

Rethinking Prism Anchors: Investigating Spatial-Time Fixity and Flexibility of Activities using Smartphone-Based Activity-Travel Survey Data

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I. Introduction

The **space-time prism** in Hägerstrand's time geography delineates all accessible locations and time for individuals given their capability, coupling and authority constraints

- ❖ The prism anchors are defined using fixed activities such as *Home*, *Work* and *School*.
- ❖ Other flexible activities such as *Shopping*, *Recreation*, and *Eating Out* are scheduled between fixed activities.

However, different social-economic status of individuals may lead to distinct views on how flexible an activity is in their daily schedules.

- ❖ Individuals may have non-routine *Home*, *Work* and *School* activities with changing locations and/or time.
- ❖ Individuals may have routine *Shopping*, *Recreation*, and *Eating Out* activities due to specific constraints.

Smartphone-based activity-travel survey allows us to track individuals' movements in space and collect detailed information about their activities and trips in near real-time.

II. Objective

Investigating **the fixity of an activity type with respect to spatial locations and time periods** using activity-travel survey data collected by smartphone.

Specific Aims

1. Spatial Stationarity

Whether an activity episode is stationary (SA) or non-stationary (NSA) based on its spatial trajectory.

2. Temporal Fragmentation

Whether the allocation of time for an activity type is fragmented based on all episodes of that type within a day

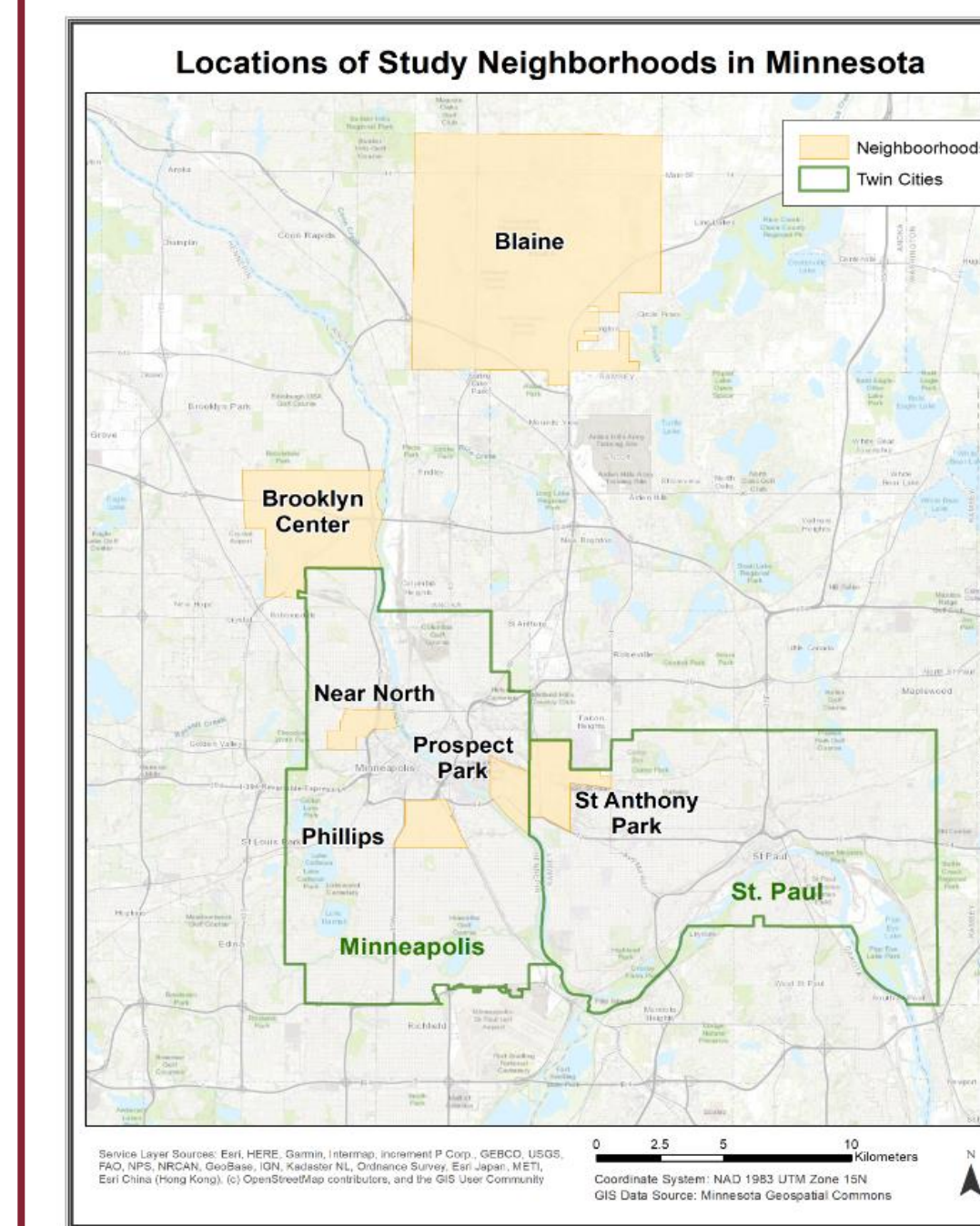
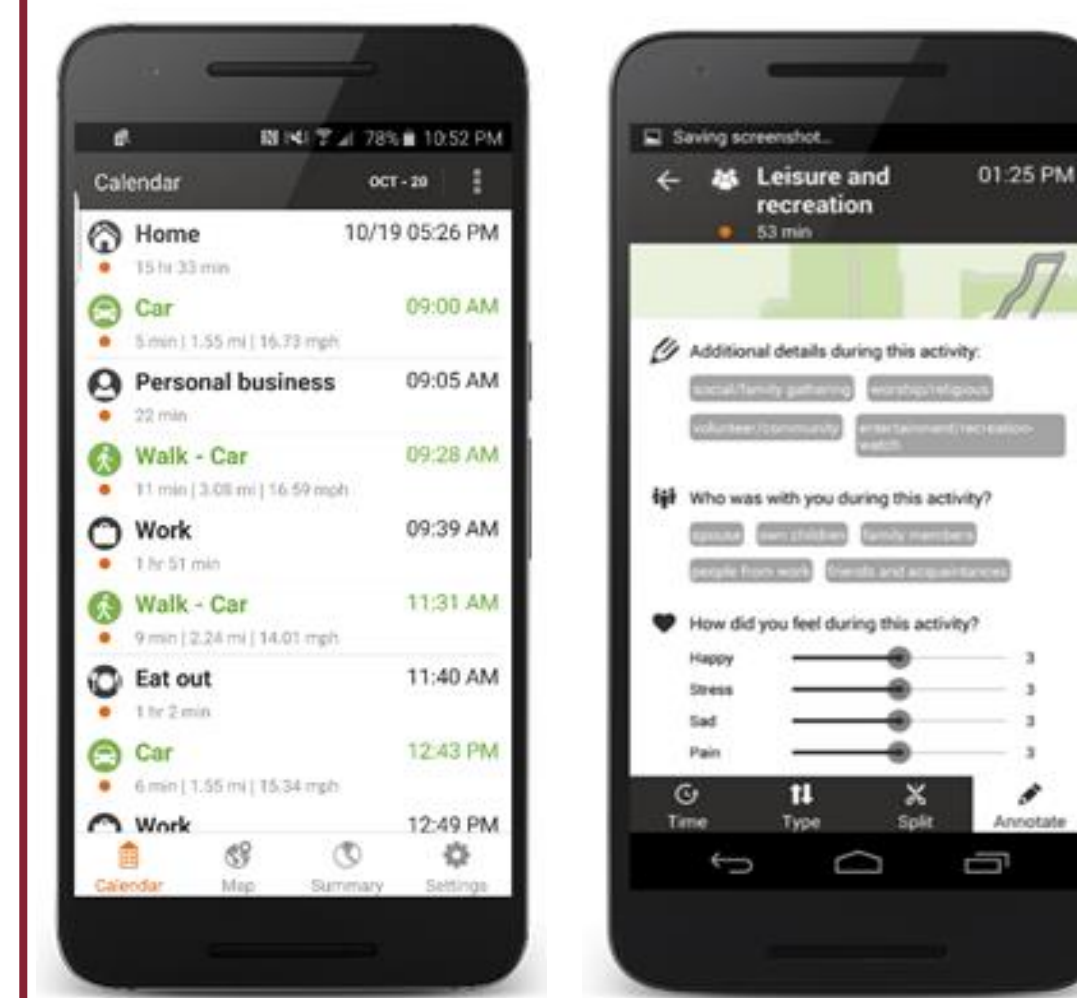
3. Spatial-temporal Recurrence

Whether episodes for an activity type occur recurrently at a location during similar time.

4. Individual Variation

Whether these findings vary across different individuals or groups

III. Data Collection



❖ Daynamica Application

- Activity Episodes (e_{ij})
 - User ID (u_i)
 - Episode Seq (s_j)
 - Activity Type ($c_{ij} \in C$)
 - Start Time (ts_{ij})
 - End Time (te_{ij})
 - Trajectory ($L_{ij} = \{(x_k, y_k)\}_{t_{ij}}$)
- Activity Types (c_{ij})
 - Home (H)
 - Work (W)
 - Education (E)
 - Personal business (P)
 - Shop (S)
 - Eat out (O)
 - Leisure/Recreation (L)
 - Other/Unknown (U)
- ❖ **Twin Cities Metro Areas**
 - 372 participants
 - 6 neighborhoods
 - 7-day survey period

IV. Methods

1. Spatial Stationarity

- (1) **Spatial region**: Convex hull; square root of area (SRA)
- (2) **Dispersion**: standard deviational ellipse (SDE); maximum distance to mean center (MDM)
- (3) **Change in status**: start and end locations

Calibrate threshold value for "SMALL": [Box-Cox t distribution](#)

Categorize activities into stationary and non-stationary

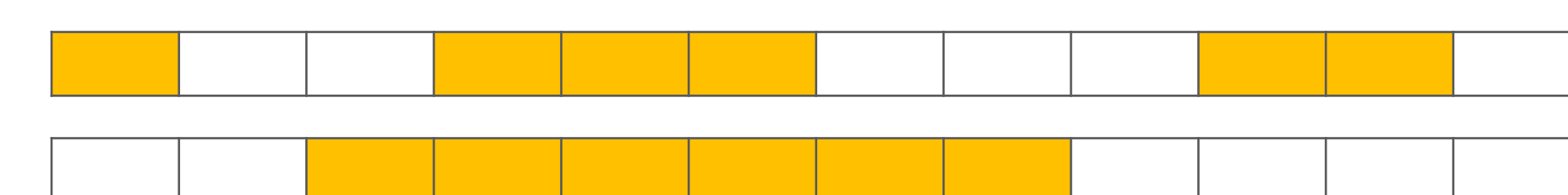
Get locations for SAs:

- ✓ Episode-level: [center of SDE](#)
- ✓ Individual-level: [list of SDE centers](#)

Get stationary part for NSA:

- ✓ Episode-level: [density-based cluster\(s\)](#)
- ✓ Individual-level: [compare cluster\(s\) to SAs' list](#)

2. Temporal Fragmentation



Fragmented
Condensed

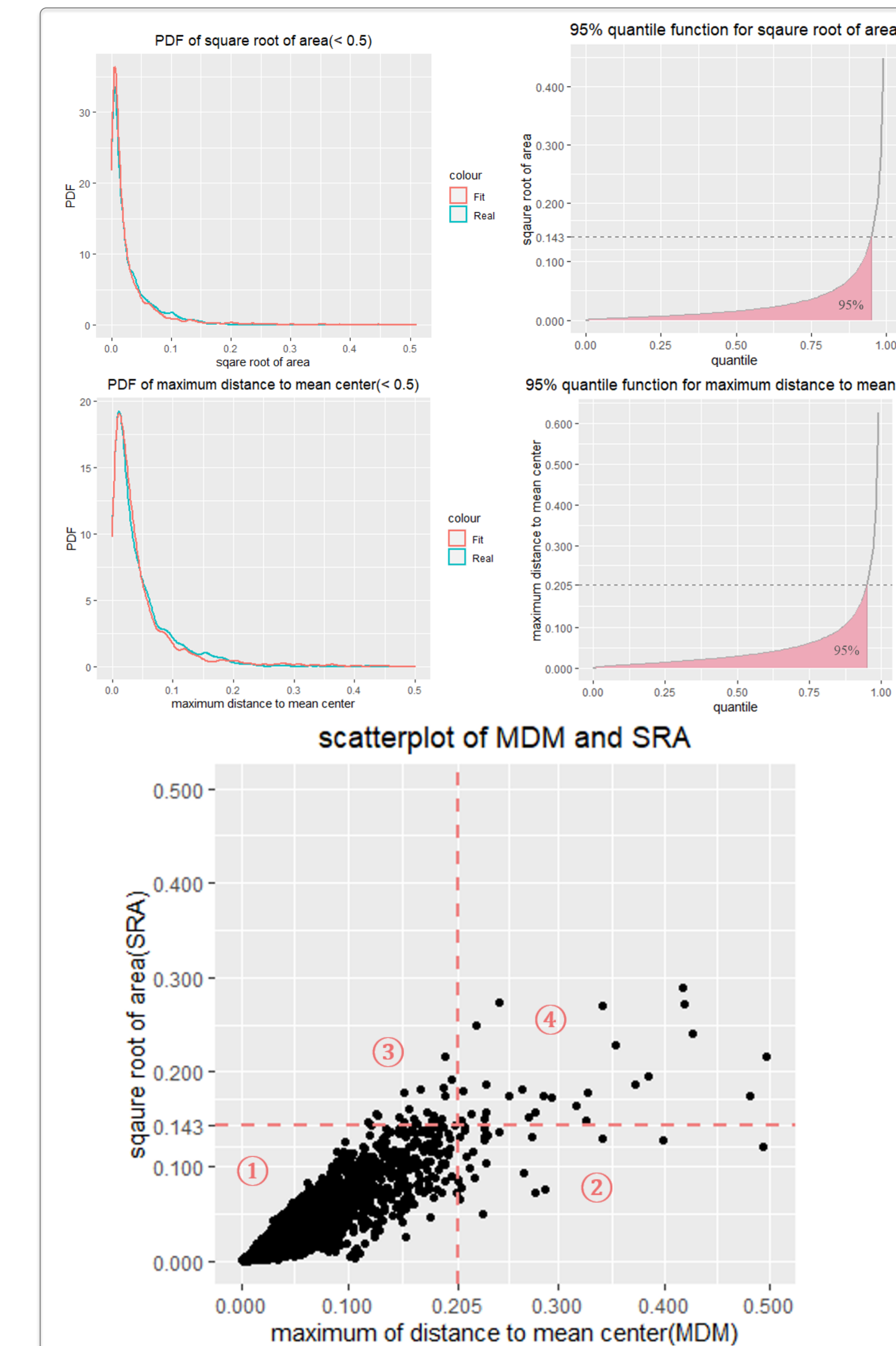
- (1) **Time range**: first starts till last ends $te_{Nj} - ts_{0j}$
- (2) **Total duration within the range** $\sum_{c_{ij}=c} (te_{ij} - ts_{ij})$

3. Spatial-temporal Recurrence

- (1) **Cluster(s) of SA locations**
- (2) **Temporal profiles of each cluster**

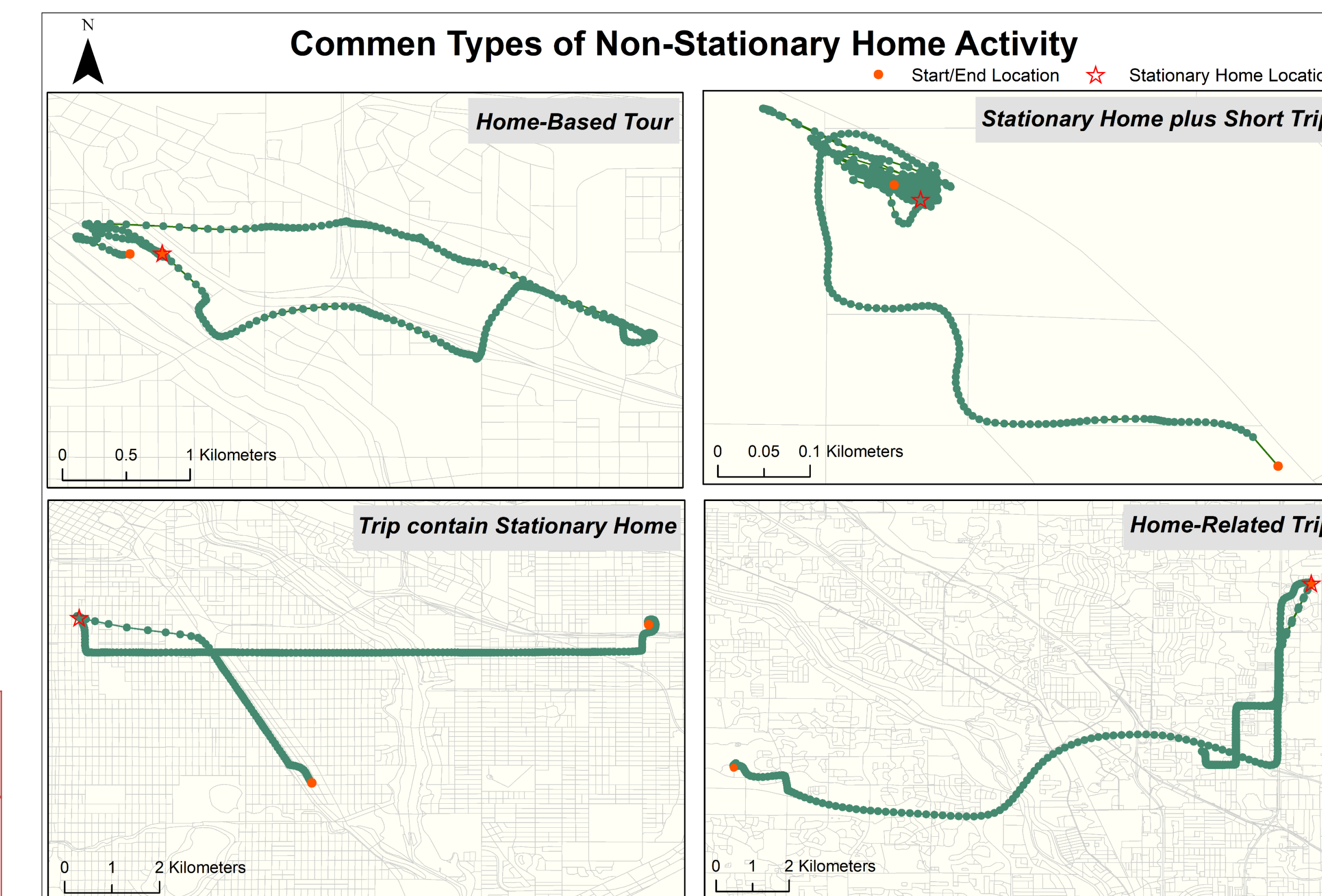
V. Preliminary Results

❖ Spatial stationarity: Home-based tours and trips are sometimes considered as home activities

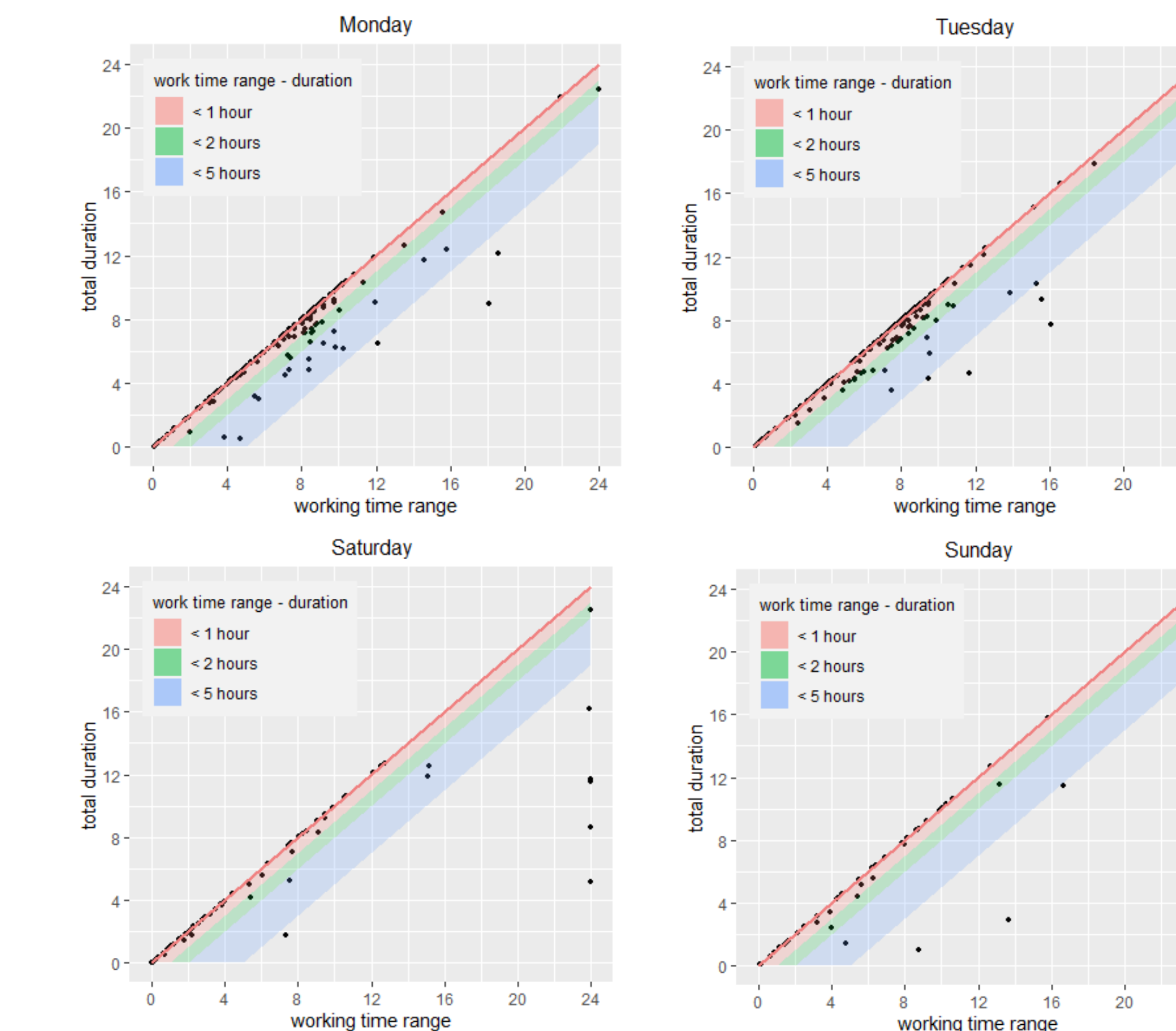


Number of Home	0	1	2	3	4	5	6	7	9	12
Number of Users	29	265	46	17	7	1	1	3	1	2

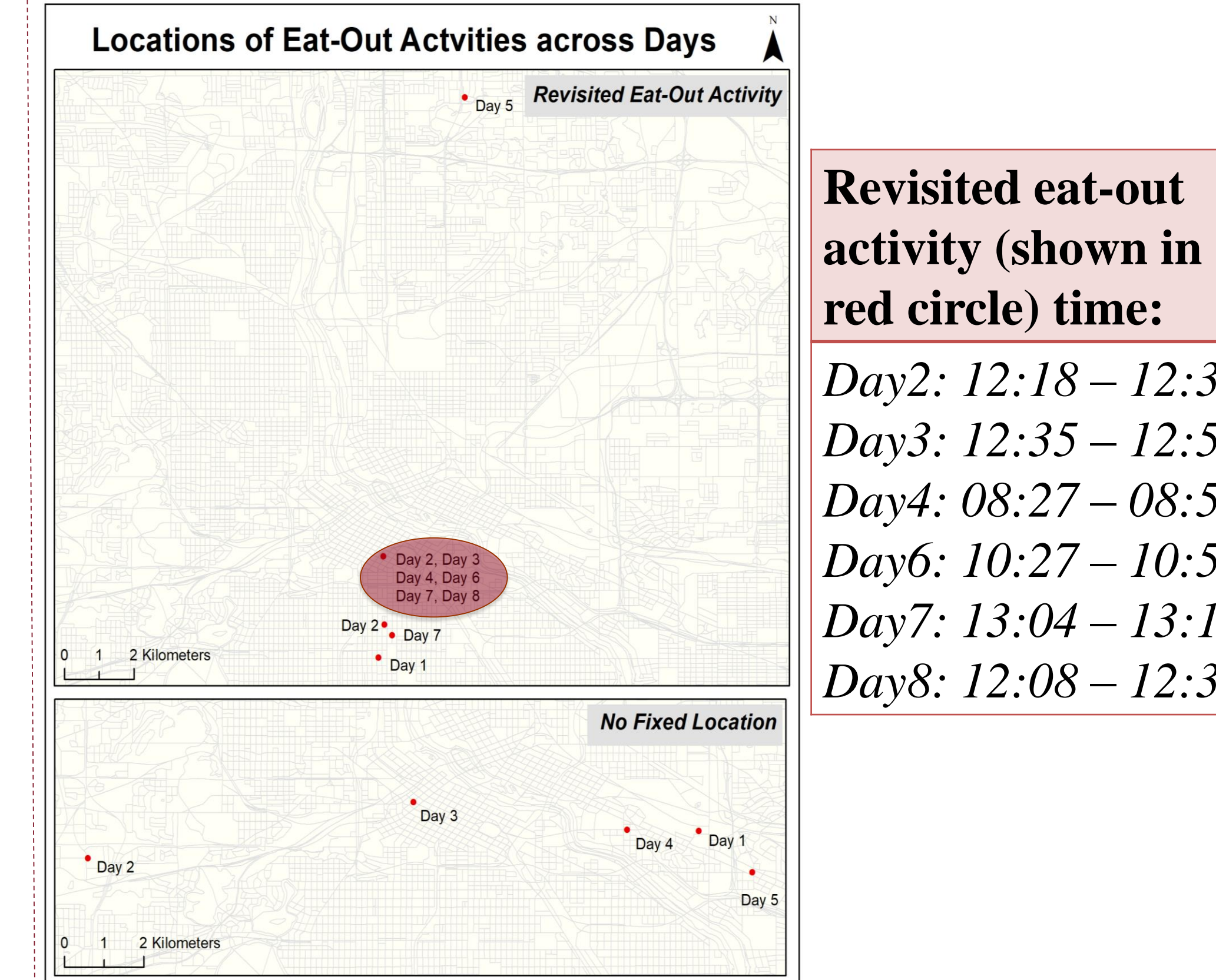
Region	Criteria			Category of activities
	SRA	MDM	start-end	
①	Small ≤ 0.143	Small ≤ 0.205	(Small) ≤ 0.205	Stationary home activity (SH)
②	Small ≤ 0.143	Large > 0.205	Small/Large	SH with GPS noises; SH plus short trip
③	Large > 0.143	Small ≤ 0.205	Small/Large	SH with GPS noises; Home-based tour
④	Large > 0.143	Large > 0.205	Small	SH with GPS noises; Home-based tour
			Large	Long trip that may contain home locations



❖ Temporal Fragmentation: Working time may scatter within a day, especially during weekends



❖ Recurrence: Eat-out at the same locations during similar time across multiple days



Revisited eat-out activity (shown in red circle) time:

Day2: 12:18 – 12:34
Day3: 12:35 – 12:58
Day4: 08:27 – 08:54
Day6: 10:27 – 10:56
Day7: 13:04 – 13:17
Day8: 12:08 – 12:37

VI. Conclusion

- ❖ Intuitively fixed activities such as home and work may be non-stationary or occur at fragmented time.
- ❖ Intuitively flexible activities such as eat out may reoccur at the same locations during similar time.
- ❖ The prism anchors could be personalized by learning from individuals' previous schedules.