercial	1 January 2019	4	93.4
3	Descartes Labs	Open	1 March 2020	2	65.3
4	Facebook	Open	1 March 2020	2	62.6
5	Google	Open	15 February 2020	6	35.0
6	PlaceIQ	Open	20 January 2020	2	57.0
7	SafeGraph	Open	1 January 2019	2	93.3
8	StreetLight	Commercial	1 January 2019	1	98.5
9	University of Maryland	Open	1 January 2020	6	97.8
10	Unacast[c]	Commercial	Feb, 24, 2020	3	–

[b]Coverage is defined as the percentage of complete (non-missing) records for all of the observed counties (n=3140) and days (n=366) in the observation period (January – December 2020) summarized for each data source.

[c]Unacast provides data on a commercial basis. Since we do not have access to this data, the coverage information is not provided and the readers are referred to their homepage (Engle *et al.* 2020). The number of metrics is calculated based on the number of products in *Unacast COVID-19 Location Data Toolkit.*, 2020

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