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MOBILE PHONE BIG DATA AND THE COVID-19 PANDEMIC

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INTRODUCTION

FROM AGGREGATED TABLES TO MICRO DATA (INDIVIDUAL RECORDS)

Census tables have been used for spatial analysis in Geography.

- Tables aggregated by region or demographic attribute have been used and are common for data analysis previously and today.

Microdata of population census are now available for researchers.

- Availability of 1% or 10% samples of individual census records enables researchers to conduct analyses based on individuals or households (decision making unit).

- However, such microdata often do not have detailed spatial units. Therefore, in the 1980s, several “spatial microsimulation” methods were invented to estimate geographical distributions at the small area level. There are several applications of spatial microsimulation developed in geography to estimate water demand, income distribution, health indicators, etc. for each neighbourhood.

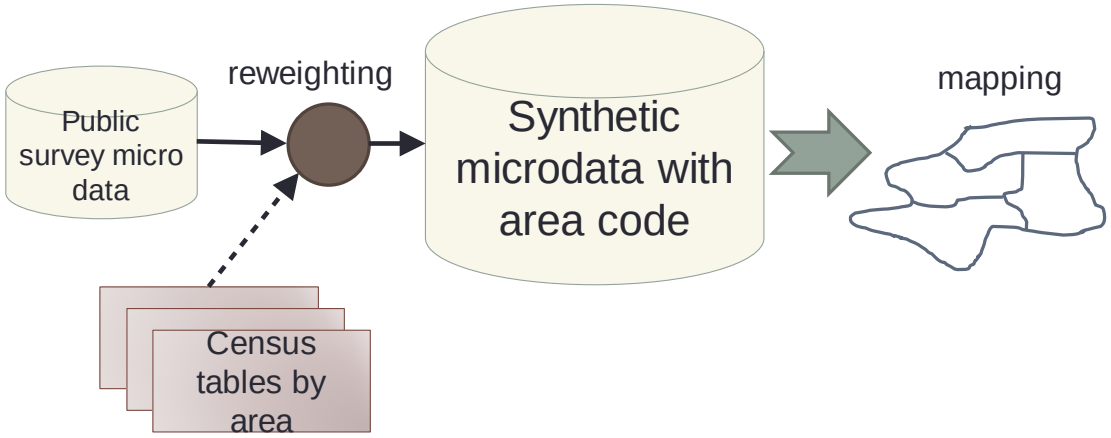
SPATIAL MICROSIUMULATION
(SMALL-AREA ESTIMATION METHOD)

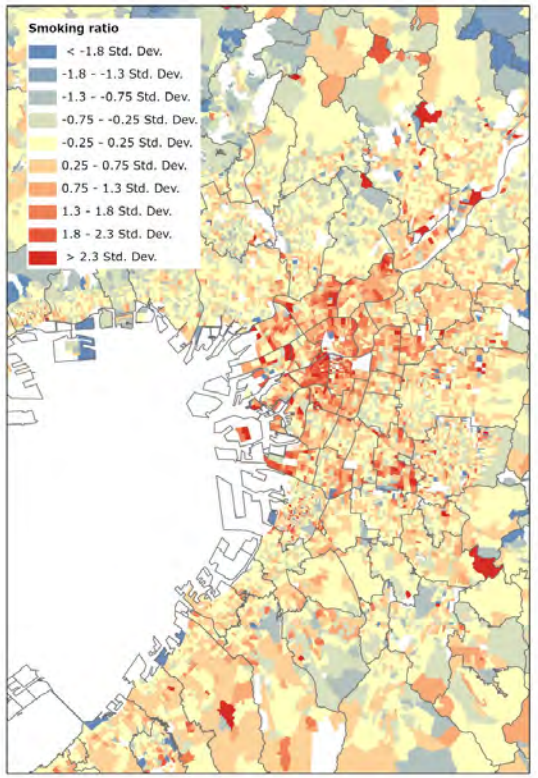
Small-area estimation using Iterative Proportional Fitting(IPF) or Combinatorial Optimization (CO) algorithm.

IPF:

Area A	Smoker	Non-smoker	Marginal total
Male	?	?	**58**
Female	?	?	**42**
Marginal total	**30**	**70**	**100**

CO





Women's smoking rate in Osaka, Japan
Result of spatial microsimulation

RECENT TRENDS OF CENSUS (BIG) DATA AVAILABILITY

In the US, samples from ACS(American Community Survey) are easily downloadable from the US Census Bureau website.

In Japan, census microdata are currently available with permission from the Japanese Statistical Bureau. Researchers can access the microdata in a high security room installed in several academic institutes.

In Australia, in addition to census microdata, researchers can use the online census tabulation system (Census TableBuilder) to produce very detailed tabulations at the small area level.

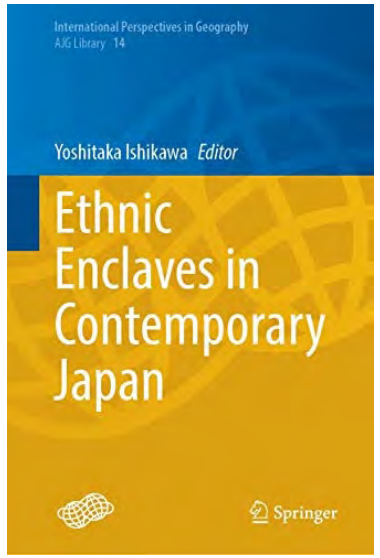
A secured room for accessing census microdata (Japan). http://www.econ.kobe-u.ac.jp/kumic/satellite/on-site/index.html

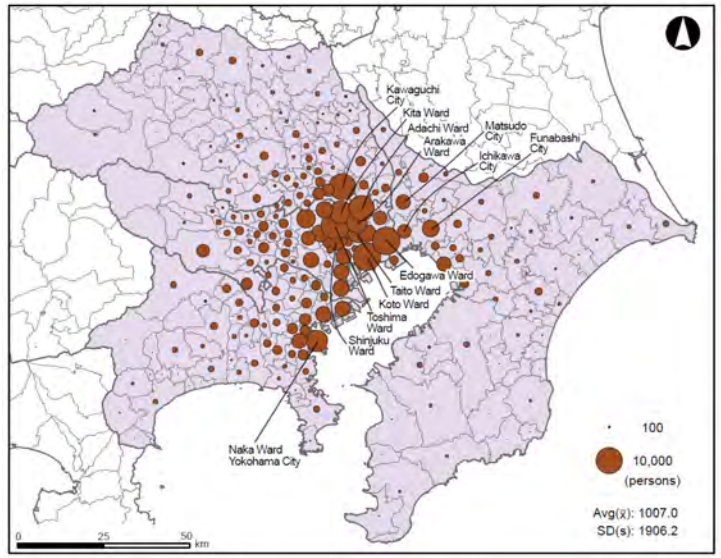
Online tabulation system in Australia

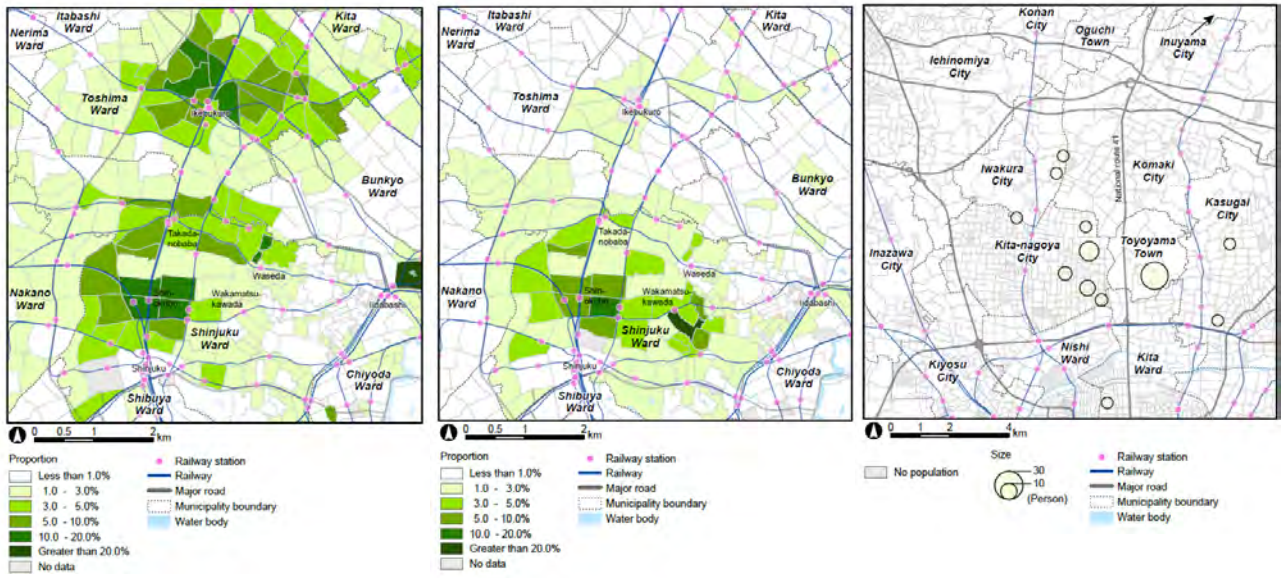
MAPPING ETHNIC ENCLAVES IN JAPAN BASED ON CENSUS MICRODATA

Ishikawa ed (2021) *Ethnic Enclaves in Contemporary Japan*, Springer.

Chapter 2: Ishikawa & Hanaoka







While the sample size of census microdata is large enough for big data, a new form of big data emerged in the late 2000s.

In Japan, big data of social network service, mobile phones, and IC transit cards began to appear. These big data are collected through commercial activities and services instead of using a traditional questionnaire survey.

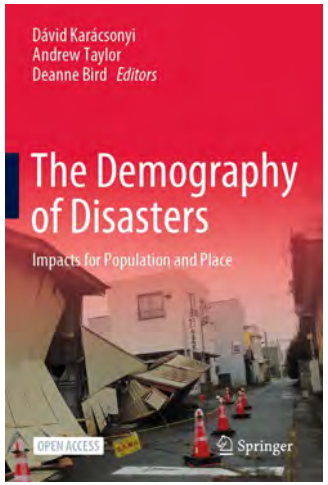
EMERGENCE OF BIG DATA IN THE 2000S

DISASTER & BIGDATA

When unexpected events such as natural disasters and pandemics occur, big data from mobile phones is particularly useful for monitoring population movements in near real-time.

For example;

Even five years after the Great East-Japan Earthquake in 2011, recovery of population in Fukushima was limited due to the nuclear power plant accident. The population distribution in Fukushima after the accident was observed with using big data from mobile phones.



A free copy is available from https://link.springer.com/book/10.1007%2F978-3-030-49920-4

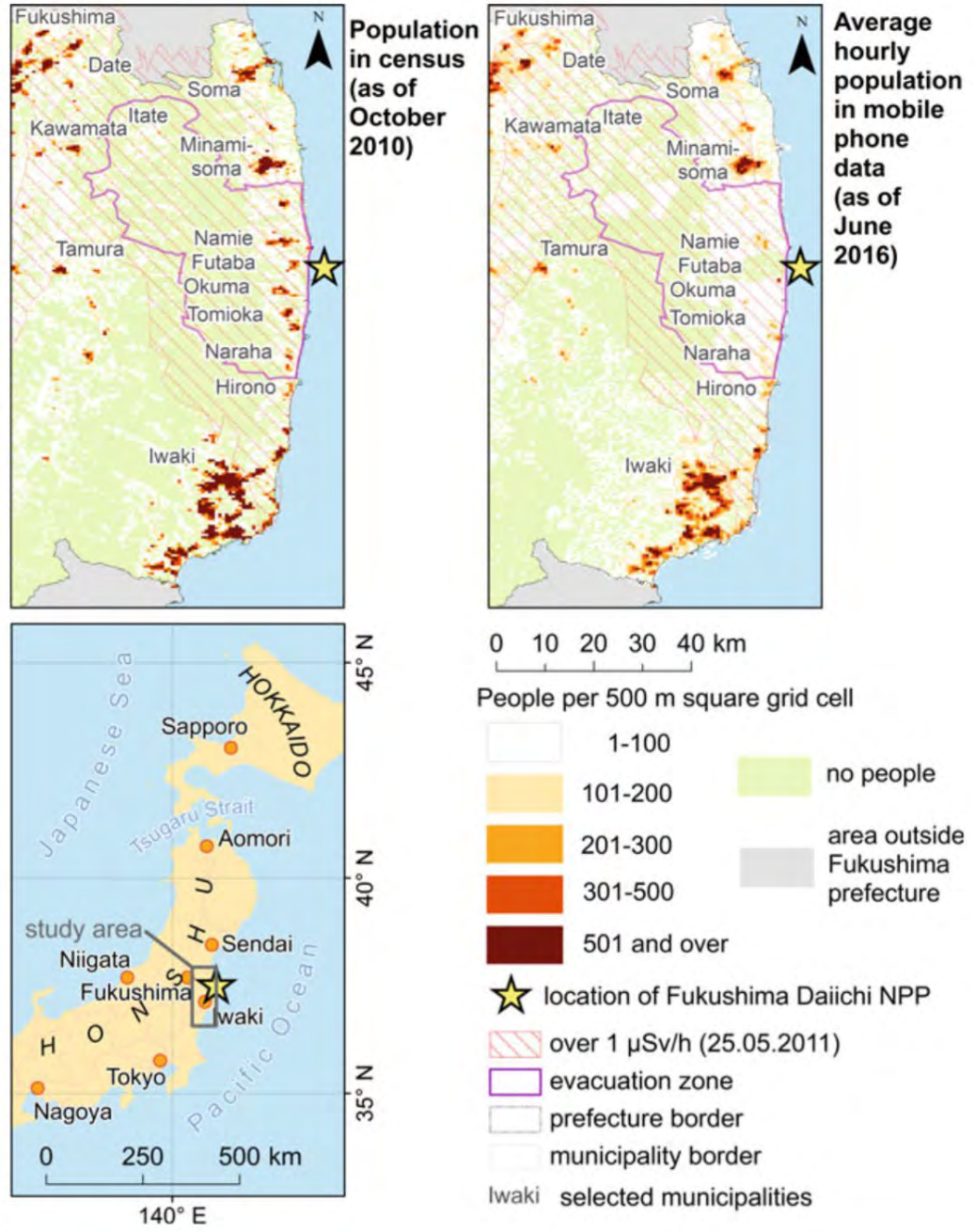
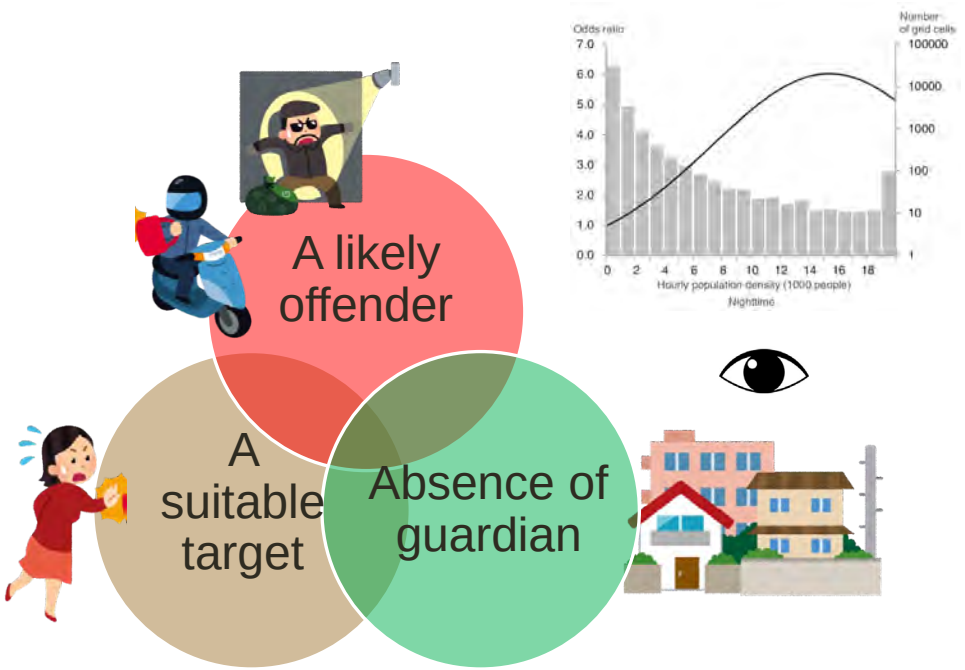


Fig. 2.7 Population distributions in census and mobile phone data (Author Hanaoka cartography by Hanaoka and Karácsonyi)

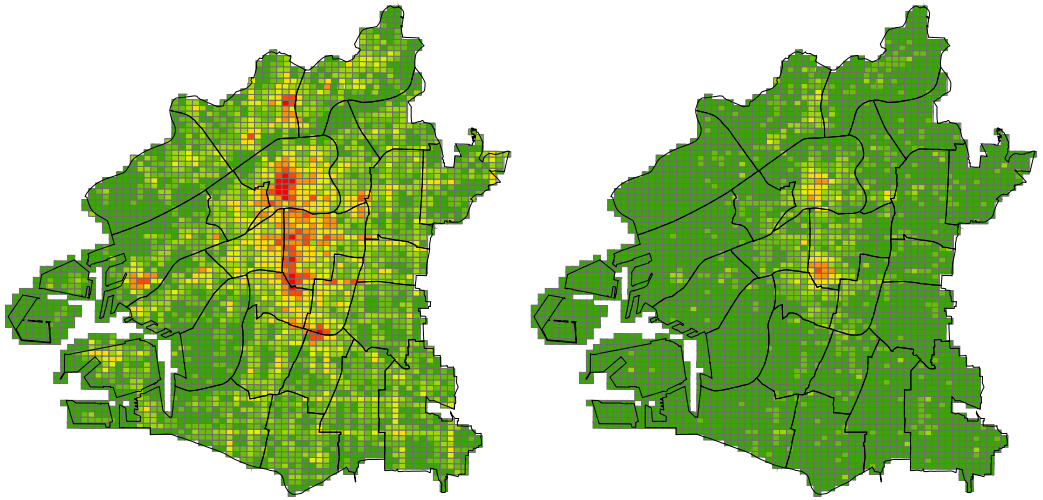
STREET CRIME & BIG DATA

Natural surveillance by citizens can be measured by hourly ambient population from mobile phone big data. Our research supports a quadratic relationship between ambient population and crime occurrence during the nighttime (Hanaoka 2018).

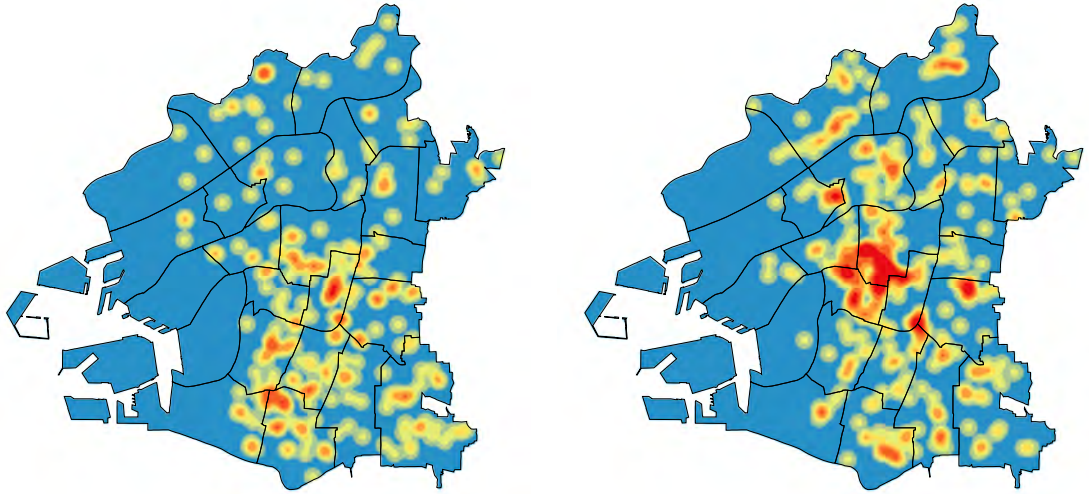


Routine Activity Theory

Daytime Nighttime

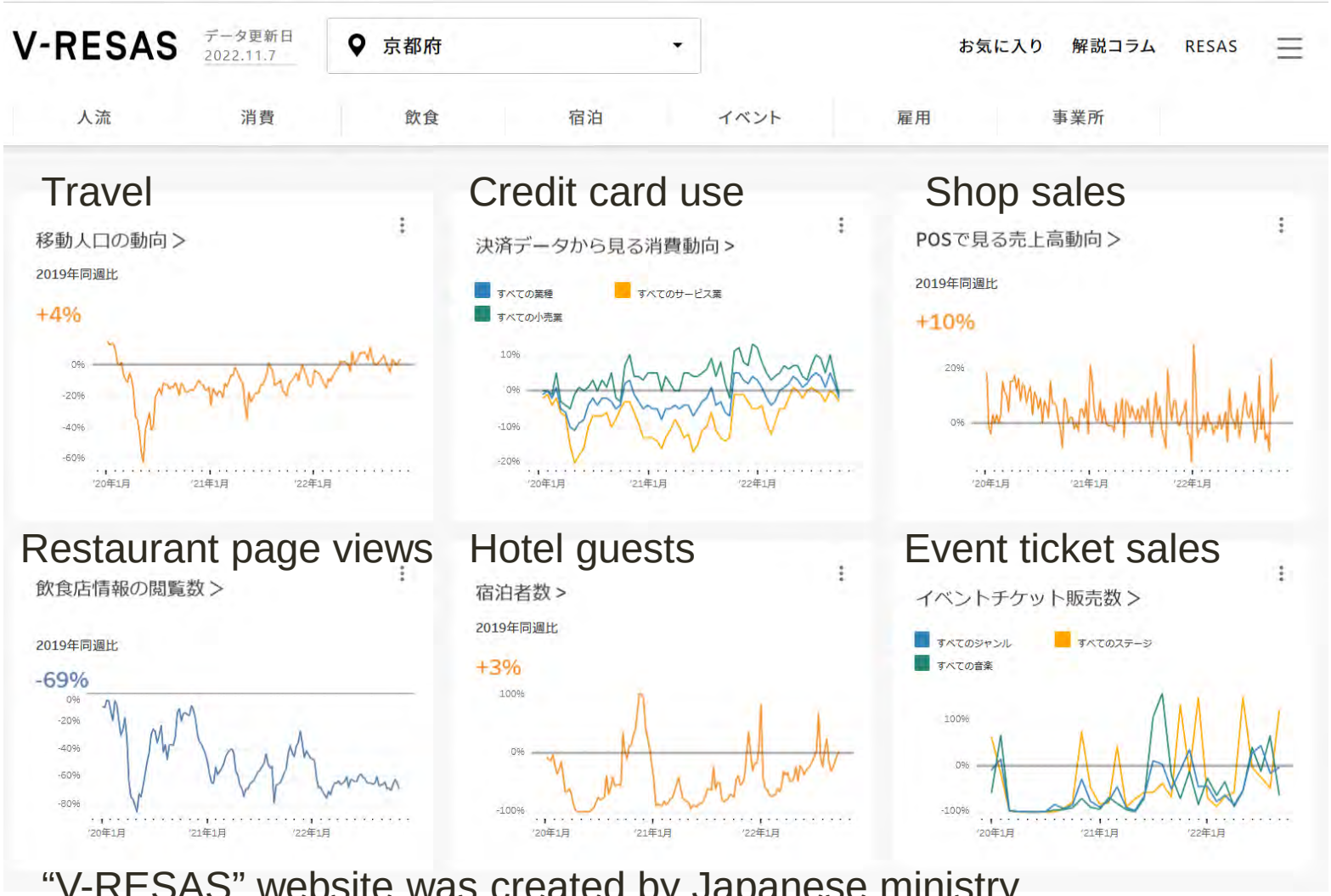


Ambient population



Snatch-and-run offense

INCREASED USE OF BIG DATA IN FIGHT FOR THE COVID-19 PANDEMIC



"V-RESAS" website was created by Japanese ministry

During the COVID-19 pandemic, "going-out rate" in city centers estimated based on locational data of mobile phone users was frequently reported on TV and in newspapers in Japan.

Japanese government ministries are also using big data to provide information on people's movements and consumption.

RELATED RESEARCHES

COVID-19 and people's movement

- In Tokyo, non-compulsory measures against the COVID-19 have sufficiently reduced people's inflow and decrease the effective reproduction number. (Yabe et al. ,2020) .
- In Osaka, compared to the pre-pandemic period, spatial extent of people's activities was reduced by half during the pandemic (Kato, 2021).

Social network and community detection

- Locations and call logs of mobile phone users were used to reconstruct interactions and functional areas among residents to study social and spatial segregation.
- Guo et al. (2018), Shi et al. (2015), Xu et al. (2021), Zhang et al. (2022)、Dannemann et al (2018)、Moya-Gomez, B. et al (2021)

The long-term behavioral changes during the pandemic period, as well as variations in the movement of people have not been fully explored **throughout the city**.

AIM OF THIS RESEARCH

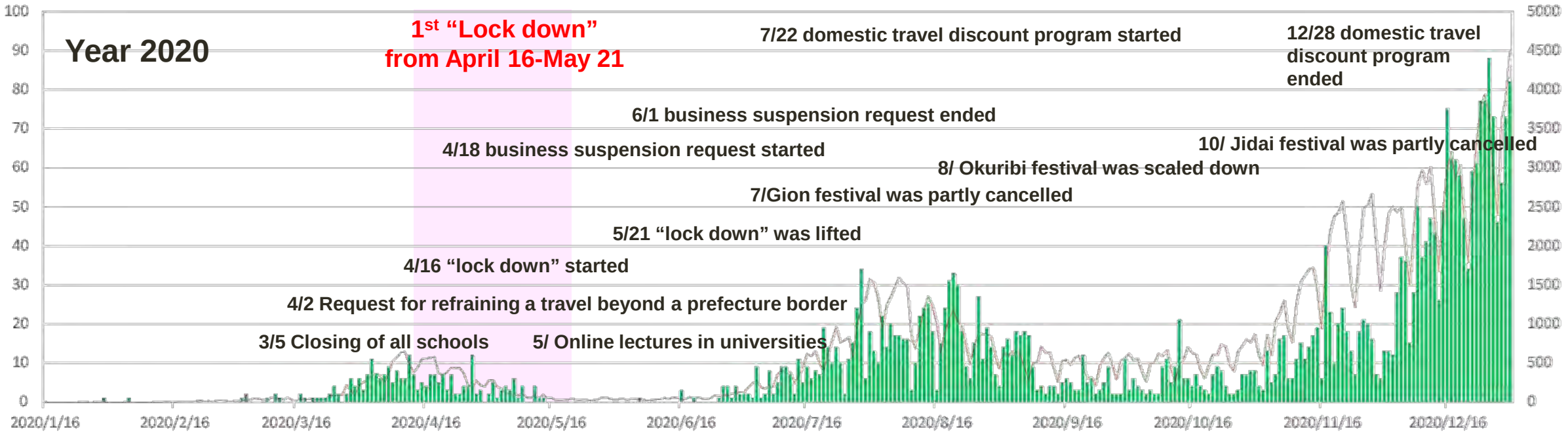
This study attempts to understand spatio-temporal distributions of people in Kyoto City based on mobile phone location data. In particular, our analysis focus on long-term changes and the differences by area.

Study area: Kyoto City, Japan

- The population size of the city is approximately 1.5 million.
- Kyoto City, the ancient capital of Japan, attracts domestic and international tourists.

Study period: 24 months from January 2019 to December 2020

COVID-19 DAILY TREND IN KYOTO & JAPAN



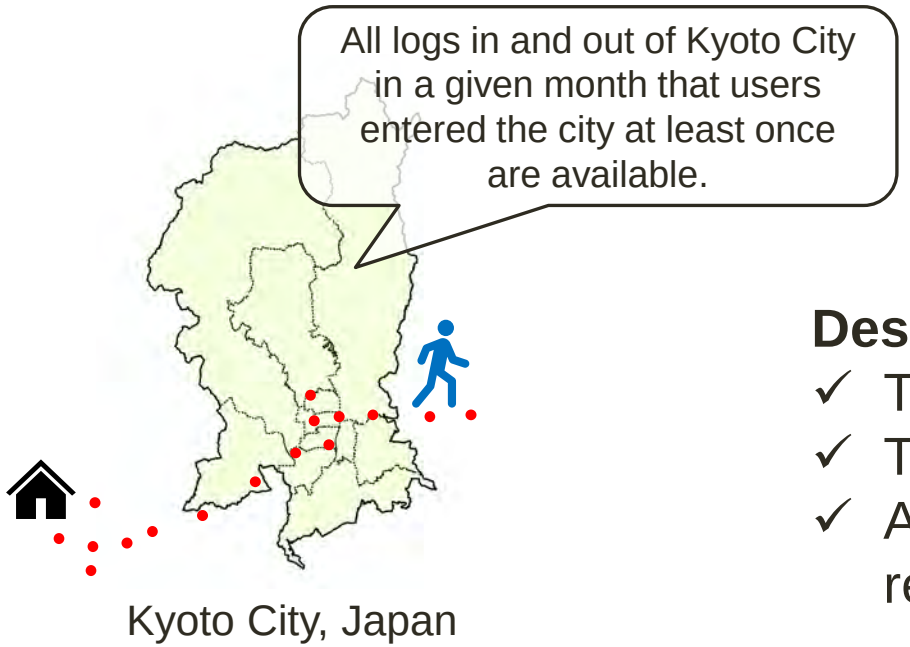
New infected cases in Kyoto City in Japan

All large traditional festivals were greatly scaled down in 2020

MOBILE PHONE BIG DATA

We use locational data of mobile phone users collected through apps installed in smartphones. The data was provided by Blogwatcher Ltd.

- The data covers 24 months from January 2019 to December 2020.
- The data includes trajectories of both Kyoto City residents and visitors.
- Estimated home and workplace locations are relocated to the center of a grid cell to protect privacy.



Kyoto City, Japan

Descriptive statistics of the data (2 years)

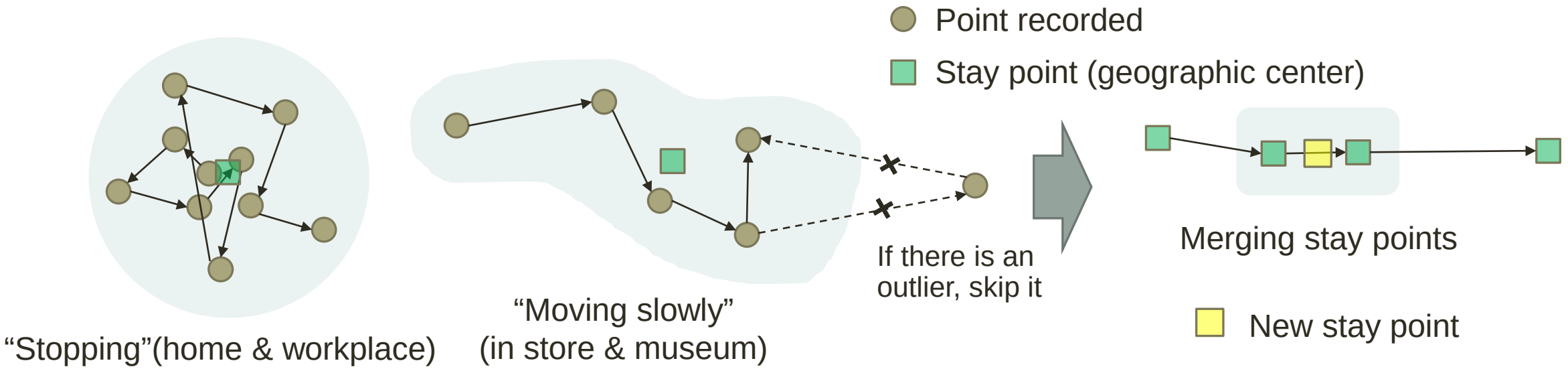
- ✓ Total recorded points: 48.7 billion points
- ✓ Total unique ids(smartphones): 4.42 million
- ✓ Average (mode) interval time between two recorded points: 5-6 minutes

ESTIMATION OF STAY POINTS

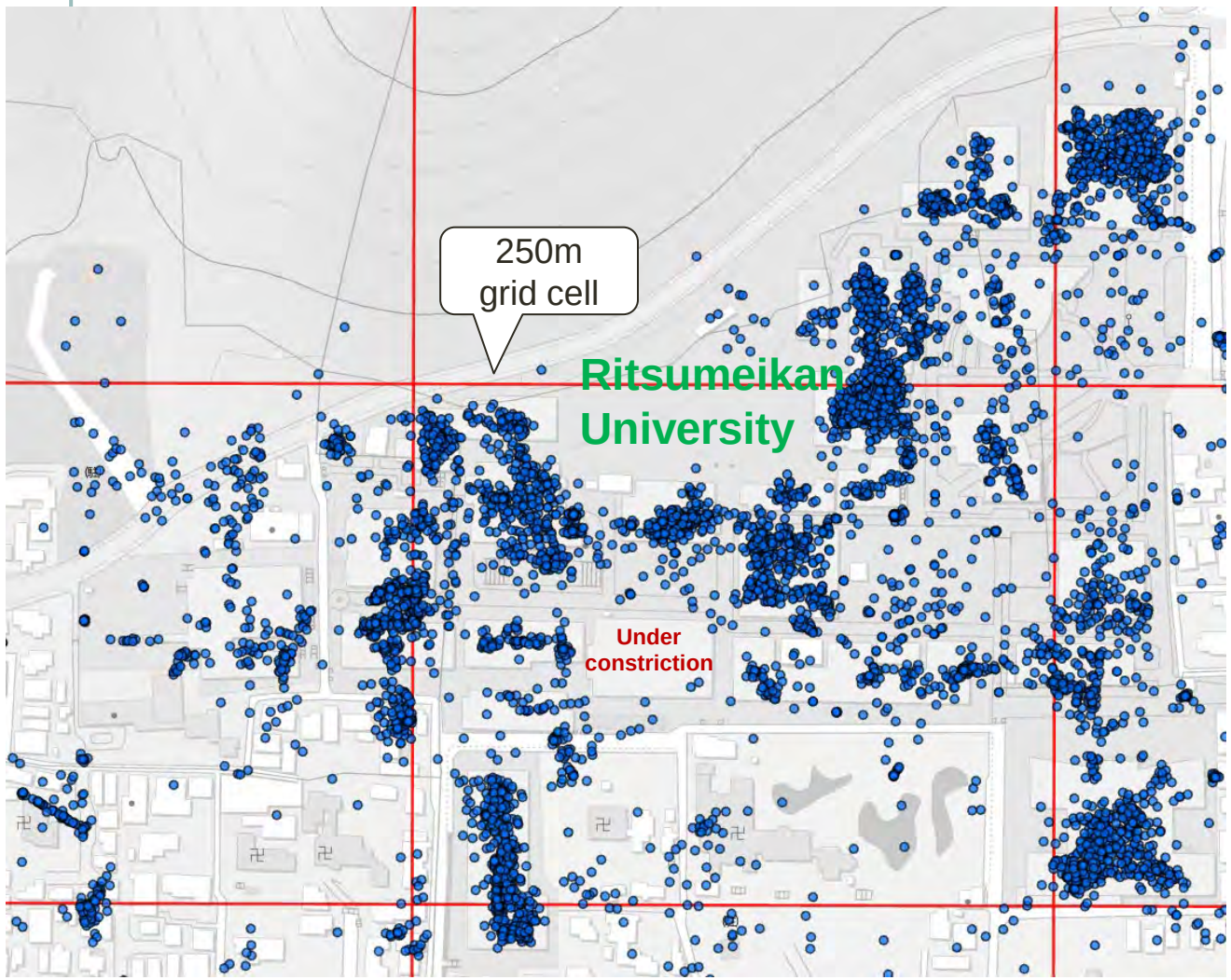
Types of stay points considered; “stopping” and “moving slowly”.

Points were considered ‘staying’ if the speed of travel between two consecutive points was less than 30m/min (normal walking speed for women in 60s: 72m/min) and the distance between them was less than 40m. We removed outliers caused by weak GPS signals.

Furthermore, if the interval between two consecutive stay points was less than 6 hours and the distance was less than 40m, they were merged as a single stay point. This procedure was performed twice.



RESULTS OF STAY POINT ESTIMATION



(Stay points outside home & workplace, May 2019)

1. We extracted 110 million points where people stayed longer than 10 minutes out of 49.7 billion log points.
2. Time spent on weekdays and weekends was calculated using the 250m grid cell or distance band from home, etc.

RESULTS OF ANALYSIS

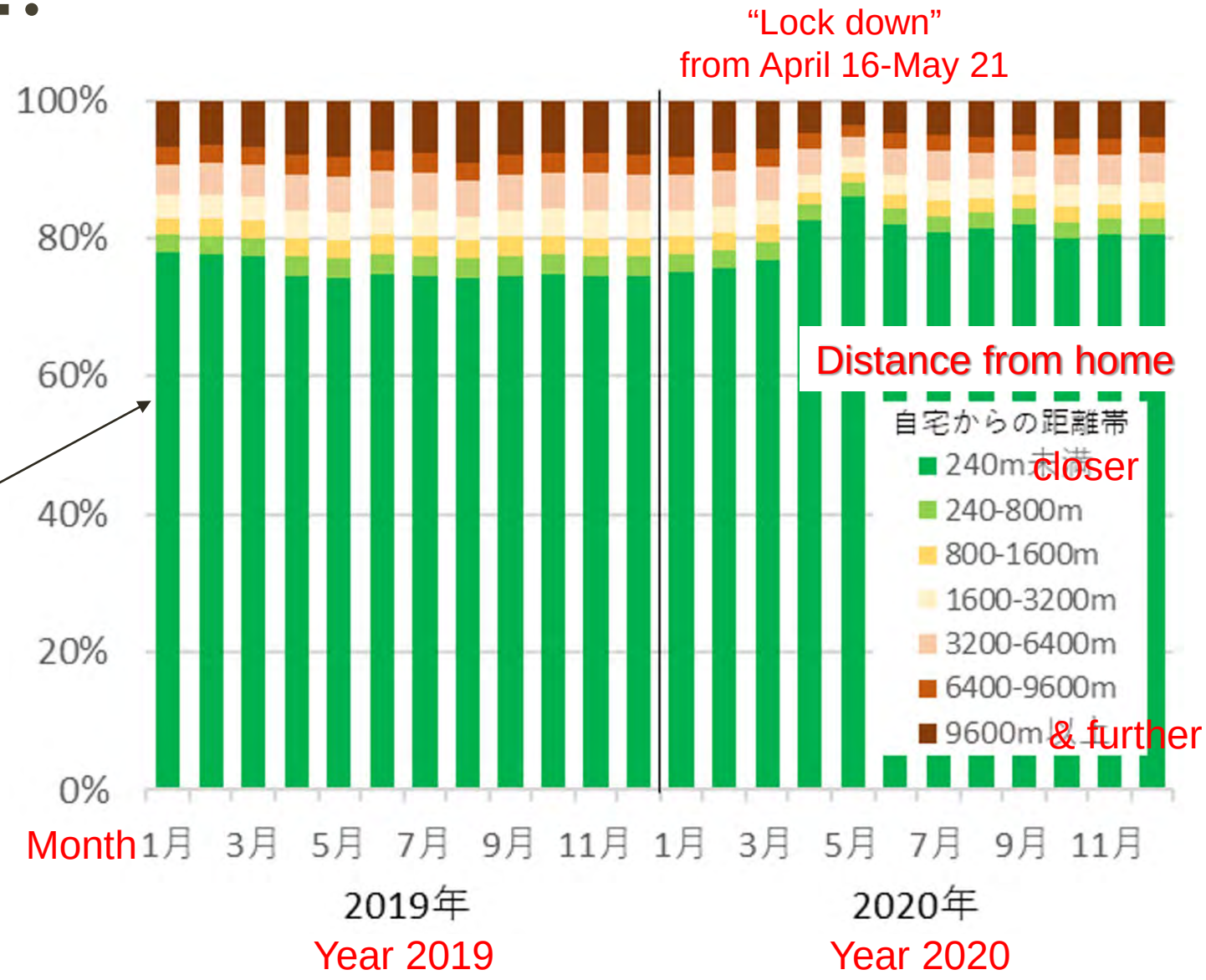
1. To what extent Kyoto residents have changed their activity space?
2. Where did Kyoto residents go on weekends in the city?
3. Where did residents of a particular neighborhood stay in the city?
4. Where do people from different regions are likely to encounter?

1. TO WHAT EXTENT KYOTO RESIDENTS HAVE CHANGED THEIR ACTIVITY SPACE?

This graph shows the percentage of time spent by distance band from home for 24 months.

The percentage of people staying closer than 240m from home (green bar) remained at just under 80% in 2019. However, **since April 2020, it has exceeded 80%.**

Even after the 'lockdown' ended in late May 2020, it remained around 5 points higher than before.

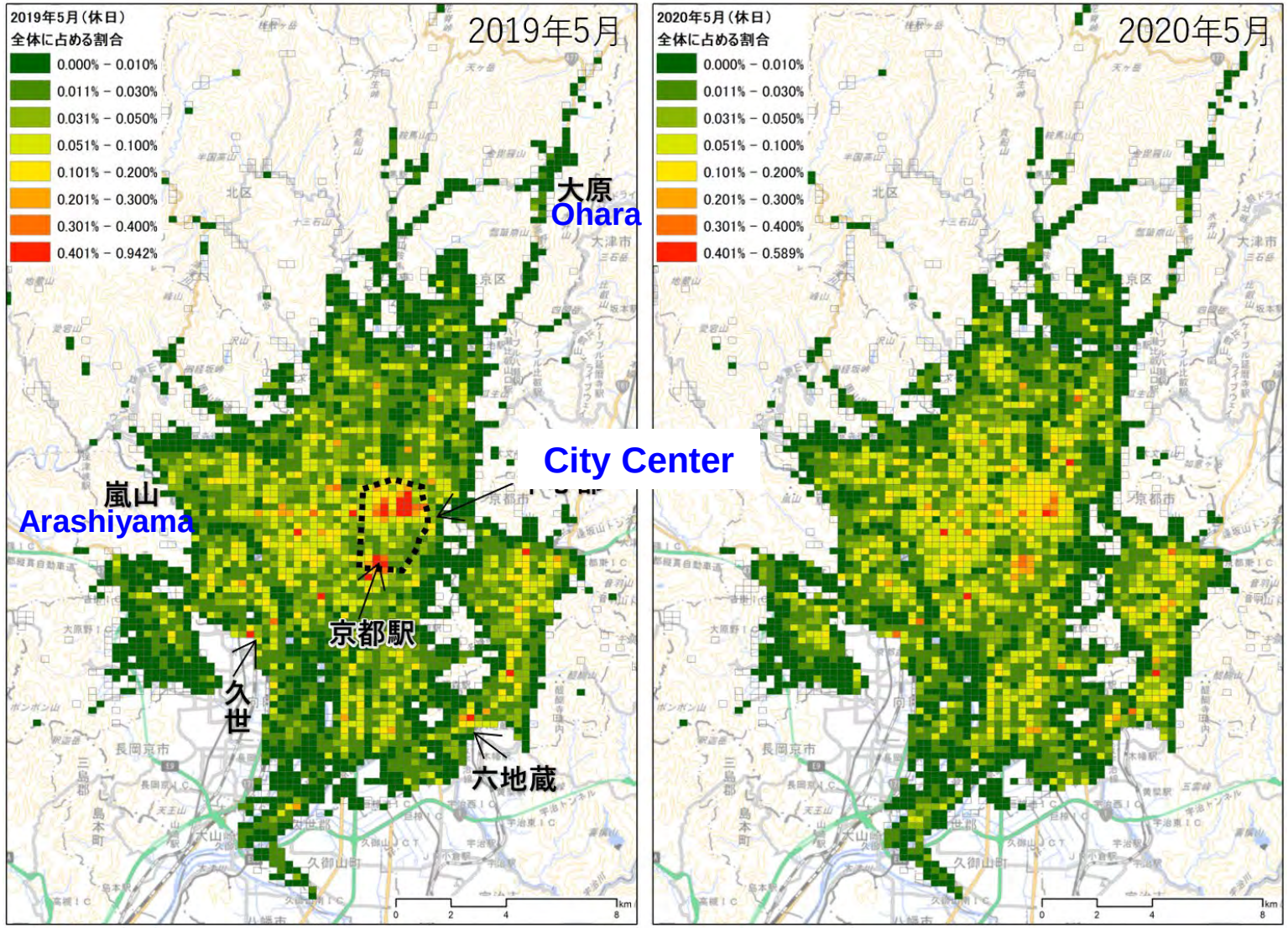


2. WHERE DID KYOTO RESIDENTS GO ON WEEKENDS IN THE CITY?

The total time spent by Kyoto residents outside of their homes on weekends were tabulated by the 250m grid cell.

These maps clearly show that during the pandemic, the residents avoided visiting the city center and stayed closer to their homes than before.

Fewer red cells in the city center and more bright green cells in suburbs.



May 2019 (Weekends)

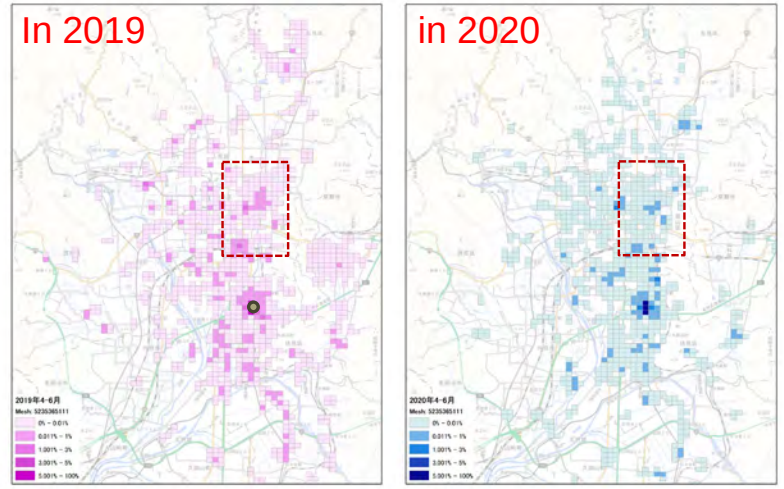
May 2020 (Weekends)

3. WHERE DID RESIDENTS OF A PARTICULAR NEIGHBORHOOD STAY IN THE CITY?

Three neighborhoods in the suburbs were selected and kernel densities of stay points were calculated for three months from April to June in 2019 and 2020, respectively.

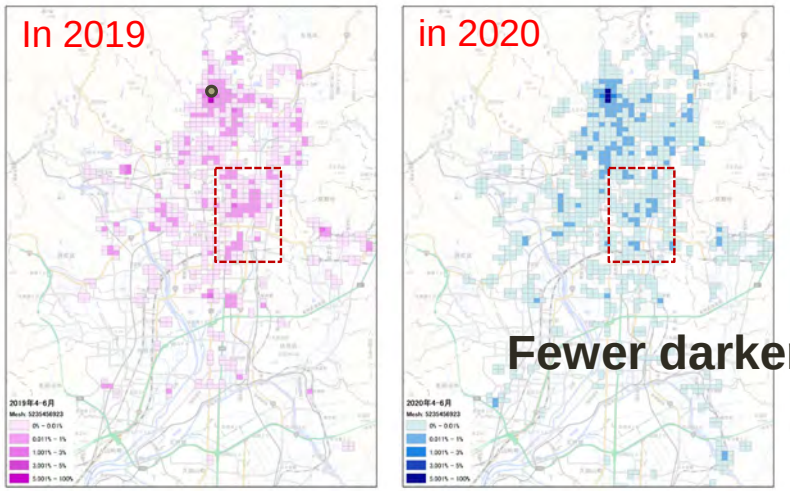
Residents in these neighborhoods stayed close to home or in places that were easily accessible from home by train or bus.

During the pandemic, **residents visited a wide area but appeared to spend less time in the center**. These results would reflect the impact of shop closures and people's attitudes to social distancing.

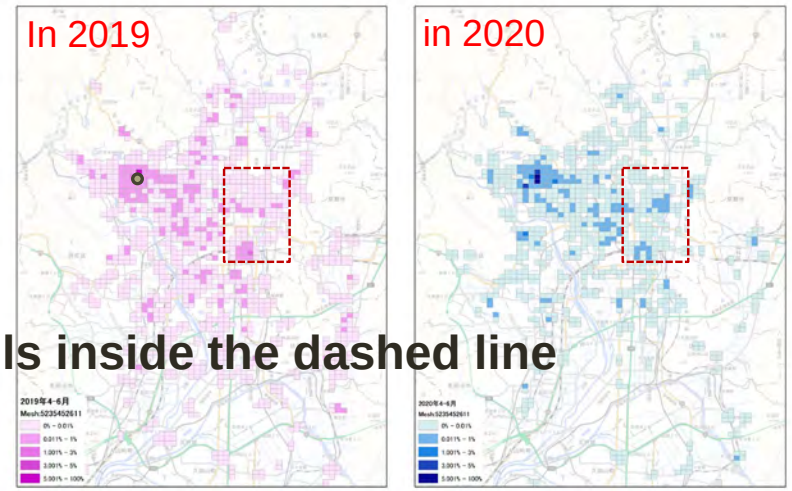


Distribution of staying points of neighborhood A

Home location City Center



Distribution of staying points of neighborhood B



Distribution of staying points of neighborhood C

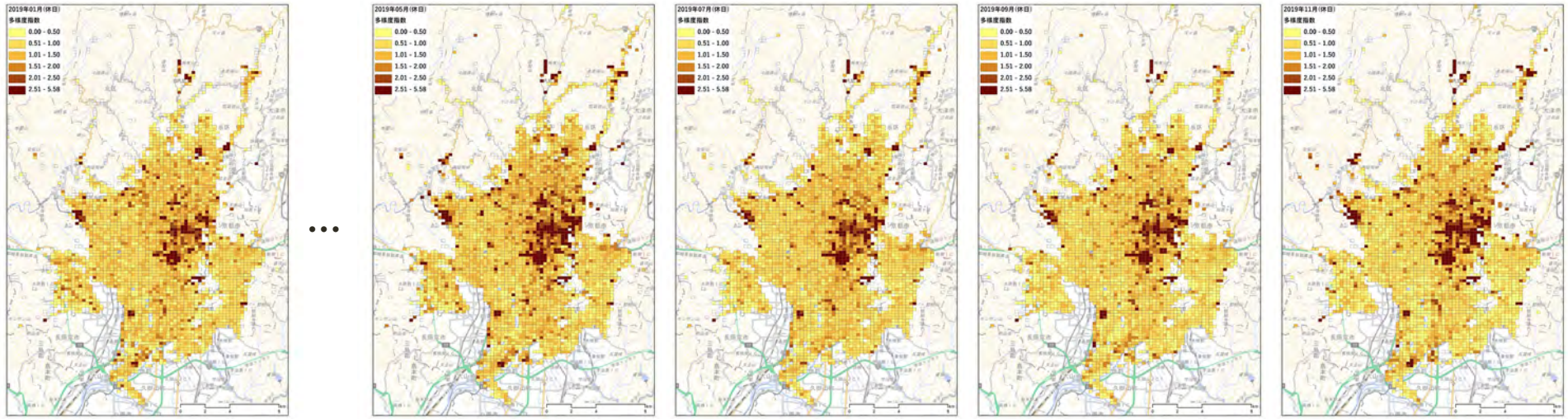
Fewer darker cells inside the dashed line

4. WHERE DO PEOPLE FROM DIFFERENT REGIONS ARE LIKELY TO ENCOUNTER?

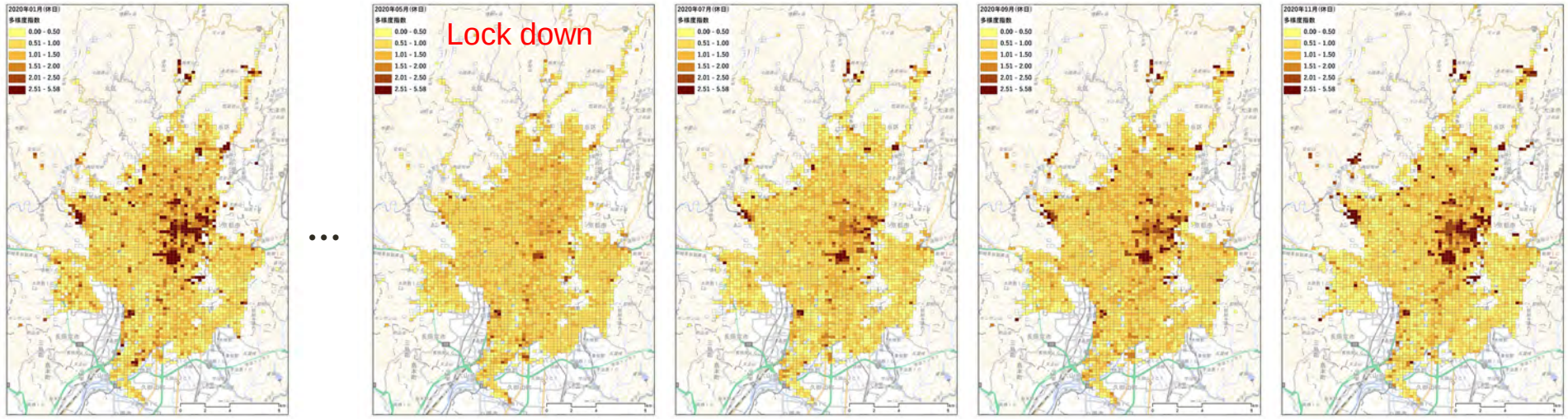
Origins of visitors (by prefecture) from Hokkaido to Okinawa prefecture and abroad (48 regions in total)

北海道	青森	・・・	・・・	・・・	・・・	滋賀	京都	大阪	・・・	・・・	・・・	・・・	沖縄	海外
0.01	0.05					0.18	0.25	0.20					0.03	0.01

$$Entropy = \sum p_i \log_2(1/p_i)$$



January, 2019 … May, 2019 July, 2019 September, 2019 November 2019



January, 2020 … May, 2020 July, 2020 September, 2020 November 2020

Diversity index (entropy bit)

- 0.00 - 0.50
- 0.51 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 2.50
- 2.51 - 5.58

Low All visitors come from the one region

High Visitors came from all 48 regions equally

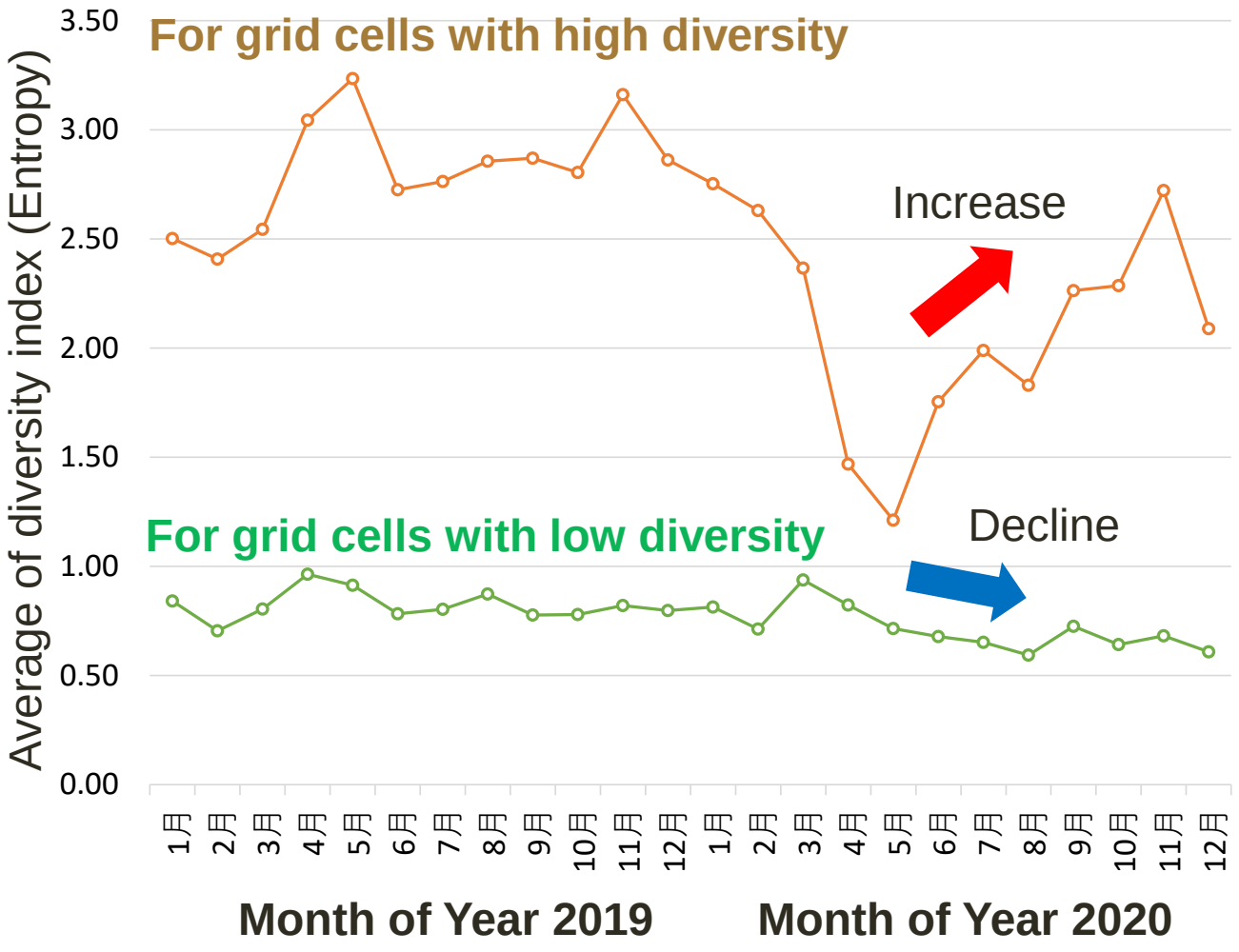
CHANGES IN DIVERSITY INDEX BY REGIONAL TYPE

To understand the changes in the diversity index by type of region, we separated regions with high and low diversity as of April 2019 (prior to COVID19).

In regions with high diversity, the index fell significantly under the lockdown. However, as soon as it was lifted, the diversity index rose again.

On the other hand, in regions with low diversity (mainly suburbs), the index has continued its gradual decline rather than rising.

These results suggest that after the “lock down” was lifted, the inflow returned in the city center and touristic sites, but in residential and neighborhood commercial areas in the suburbs, residents continued to avoid meeting visitors (relatives & friends) from outside Kyoto City.



SUMMARIES

1. During the pandemic, the percentage of “stay home” increased by more than 10 percentage points in May 2020 compared to the pre-pandemic period. Even after the emergency declaration was lifted, it did not return to its previous level and remained about 5 percentage points higher.
2. During the pandemic, people moved widely around the city, but did not visit the city center where people could not maintain social distancing and stores were closed due to government requests. These changes in people’s mind and spatial behavior were revealed and visualized using big data from mobile phones.
3. Based on our long-term observation of people’s movements, visitors from other regions disappeared during the pandemic. After the end of the emergency declaration, the number of visitors from various prefectures were recovered rapidly in the city center and touristic sites, but not in residential areas and neighborhood commercial areas.

In conclusion, using big data from mobile phones allows us to perform long-term spatio-temporal analysis of people's movements at a very fine spatial scale across an entire city. We plan to add the 2021 and 2022 datasets for the further analysis.

20-MINUTE NEIGHBOURHOOD/CITY

In European countries, lockdowns were implemented during the COVID-19 pandemic. Urban planners discussed “20-minute neighbourhood”. It is a neighbourhood where one can live within a 20-minute walking distance from their homes.

THANK YOU FOR LISTENING

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