all-city matrics result 930

⚠️Methodological Notes

Data filtering:

- Users were filtered out if their predictability q<0.8 or if they had fewer than 5 check-ins.
- Hourly indicators (R(t), N(t)) were computed only when there were at least 4 active users in a time slot, to reduce the impact of sparse data.

Smoothing:

- Both R(t) and N(t) were smoothed using a **6-hour rolling average**.
- Time was aggregated into **2-hour bins**, which improves stability compared to purely hourly granularity.

Interpretation limits:

- **Data sparsity is a major issue**: in many cities, the number of valid users after filtering is very small (e.g., Tokyo with only 2 users, Palembang with only 3 users). This leads to highly discontinuous or even blank R(t) and N(t) curves, which limits interpretability.
- Some cities (e.g., São Paulo) show **extreme outliers** in the radius of gyration (Rg max ~450 km), which skews the mean. For such cases, the **median values provide a more reliable picture**.
- For sparse cities, results often reflect **data limitations rather than true behavioral patterns**, and this needs to be emphasized in interpretation.

Cross-city observations:

- **Large differences in valid users:** New York, Istanbul, and Petaling Jaya retain over a hundred valid users after filtering, while Tokyo and Palembang are reduced to only a handful.
- **Regularity (R):** Bandung (~0.88), Palembang (~0.92), and Tangerang (~0.96) show very high regularity, indicating fixed travel patterns; Tokyo (~0.45) and Moscow (~0.70) are less regular, with more variable mobility.
- **Radius of gyration (Rg):** In most cities, the median Rg falls between 2–5 km, reflecting typical intra-city movement. São Paulo is an outlier, with

extreme long-distance movers that raise the mean (~12 km).

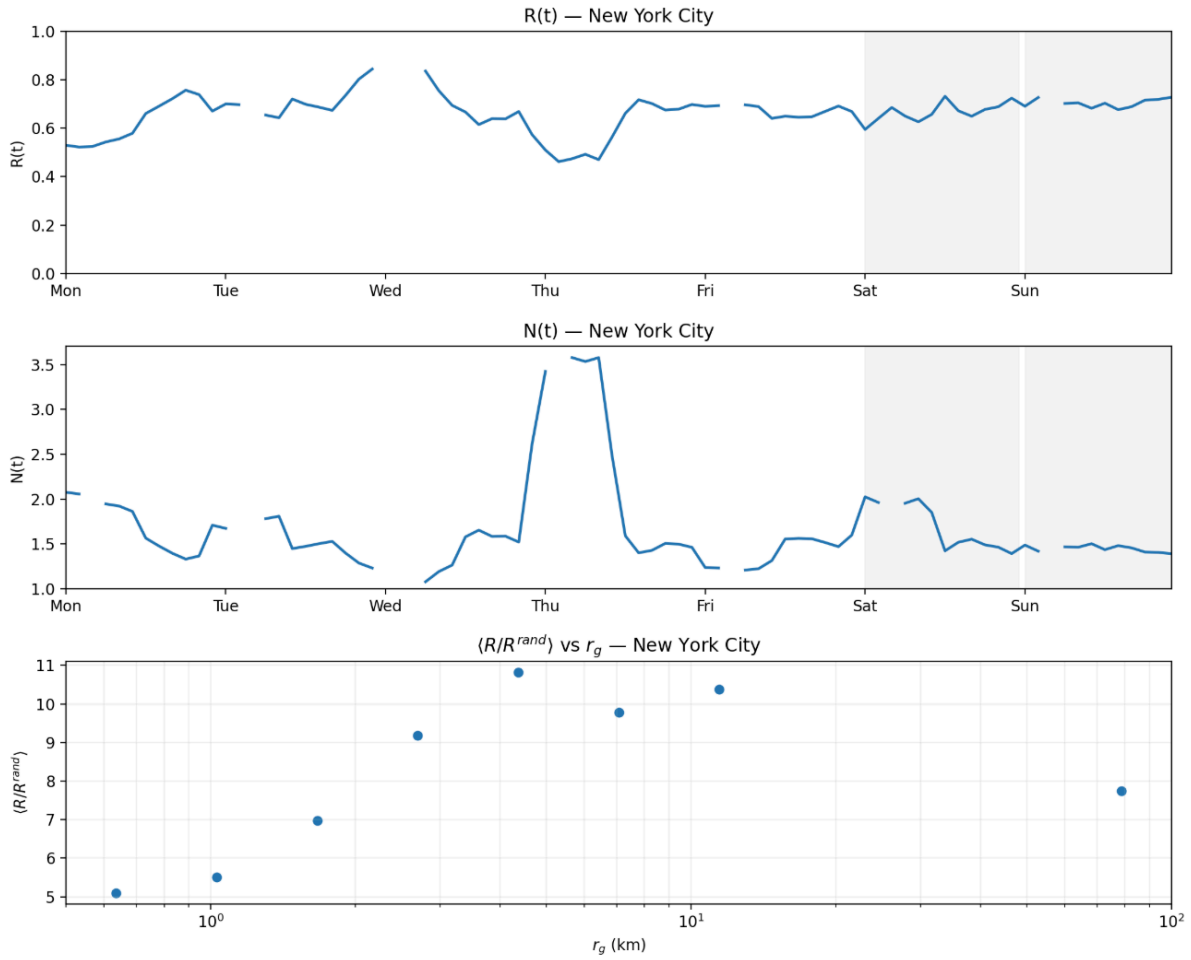
- **Theoretical predictability upper bound (Π_max):** Across most cities, the median Π_max falls around 0.14–0.2.

Beijing city:

- No valid users after filtering—so no figure and summary

New York

Figure



Summary

```
{
  "city": "New York City",
  "tz": "America/New_York",
  "n_users_total": 6917,
  "n_users_valid": 224,
  "q": {
    "mean": 0.7051434231956532,
    "median": 0.7523645670532022,
    "p25": 0.7036803112261505,
    "p75": 0.7836779371873733,
    "min": -0.36363636363636354,
    "max": 0.7993311036789298,
    "count": 224
  },
  "S_unc": {
    "mean": 3.3604178389559722,
    "median": 3.321928094887362,
    "p25": 2.807354922057604,
    "p75": 3.906890595608518,
    "min": 1.9182958340544893,
    "max": 5.76271457556825,
    "count": 224
  },
  "S_rand": {
    "mean": 3.379249096276548,
    "median": 3.321928094887362,
    "p25": 2.807354922057604,
    "p75": 3.906890595608518,
    "min": 2.0,
    "max": 5.78135971352466,
    "count": 224
  },
  "Pi_max": {
    "mean": 0.42643558004200216,
    "median": 0.14285714285714285,
    "p25": 0.1,
    "p75": 1.0,
    "min": 0.03225806451612903,
```

```
    "max": 1.0,
    "count": 224
  },
  "Rg_km": {
    "mean": 5.378410291668346,
    "median": 3.114735727054386,
    "p25": 2.320963412224152,
    "p75": 3.87176208838558,
    "min": 0.24318912156265377,
    "max": 475.2944062854159,
    "count": 224
  },
  "R": {
    "mean": 0.8444459208053673,
    "median": 0.875,
    "p25": 0.7692307692307693,
    "p75": 1.0,
    "min": 0.2631578947368421,
    "max": 1.0,
    "count": 224
  },
  "figure": "reports/figures/new-york-city_fig3_combined.png"
}
```


Analyze

For New York City, after filtering sparse trajectories (6917 users → 224 valid users), we calculated multiple mobility metrics:

- **Sparsity (q):**

  Median q ≈ 0.75, indicating that user trajectories are moderately sparse but still usable for analysis.

- **Entropy (S_unc and S_rand):**

  Both entropies center around 3.3–3.4 bits, showing that users visit a limited but diverse set of places, with random entropy (S_rand) only slightly higher than empirical entropy (S_unc).

- **Predictability (Π_max):**

The median predictability upper bound is low (≈0.14), but the distribution is highly skewed — some users can be predicted with very high certainty (Π_max=1). This matches the intuition that certain individuals have highly regular mobility patterns.

- **Radius of gyration (R_g):**

  The median R_g ≈ 3.1 km suggests most users' daily activity is concentrated locally, while the extreme maximum of 475 km reflects occasional long-distance travelers or noise.

- **Regularity (R):**

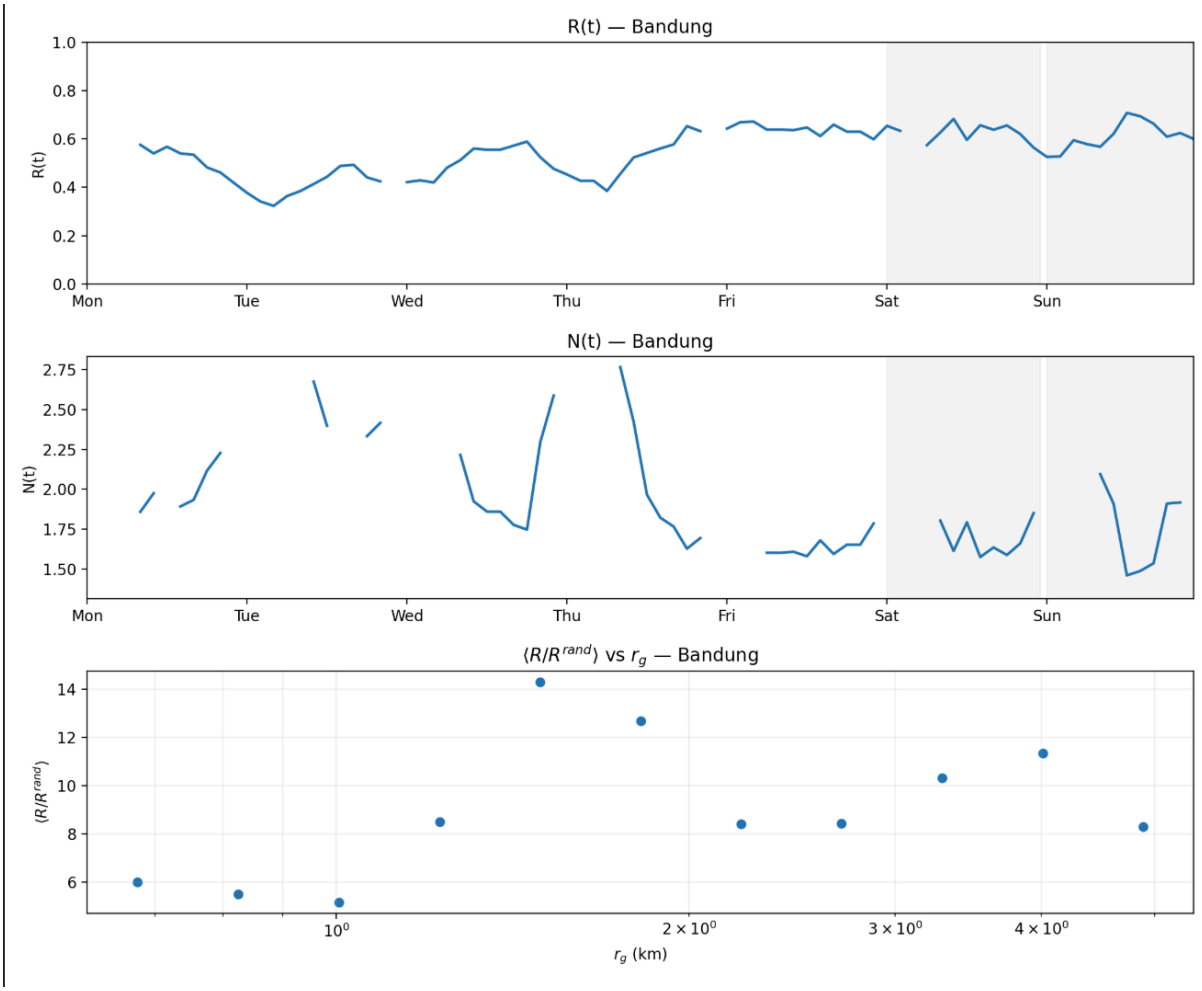
  The median R is very high (≈0.875), confirming that New York users tend to return to the same locations at similar times each week.

Conclusion:

New York mobility patterns are overall regular (high R), geographically localized (low R_g median), and moderately sparse (q ≈0.75). While entropy indicates some diversity in visited places, the predictability bound shows strong variation across individuals, from highly unpredictable to perfectly predictable.

Bandung

Figure



Summary


```
{
  "city": "Bandung",
  "tz": "Asia/Jakarta",
  "n_users_total": 3373,
  "n_users_valid": 48,
  "q": {
    "mean": 0.7047688276885253,
    "median": 0.7435894509157113,
    "p25": 0.6958683157982745,
    "p75": 0.7799156091739264,
    "min": 0.31034482758620685,
    "max": 0.7994530537830447,
    "count": 48
  },
  "S_unc": {
```

```
  "mean": 3.1642473074942856,
  "median": 3.0,
  "p25": 2.584962500721156,
  "p75": 3.6676679467063886,
  "min": 1.9219280948873623,
  "max": 5.980470166135719,
  "count": 48
 },
 "S_rand": {
  "mean": 3.208923121815893,
  "median": 3.0,
  "p25": 2.584962500721156,
  "p75": 3.7271685191202204,
  "min": 2.0,
  "max": 6.754887502163468,
  "count": 48
 },
 "Pi_max": {
  "mean": 0.5195526695526695,
  "median": 0.2,
  "p25": 0.13839285714285715,
  "p75": 1.0,
  "min": 0.09090909090909091,
  "max": 1.0,
  "count": 48
 },
 "Rg_km": {
  "mean": 2.1399213537467,
  "median": 1.946151337042658,
  "p25": 1.644743086301246,
  "p75": 2.583421127027563,
  "min": 0.6131578998881695,
  "max": 5.394572145105465,
  "count": 48
 },
 "R": {
  "mean": 0.8776384052501248,
  "median": 0.9,
```

```
    "p25": 0.8,
    "p75": 1.0,
    "min": 0.511400651465798,
    "max": 1.0,
    "count": 48
  },
  "figure": "reports/figures/bandung_fig3_combined.png"
}
```


Analyze

For Bandung, the dataset contains a total of **3373 users**, out of which **48 users** remain valid after filtering with thresholds (`q < 0.8` and at least 5 trajectory points). This is a relatively small subset (≈1.4% of total users), indicating that the data is **very sparse**.

- **Sparsity (q):**

  The average sparsity (q) is around **0.70**, with most users clustered between 0.69 and 0.78. This shows that user trajectories are generally sparse, with many hours having no data.

- **Entropy (S_unc vs S_rand):**

  The mean uncorrelated entropy (S_{unc}) is **3.16**, while the random entropy (S_{rand}) is slightly higher at **3.21**. This suggests that while users have some diversity in location visits, their actual uncertainty is slightly lower than random, implying recognizable mobility patterns.

- **Predictability ((\Pi_{max})):**

  The mean theoretical predictability is **0.52**, with a median of **0.20** but also many users reaching **1.0**. This wide spread indicates heterogeneity: some users are highly predictable, while others move more randomly.

- **Radius of Gyration (R_g):**

  The average (R_g) is **2.14 km**, with most users falling in the 1.6–2.6 km range. This shows that Bandung users tend to move within compact areas, with limited long-distance travel.

- **Regularity (R):**

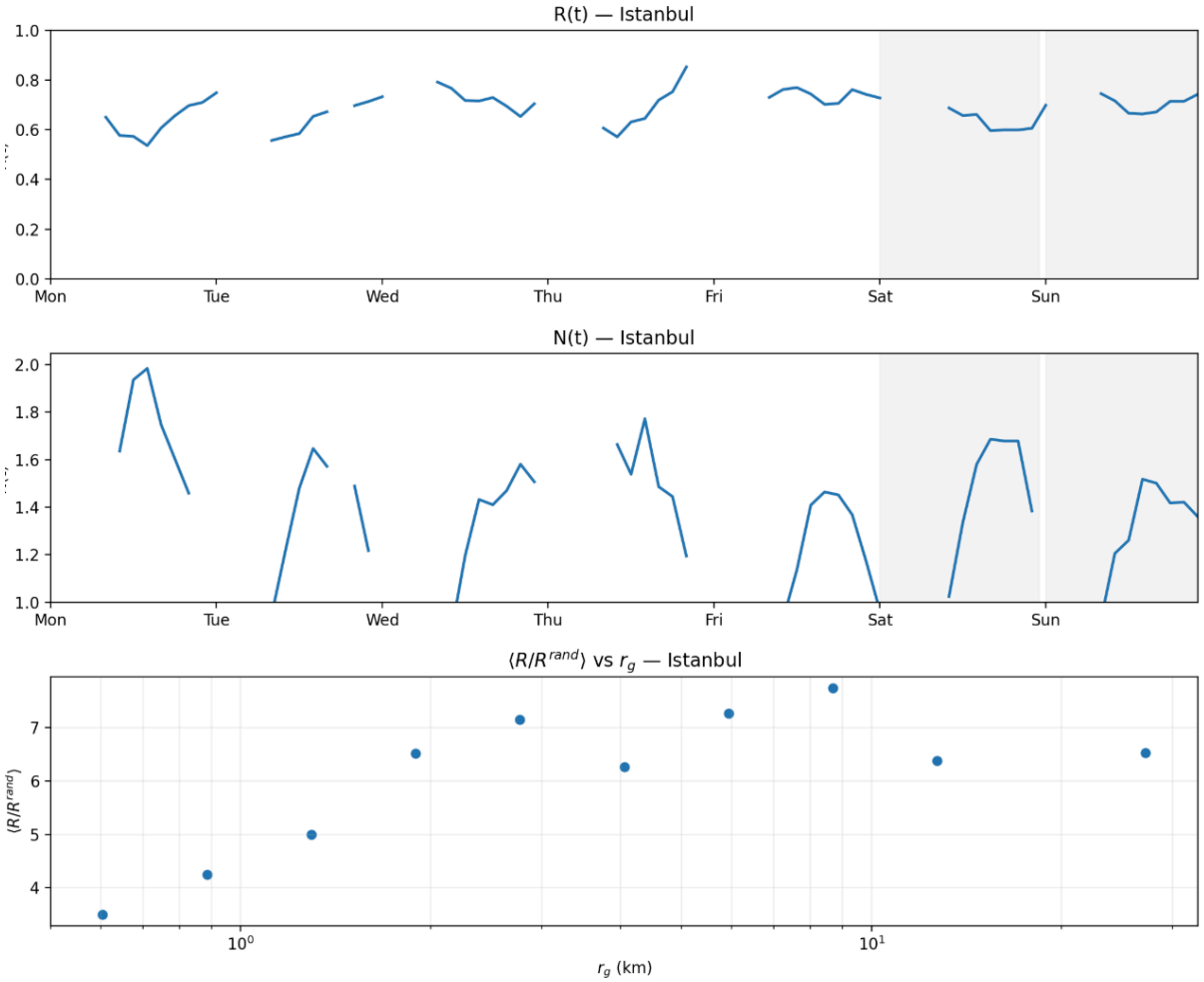
The mean regularity is high at **0.88**, with a median of **0.90**. This means users often return to their most visited places at the same hours of the week, reflecting strong routine behaviors.

Conclusion:

Bandung has **sparser data** compared to New York, with far fewer valid users. However, the remaining users show **strong regularity (high R)** and **moderate spatial mobility (low R_g)**. The predictability varies greatly across individuals, but overall, mobility patterns appear **highly routine and localized**.

Istanbul

Figure



Summary

```
{
  "city": "Istanbul",
  "tz": "Europe/Istanbul",
  "n_users_total": 23627,
  "n_users_valid": 84,
  "q": {
    "mean": 0.6631177008829424,
    "median": 0.7453754920373563,
    "p25": 0.6728124338022423,
    "p75": 0.7849652009060848,
    "min": -0.025641025641025772,
    "max": 0.7999722183636616,
    "count": 84
  },
  "S_unc": {
    "mean": 2.9133286097270403,
    "median": 2.807354922057604,
    "p25": 2.4960759636690817,
    "p75": 3.169925001442312,
    "min": 1.9219280948873623,
    "max": 5.193706615167214,
    "count": 84
  },
  "S_rand": {
    "mean": 2.938429967733712,
    "median": 2.807354922057604,
    "p25": 2.584962500721156,
    "p75": 3.169925001442312,
    "min": 2.0,
    "max": 5.247927513443585,
    "count": 84
  },
  "Pi_max": {
    "mean": 0.4102303885198622,
    "median": 0.16666666666666666,
    "p25": 0.125,
    "p75": 1.0,
    "min": 0.05263157894736842,
```

```
    "max": 1.0,
    "count": 84
  },
  "Rg_km": {
    "mean": 5.157928705090056,
    "median": 3.5340297123267064,
    "p25": 2.5112483009904145,
    "p75": 6.7567673114818225,
    "min": 0.19687468373417752,
    "max": 32.89865112797533,
    "count": 84
  },
  "R": {
    "mean": 0.8103550496402175,
    "median": 0.8516483516483516,
    "p25": 0.7708333333333334,
    "p75": 0.9109848484848484,
    "min": 0.3333333333333333,
    "max": 1.0,
    "count": 84
  },
  "figure": "reports/figures/istanbul_fig3_combined.png"
}
```


Analyze

For Istanbul, we analyzed 23,627 users, of which 84 valid users remained after filtering.

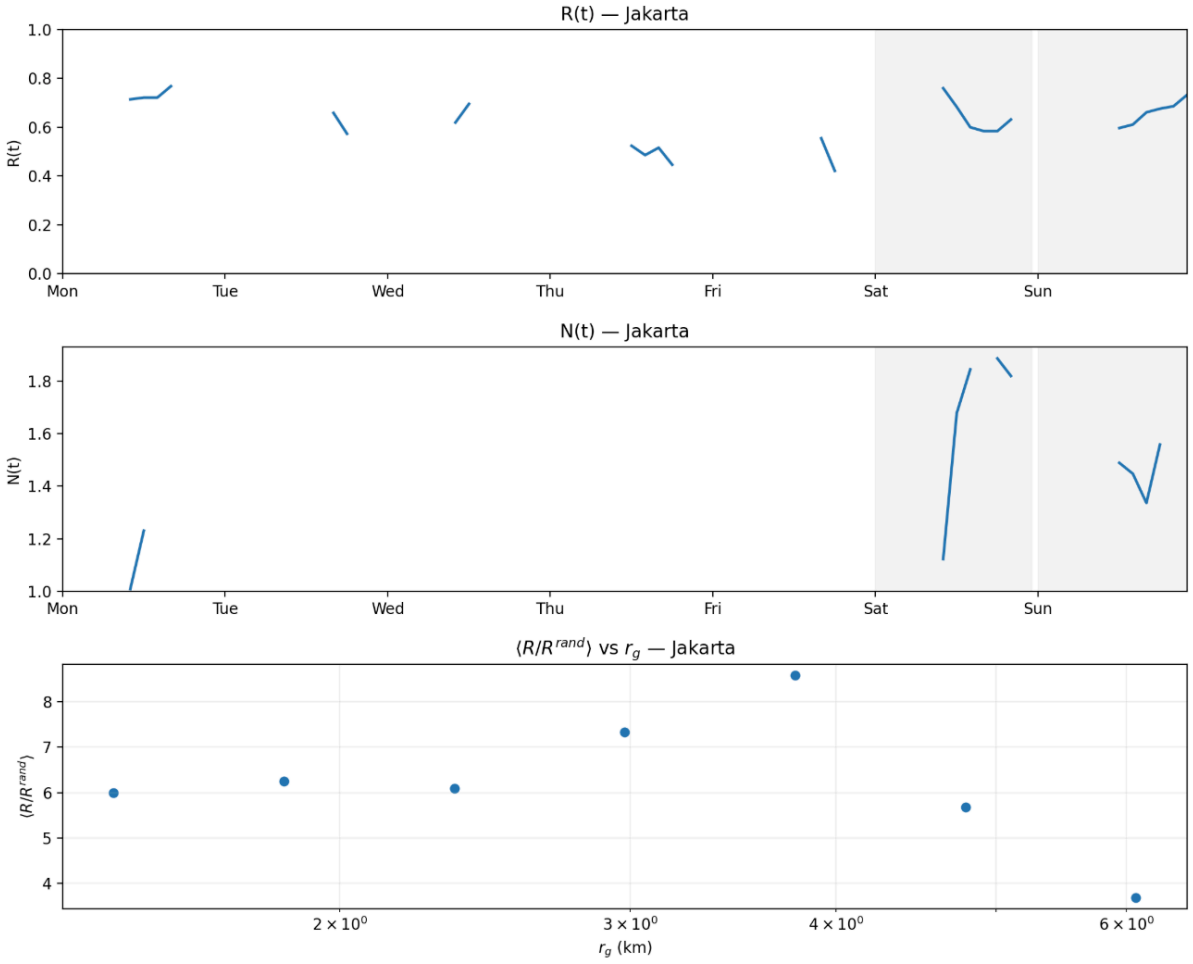
- **Sparsity (q):** Mean ~0.66, median ~0.75. The distribution is skewed toward high sparsity, indicating that many users check in infrequently, though less sparse than New York.
- **Uncertainty entropy (S_unc):** Mean ~2.91, showing moderate unpredictability in user trajectories.
- **Random entropy (S_rand):** Very close to S_unc, suggesting user movements are not far from random baselines.

- **Theoretical predictability (Π_max):** Mean ~0.41, median ~0.17, but with a wide spread up to 1.0, showing that some users are highly predictable while most are less so.
- **Radius of gyration (R_g):** Mean ~5.16 km, median ~3.53 km, much lower than New York. Users tend to stay in smaller areas, with few traveling longer distances.
- **Regularity (R):** Mean ~0.81, median ~0.85, higher than New York. Istanbul users show relatively strong weekly regularity.

Overall, Istanbul users display **higher regularity but smaller travel ranges** compared to New York. This suggests that movement is more routine and localized, though still with some unpredictability.

Jakarta

Figure



Summary


```
{
  "city": "Jakarta",
  "tz": "Asia/Jakarta",
  "n_users_total": 8326,
  "n_users_valid": 24,
  "q": {
    "mean": 0.6207457493098958,
    "median": 0.7090870623082619,
    "p25": 0.5150380313446975,
    "p75": 0.7556369104815015,
    "min": 0.13875598086124408,
    "max": 0.7894736842105263,
    "count": 24
  },
  "S_unc": {
    "mean": 2.983182223603206,
    "median": 2.94770277922009,
    "p25": 2.4579257748035745,
    "p75": 3.1211153651692722,
    "min": 1.9219280948873623,
    "max": 5.014997302659251,
    "count": 24
  },
  "S_rand": {
    "mean": 3.0113727700929545,
    "median": 3.0,
    "p25": 2.5192038992627075,
    "p75": 3.242301655741058,
    "min": 2.0,
    "max": 5.044394119358453,
    "count": 24
  },
  "Pi_max": {
    "mean": 0.5418855042016807,
    "median": 0.2,
    "p25": 0.16666666666666666,
```

```
    "p75": 1.0,
    "min": 0.058823529411764705,
    "max": 1.0,
    "count": 24
   },
   "Rg_km": {
    "mean": 3.194445648080425,
    "median": 3.019102323614841,
    "p25": 2.067856601904899,
    "p75": 4.008717677549891,
    "min": 0.153655653820057,
    "max": 6.8478810209742615,
    "count": 24
   },
   "R": {
    "mean": 0.7860196856520387,
    "median": 0.8,
    "p25": 0.6666666666666666,
    "p75": 1.0,
    "min": 0.25,
    "max": 1.0,
    "count": 24
   },
   "figure": "reports/figures/jakarta_fig3_combined.png"
 }
```


Analyze

For Jakarta, we analyzed 8,326 users, with only 24 valid users after filtering.

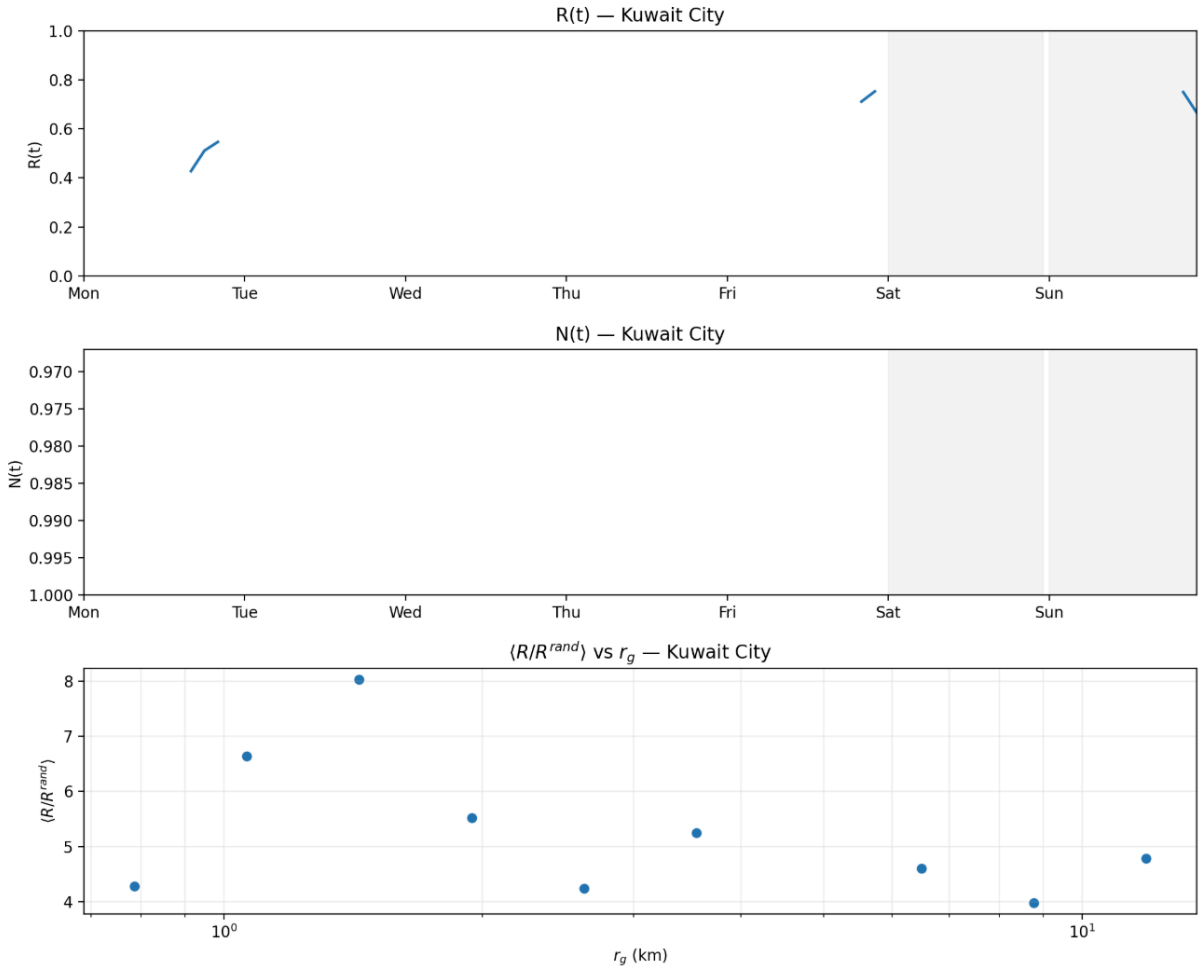
- **Sparsity (q):** Mean ~0.62, median ~0.71, lower than New York and Istanbul. Users show slightly denser activity, but the small sample size limits generalization.
- **Uncertainty entropy (S_unc):** Mean ~2.98, indicating moderate trajectory unpredictability.
- **Random entropy (S_rand):** Mean ~3.01, close to S_unc, suggesting user mobility is not far from random baseline.

- **Theoretical predictability (Π_max):** Mean ~0.54, relatively high compared to other cities. Some users reach Π_max = 1.0, meaning they are highly predictable.
- **Radius of gyration (R_g):** Mean ~3.19 km, median ~3.02 km, suggesting moderate travel ranges—users move across neighborhoods but rarely long distances.
- **Regularity (R):** Mean ~0.79, median ~0.80, reflecting relatively strong weekly routines, though weaker than Istanbul.

Overall, Jakarta users show **moderate mobility with relatively high predictability**, but the very small number of valid users makes the results less robust.

Kuwait-city

Figure



Summary


```
{
  "city": "Kuwait City",
  "tz": "Asia/Kuwait",
  "n_users_total": 9590,
  "n_users_valid": 16,
  "q": {
    "mean": 0.6378899133058636,
    "median": 0.7322401923450264,
    "p25": 0.6501265228452178,
    "p75": 0.7746169461879677,
    "min": 0.0055248618784530246,
    "max": 0.799554565701559,
    "count": 16
  },
  "S_unc": {
    "mean": 2.5856871703993702,
    "median": 2.6817661313779775,
    "p25": 2.247703463198125,
    "p75": 2.8717552033082843,
    "min": 1.7924812503605778,
    "max": 3.7004397181410926,
    "count": 16
  },
  "S_rand": {
    "mean": 2.659838861800349,
    "median": 2.807354922057604,
    "p25": 2.321928094887362,
    "p75": 3.0,
    "min": 2.0,
    "max": 3.700439718141092,
    "count": 16
  },
  "Pi_max": {
    "mean": 0.7019307081807082,
    "median": 1.0,
    "p25": 0.2,
```

```
    "p75": 1.0,
    "min": 0.07692307692307693,
    "max": 1.0,
    "count": 16
   },
   "Rg_km": {
    "mean": 3.838585626696937,
    "median": 2.4515078569293394,
    "p25": 1.3993967224950652,
    "p75": 3.7256295472276495,
    "min": 0.334796490760094,
    "max": 13.797113923158463,
    "count": 16
   },
   "R": {
    "mean": 0.8066620879120879,
    "median": 0.8285714285714285,
    "p25": 0.6666666666666666,
    "p75": 0.925,
    "min": 0.6,
    "max": 1.0,
    "count": 16
   },
   "figure": "reports/figures/kuwait-city_fig3_combined.png"
 }
```


Analyze

For Kuwait City, we analyzed 9,590 users, but only **16 valid users** remained after filtering, so results should be interpreted with caution.

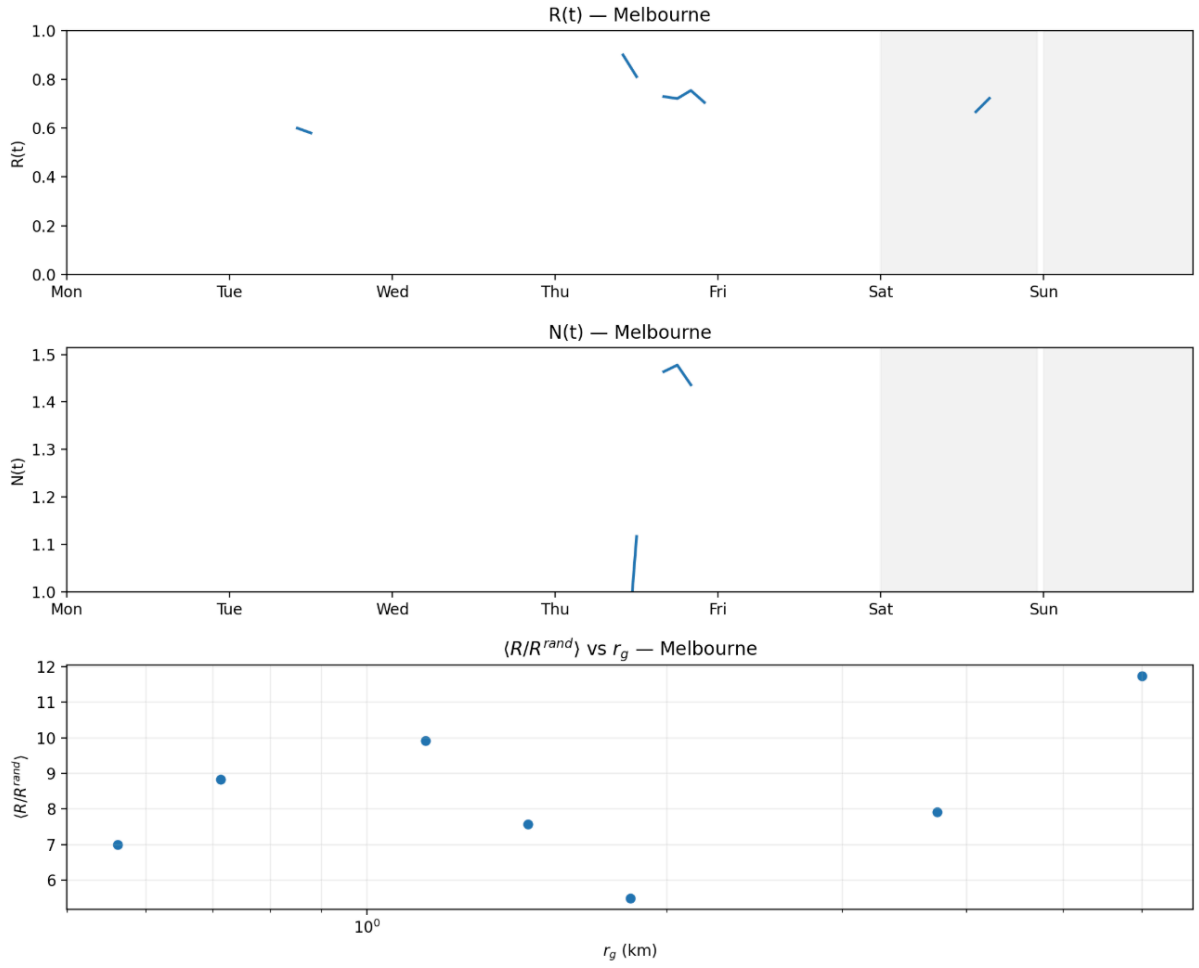
- **Sparsity (q):** Mean ~0.64, median ~0.73. Activity appears moderately sparse, though some trajectories are extremely sparse (min ~0.006).
- **Uncertainty entropy (S_unc):** Mean ~2.59, reflecting relatively low trajectory diversity compared with cities like New York.
- **Random entropy (S_rand):** Mean ~2.66, close to S_unc, implying mobility is not much more structured than random.

- **Theoretical predictability (Π_max):** Mean ~0.70, median 1.0, suggesting **a large share of users are theoretically highly predictable**.
- **Radius of gyration (R_g):** Mean ~3.84 km, median ~2.45 km, showing most movements are within local neighborhoods, with a few users traveling up to ~14 km.
- **Regularity (R):** Mean ~0.81, median ~0.83, indicating relatively strong weekly routines despite the small sample size.

Overall, Kuwait City's results show **relatively high predictability and regularity**, but the very small number of valid users makes the findings less stable and representative.

Melbourne

Figure



Summary


```
{
  "city": "Melbourne",
  "tz": "Australia/Melbourne",
  "n_users_total": 642,
  "n_users_valid": 13,
  "q": {
    "mean": 0.7114586656904566,
    "median": 0.7475728155339806,
    "p25": 0.6931407942238267,
    "p75": 0.7769516728624535,
    "min": 0.42245989304812837,
    "max": 0.7974341661039838,
    "count": 13
  },
  "S_unc": {
    "mean": 3.246141486214226,
    "median": 3.321928094887362,
    "p25": 3.169925001442312,
    "p75": 3.4594316186372978,
    "min": 1.9219280948873623,
    "max": 4.6717805845106355,
    "count": 13
  },
  "S_rand": {
    "mean": 3.3012325358451804,
    "median": 3.321928094887362,
    "p25": 3.169925001442312,
    "p75": 3.584962500721156,
    "min": 2.0,
    "max": 4.754887502163468,
    "count": 13
  },
  "Pi_max": {
    "mean": 0.4556499056499057,
    "median": 0.16666666666666666,
    "p25": 0.1,
```

```
    "p75": 1.0,
    "min": 0.07142857142857142,
    "max": 1.0,
    "count": 13
  },
  "Rg_km": {
    "mean": 2.2664572661296947,
    "median": 1.167120666894147,
    "p25": 0.7511192928978161,
    "p75": 3.3999557711798385,
    "min": 0.10426127058303039,
    "max": 6.749430147002409,
    "count": 13
  },
  "R": {
    "mean": 0.8445166771469501,
    "median": 0.8333333333333334,
    "p25": 0.7741935483870968,
    "p75": 0.9285714285714286,
    "min": 0.5555555555555556,
    "max": 1.0,
    "count": 13
  },
  "figure": "reports/figures/melbourne_fig3_combined.png"
}
```


Analyze

For Melbourne, we analyzed 642 users, with **13 valid users** after filtering, which is a relatively small sample size.

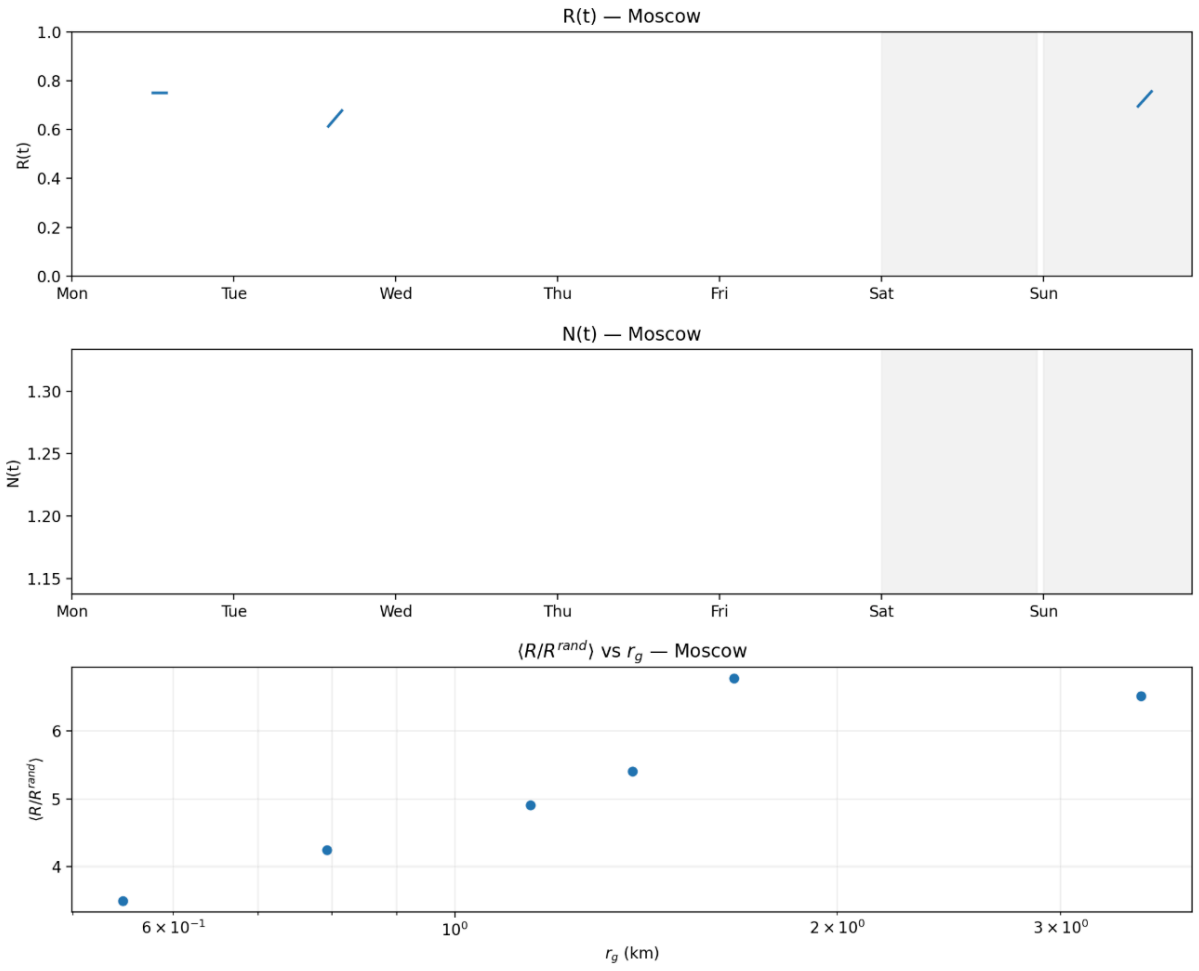
- **Sparsity (q):** Mean ~0.71, median ~0.75, suggesting fairly sparse mobility records but within a consistent range.
- **Uncertainty entropy (S_unc):** Mean ~3.25, indicating moderate diversity in visited locations.
- **Random entropy (S_rand):** Mean ~3.30, close to S_unc, suggesting mobility patterns are somewhat structured but not strongly distinct from random.

- **Theoretical predictability (Π_max):** Mean ~0.46, median ~0.17, with high variability—some users are almost perfectly predictable, while others are not.
- **Radius of gyration (R_g):** Mean ~2.27 km, median ~1.17 km, showing movements are largely local with occasional trips up to ~6.7 km.
- **Regularity (R):** Mean ~0.84, median ~0.83, indicating relatively high weekly routine strength among the small user group.

Overall, Melbourne's mobility patterns show **strong regularity but moderate predictability**, with travel concentrated within local neighborhoods. The small valid sample limits generalization.

Moscow

Figure



Summary


```
{
  "city": "Moscow",
  "tz": "Europe/Moscow",
  "n_users_total": 3977,
  "n_users_valid": 18,
  "q": {
    "mean": 0.5474629194879229,
    "median": 0.6338508844548818,
    "p25": 0.35850116344379357,
    "p75": 0.7601111827263938,
    "min": 0.05882352941176472,
    "max": 0.7897897897897898,
    "count": 18
  },
  "S_unc": {
    "mean": 2.7542257677772555,
    "median": 2.655221528859512,
    "p25": 2.321928094887362,
    "p75": 3.114369445886757,
    "min": 2.321928094887362,
    "max": 3.584962500721156,
    "count": 18
  },
  "S_rand": {
    "mean": 2.767482947488383,
    "median": 2.69615871138938,
    "p25": 2.321928094887362,
    "p75": 3.127443751081734,
    "min": 2.321928094887362,
    "max": 3.584962500721156,
    "count": 18
  },
  "Pi_max": {
    "mean": 0.34581128747795414,
    "median": 0.2,
    "p25": 0.14285714285714285,
```

```
    "p75": 0.2,
    "min": 0.08333333333333333,
    "max": 1.0,
    "count": 18
   },
   "Rg_km": {
    "mean": 1.3852471294882363,
    "median": 1.1450475107768057,
    "p25": 0.5936067091690265,
    "p75": 1.5389831531554299,
    "min": 0.24632736591602986,
    "max": 3.8079444037013204,
    "count": 18
   },
   "R": {
    "mean": 0.7027777777777778,
    "median": 0.6833333333333333,
    "p25": 0.6166666666666667,
    "p75": 0.8,
    "min": 0.2857142857142857,
    "max": 1.0,
    "count": 18
   },
   "figure": "reports/figures/moscow_fig3_combined.png"
 }
```


Analyze

For Moscow, we analyzed **3,977 users**, with **18 valid users** retained after filtering.

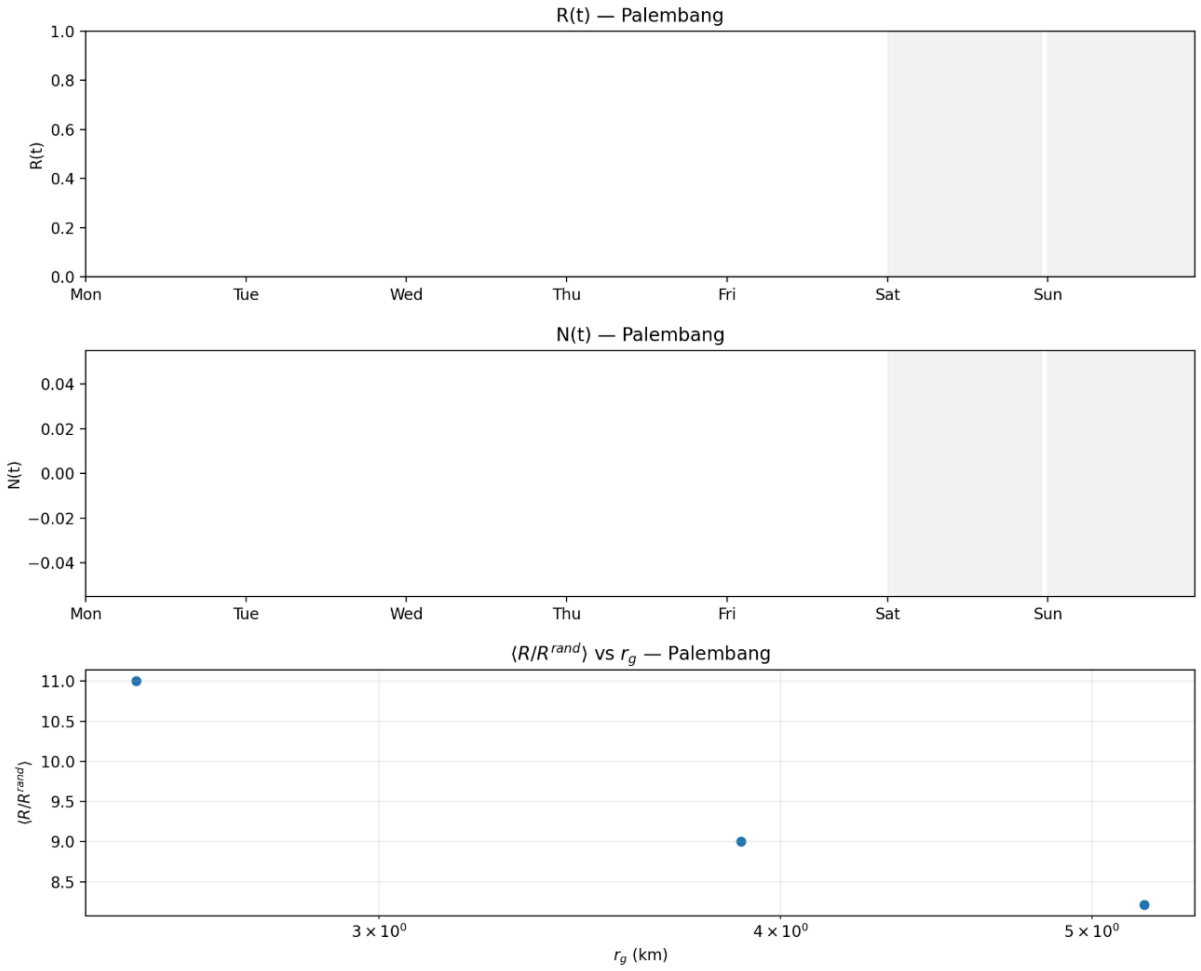
- **Sparsity (q):** Mean ~0.55, median ~0.63. The data is moderately sparse, with some users showing very limited activity (min ~0.06).
- **Uncertainty entropy (S_unc):** Mean ~2.75, reflecting a moderate variety of visited locations.
- **Random entropy (S_rand):** Mean ~2.77, very close to S_unc, indicating mobility patterns are only slightly more structured than random.

- **Theoretical predictability (Π_max):** Mean ~0.35, median ~0.20, suggesting relatively low theoretical predictability compared to other cities.
- **Radius of gyration (R_g):** Mean ~1.39 km, median ~1.15 km, showing that most mobility is highly localized with limited long-distance travel.
- **Regularity (R):** Mean ~0.70, median ~0.68, which is moderate regularity, weaker than cities like Melbourne or Bandung.

Overall, Moscow's mobility patterns appear **localized and moderately regular but with relatively low predictability**, reflecting more variability in movement routines.

Palembang

Figure



Summary

```
{
  "city": "Palembang",
  "tz": "Asia/Jakarta",
  "n_users_total": 267,
  "n_users_valid": 3,
  "q": {
    "mean": 0.7316863925858303,
    "median": 0.7001873828856964,
    "p25": 0.7000936914428482,
    "p75": 0.7475295888787457,
    "min": 0.7,
    "max": 0.7948717948717949,
    "count": 3
  },
  "S_unc": {
    "mean": 3.2199418194461713,
    "median": 3.3248629576173565,
    "p25": 3.0374314788086783,
    "p75": 3.4549127291692563,
    "min": 2.75,
    "max": 3.584962500721156,
    "count": 3
  },
  "S_rand": {
    "mean": 3.2839163471386854,
    "median": 3.4594316186372973,
    "p25": 3.133393270347451,
    "p75": 3.5221970596792267,
    "min": 2.807354922057604,
    "max": 3.584962500721156,
    "count": 3
  },
  "Pi_max": {
    "mean": 0.6944444444444443,
    "median": 1.0,
    "p25": 0.5416666666666667,
    "p75": 1.0,
    "min": 0.08333333333333333,
```

```
    "max": 1.0,
    "count": 3
  },
  "Rg_km": {
    "mean": 3.9111988816397787,
    "median": 3.91814575311959,
    "p25": 3.1751858797058663,
    "p75": 4.650685319313597,
    "min": 2.4322260062921424,
    "max": 5.3832248855076035,
    "count": 3
  },
  "R": {
    "mean": 0.9246031746031745,
    "median": 0.9166666666666666,
    "p25": 0.8869047619047619,
    "p75": 0.9583333333333333,
    "min": 0.8571428571428571,
    "max": 1.0,
    "count": 3
  },
  "figure": "reports/figures/palembang_fig3_combined.png"
}
```


Analyze

For Palembang, we analyzed **267 users**, with only **3 valid users** after filtering, which indicates a very sparse dataset.

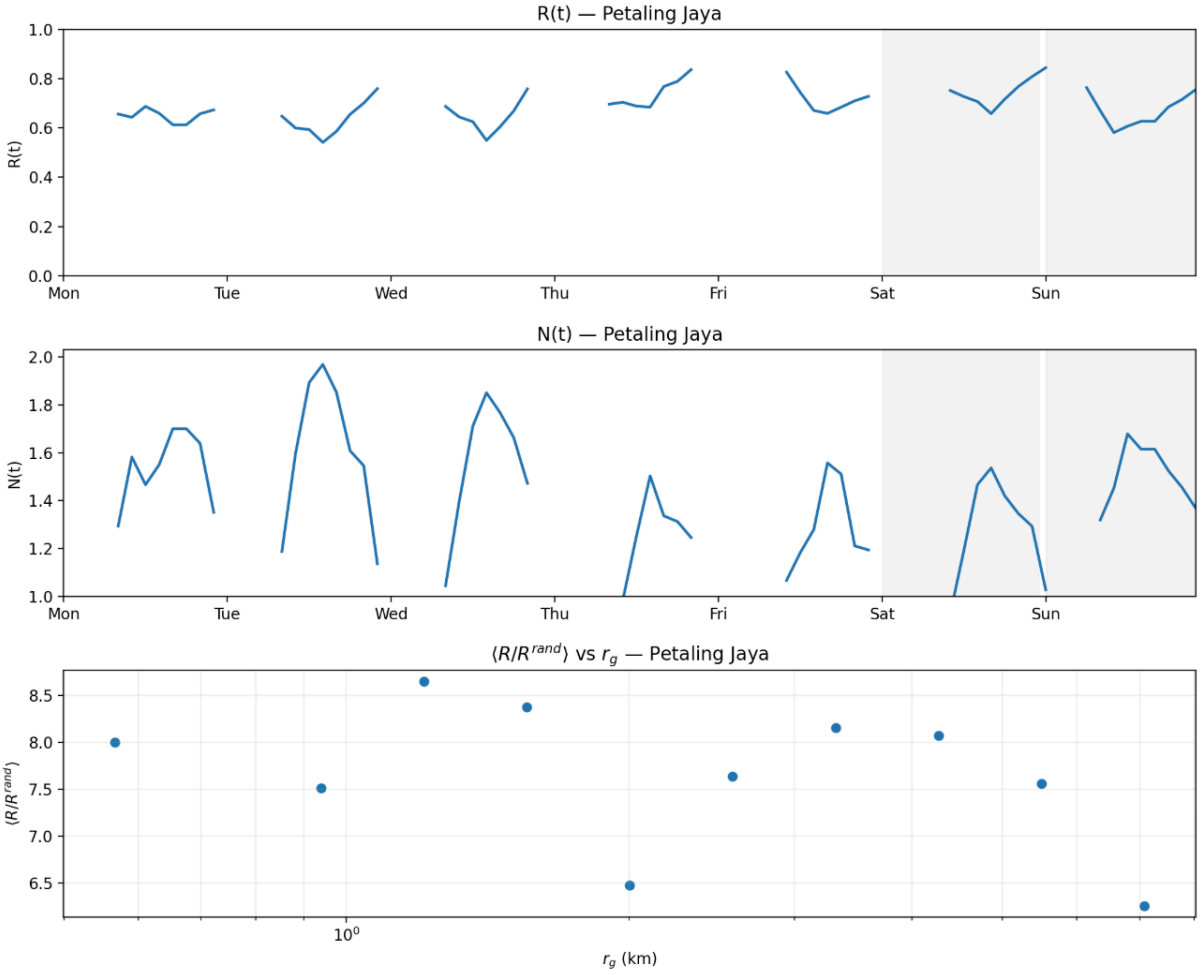
- **Sparsity (q):** Mean ~0.73, median ~0.70. Despite the small sample, the retained users show relatively consistent activity.
- **Uncertainty entropy (S_unc):** Mean ~3.22, median ~3.32, reflecting a moderate level of location diversity.
- **Random entropy (S_rand):** Mean ~3.28, slightly higher than S_unc, suggesting some structured mobility patterns.
- **Theoretical predictability (Π_max):** Mean ~0.69, median = 1.0, which implies that, for some users, movement is highly predictable.

- **Radius of gyration (R_g):** Mean ~3.91 km, median ~3.92 km, showing mobility concentrated within a few kilometers.
- **Regularity (R):** Mean ~0.92, median ~0.92, indicating highly regular mobility among the very small valid sample.

Overall, due to the **extremely limited sample size**, these results should be interpreted cautiously. The few valid users show **high regularity and predictability**, but they may not represent the broader population.

Petaling jaya

Figure



Summary

```
{
  "city": "Petaling Jaya",
  "tz": "Asia/Kuala_Lumpur",
  "n_users_total": 14262,
  "n_users_valid": 93,
  "q": {
    "mean": 0.6478356349527784,
    "median": 0.72875226039783,
    "p25": 0.5973154362416107,
    "p75": 0.7684887459807074,
    "min": -0.02739726027397249,
    "max": 0.7991071428571428,
    "count": 93
  },
  "S_unc": {
    "mean": 2.9373266622321212,
    "median": 2.807354922057604,
    "p25": 2.584962500721156,
    "p75": 3.182005814760214,
    "min": 0.9709505944546686,
    "max": 4.6150610122030695,
    "count": 93
  },
  "S_rand": {
    "mean": 2.967748002964126,
    "median": 2.807354922057604,
    "p25": 2.584962500721156,
    "p75": 3.321928094887362,
    "min": 1.0,
    "max": 4.700439718141092,
    "count": 93
  },
  "Pi_max": {
    "mean": 0.5128008356597323,
    "median": 0.2,
    "p25": 0.16666666666666666,
    "p75": 1.0,
    "min": 0.05555555555555555,
```

```
    "max": 1.0,
    "count": 93
  },
  "Rg_km": {
    "mean": 2.502546171356595,
    "median": 1.757447489927854,
    "p25": 0.5036017215565091,
    "p75": 4.194657994380028,
    "min": 0.025103167039225518,
    "max": 8.030611033247114,
    "count": 93
  },
  "R": {
    "mean": 0.8253388400884156,
    "median": 0.8571428571428571,
    "p25": 0.7142857142857143,
    "p75": 1.0,
    "min": 0.4,
    "max": 1.0,
    "count": 93
  },
  "figure": "reports/figures/petaling-jaya_fig3_combined.png"
}
```


Analyze

For Petaling Jaya, we analyzed **14,262 users**, with **93 valid users** retained after filtering.

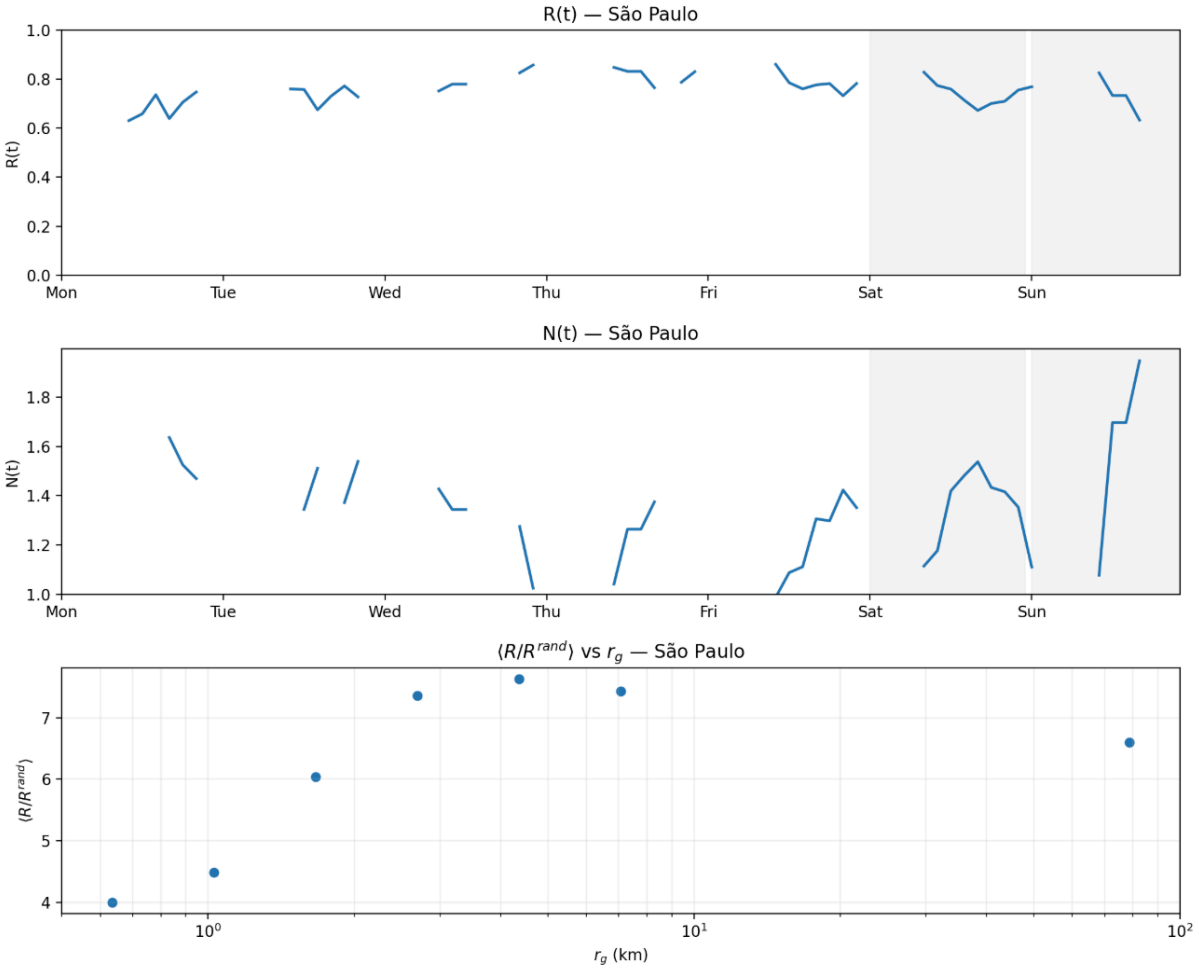
- **Sparsity (q):** Mean ~0.65, median ~0.73, suggesting that users included in the analysis exhibit moderately consistent activity.
- **Uncertainty entropy (S_unc):** Mean ~2.94, median ~2.81, showing moderate diversity in location choices.
- **Random entropy (S_rand):** Mean ~2.97, close to S_unc, reflecting structured but not overly complex mobility.
- **Theoretical predictability (Π_max):** Mean ~0.51, median = 0.2, with high variation, meaning some users are highly predictable while others are not.

- **Radius of gyration (R_g):** Mean ~2.50 km, median ~1.76 km, indicating most movements occur within a few kilometers, though some extend further.
- **Regularity (R):** Mean ~0.83, median ~0.86, suggesting strong temporal regularity in mobility.

Overall, Petaling Jaya shows **relatively high regularity and predictability**, with mobility largely concentrated within a limited geographic range.

Sao-Paulo

Figure



Summary

```
{
  "city": "Sao Paulo",
  "tz": "America/Sao_Paulo",
  "n_users_total": 5815,
  "n_users_valid": 47,
  "q": {
    "mean": 0.7012028140490997,
    "median": 0.7602131438721137,
    "p25": 0.6941259635913232,
    "p75": 0.7871768258161917,
    "min": 0.0,
    "max": 0.7980931015143018,
    "count": 47
  },
  "S_unc": {
    "mean": 2.9816733370637447,
    "median": 2.94770277922009,
    "p25": 2.5533015685322376,
    "p75": 3.3479546354368024,
    "min": 1.7924812503605778,
    "max": 4.875,
    "count": 47
  },
  "S_rand": {
    "mean": 3.0358243704916843,
    "median": 3.0,
    "p25": 2.584962500721156,
    "p75": 3.39067985676233,
    "min": 2.0,
    "max": 4.906890595608519,
    "count": 47
  },
  "Pi_max": {
    "mean": 0.5454283010134073,
    "median": 0.2,
    "p25": 0.125,
    "p75": 1.0,
    "min": 0.0625,
```

```
    "max": 1.0,
    "count": 47
  },
  "Rg_km": {
    "mean": 11.976888831265681,
    "median": 2.3867523784465416,
    "p25": 1.5784462037346,
    "p75": 3.12543935909681,
    "min": 0.2108394236622318,
    "max": 449.89794348371544,
    "count": 47
  },
  "R": {
    "mean": 0.7988765666957156,
    "median": 0.8181818181818182,
    "p25": 0.7303030303030302,
    "p75": 0.9258241758241759,
    "min": 0.14285714285714285,
    "max": 1.0,
    "count": 47
  },
  "figure": "reports/figures/s\u00e3o-paulo_fig3_combined.png"
}
```


Analyze

For São Paulo, we analyzed **5,815 users**, with **47 valid users** retained.

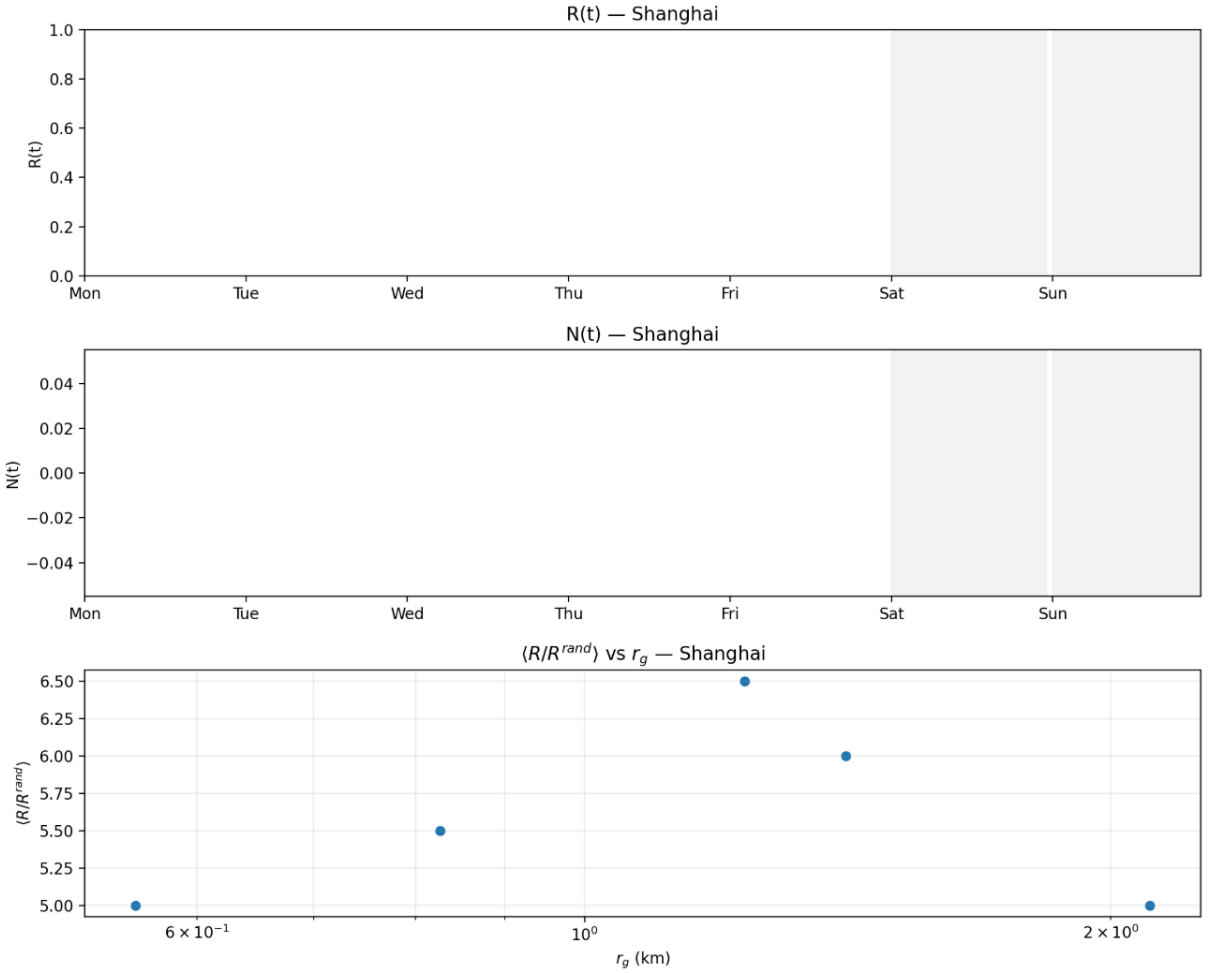
- **Sparsity (q):** Mean ~0.70, median ~0.76, showing moderately high user activity consistency.
- **Uncertainty entropy (S_unc):** Mean ~2.98, median ~2.95, reflecting moderate diversity of visited locations.
- **Random entropy (S_rand):** Mean ~3.04, slightly higher than S_unc, indicating mobility patterns are structured but not overly random.
- **Theoretical predictability (Π_max):** Mean ~0.55, median = 0.20, showing large variability in predictability among users.

- **Radius of gyration (R_g):** Mean ~11.98 km, but median ~2.39 km. This suggests most mobility happens in relatively small ranges, though some users travel extremely far (outliers).
- **Regularity (R):** Mean ~0.80, median ~0.82, showing strong temporal regularity.

Overall, São Paulo exhibits **high mobility heterogeneity**: most users are highly regular and predictable in smaller ranges, but a subset engages in very large-scale movement.

Shanghai

Figure



Summary

```
{
  "city": "Shanghai",
  "tz": "Asia/Shanghai",
  "n_users_total": 296,
  "n_users_valid": 6,
  "q": {
    "mean": 0.7433915590375156,
    "median": 0.7788080276440419,
    "p25": 0.6936191664135358,
    "p75": 0.7878557641758858,
    "min": 0.653179190751445,
    "max": 0.7934595524956971,
    "count": 6
  },
  "S_unc": {
    "mean": 2.578445297804259,
    "median": 2.453445297804259,
    "p25": 2.321928094887362,
    "p75": 2.708740625180289,
    "min": 2.321928094887362,
    "max": 3.169925001442312,
    "count": 6
  },
  "S_rand": {
    "mean": 2.588004451480526,
    "median": 2.453445297804259,
    "p25": 2.321928094887362,
    "p75": 2.7517568167234923,
    "min": 2.321928094887362,
    "max": 3.169925001442312,
    "count": 6
  },
  "Pi_max": {
    "mean": 0.31296296296296294,
    "median": 0.2,
    "p25": 0.175,
    "p75": 0.2,
    "min": 0.1111111111111111,
```

```
    "max": 1.0,
    "count": 6
  },
  "Rg_km": {
    "mean": 1.3839040325478085,
    "median": 1.3116209653390305,
    "p25": 0.9774878940898749,
    "p75": 1.86088543476839,
    "min": 0.5180911074043697,
    "max": 2.2520073622860877,
    "count": 6
  },
  "R": {
    "mean": 0.911111111111111,
    "median": 1.0,
    "p25": 0.8500000000000001,
    "p75": 1.0,
    "min": 0.6666666666666666,
    "max": 1.0,
    "count": 6
  },
  "figure": "reports/figures/shanghai_fig3_combined.png"
}
```


Analyze

For Shanghai, we analyzed **296 users**, retaining only **6 valid users** due to strict filtering.

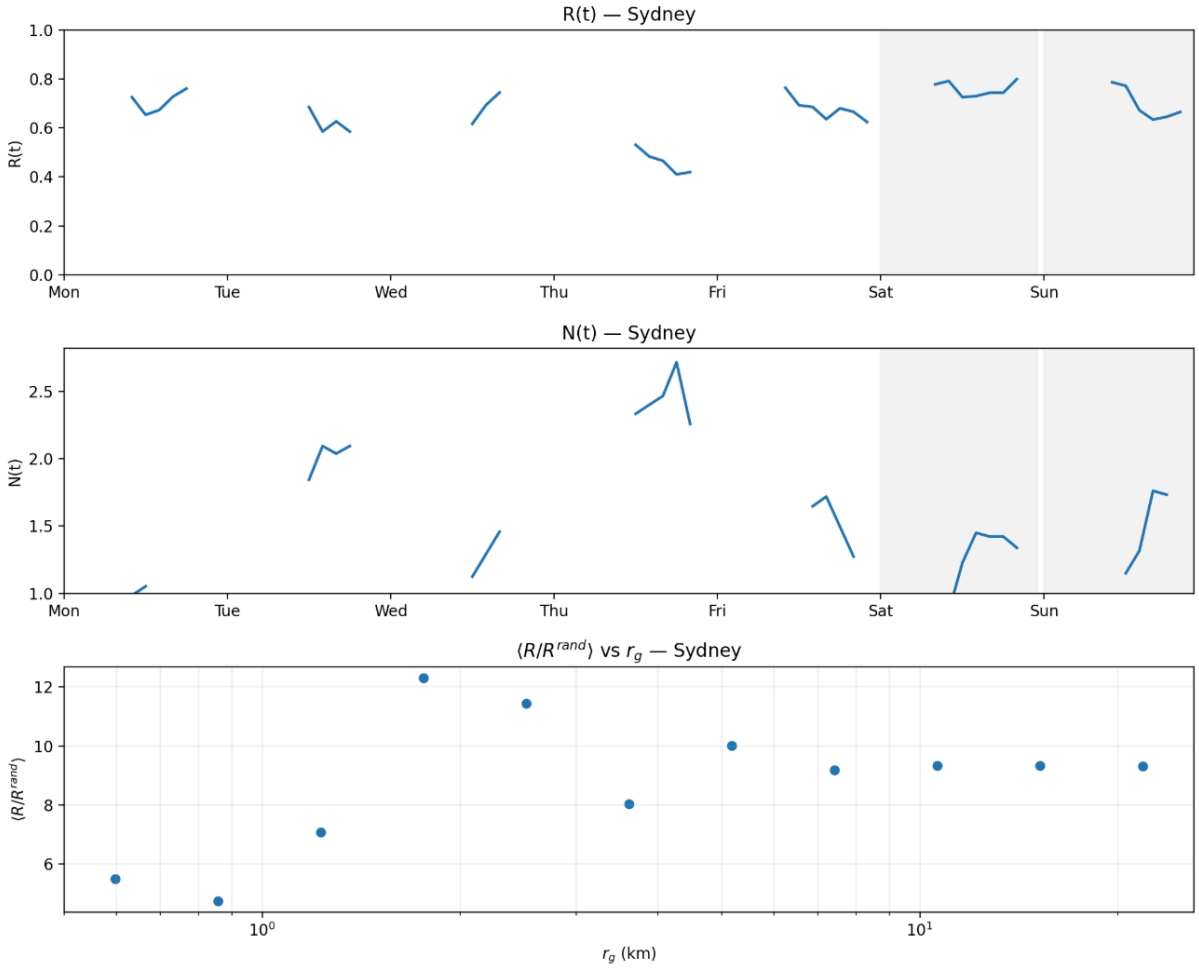
- **Sparsity (q):** Mean ~0.74, median ~0.78, showing relatively consistent activity despite the small sample size.
- **Uncertainty entropy (S_unc):** Mean ~2.58, median ~2.45, indicating moderate diversity in visited places.
- **Random entropy (S_rand):** Mean ~2.59, close to S_unc, suggesting mobility is structured but with limited randomness.
- **Theoretical predictability (Π_max):** Mean ~0.31, median = 0.20, relatively low predictability compared to other cities.

- **Radius of gyration (R_g):** Mean ~1.38 km, median ~1.31 km, showing mobility is concentrated in very small spatial ranges.
- **Regularity (R):** Mean ~0.91, median = 1.0, indicating very high temporal regularity among the small group of valid users.

Overall, Shanghai's results are strongly shaped by **sample sparsity** (only 6 valid users). Within this group, movements are highly regular and localized, but the low Π_max suggests weaker predictability compared to other cities.

Sydney

Figure



Summary

```
{
  "city": "Sydney",
  "tz": "Australia/Sydney",
  "n_users_total": 740,
  "n_users_valid": 28,
  "q": {
    "mean": 0.6906145219316844,
    "median": 0.7192182817182817,
    "p25": 0.6445482624939316,
    "p75": 0.7714742063796785,
    "min": 0.3023255813953488,
    "max": 0.7898949474737369,
    "count": 28
  },
  "S_unc": {
    "mean": 3.2752566885845904,
    "median": 2.94770277922009,
    "p25": 2.584962500721156,
    "p75": 3.8721610526423045,
    "min": 1.9219280948873623,
    "max": 5.7413730052362935,
    "count": 28
  },
  "S_rand": {
    "mean": 3.3009633617318412,
    "median": 3.0,
    "p25": 2.584962500721156,
    "p75": 3.930167946706389,
    "min": 2.0,
    "max": 5.832890014164741,
    "count": 28
  },
  "Pi_max": {
    "mean": 0.4386272457701028,
    "median": 0.16666666666666666,
    "p25": 0.11298076923076923,
    "p75": 1.0,
    "min": 0.05,
```

```
    "max": 1.0,
    "count": 28
  },
  "Rg_km": {
    "mean": 4.5923546234905,
    "median": 3.1027325943479527,
    "p25": 1.3631674753397127,
    "p75": 4.196939392861253,
    "min": 0.47668806552533244,
    "max": 26.10777070433403,
    "count": 28
  },
  "R": {
    "mean": 0.8217577854353617,
    "median": 0.8284313725490196,
    "p25": 0.7638888888888888,
    "p75": 0.9230769230769231,
    "min": 0.38461538461538464,
    "max": 1.0,
    "count": 28
  },
  "figure": "reports/figures/sydney_fig3_combined.png"
}
```


Analyze

For Sydney, we analyzed **740 users**, with **28 valid users** retained after filtering.

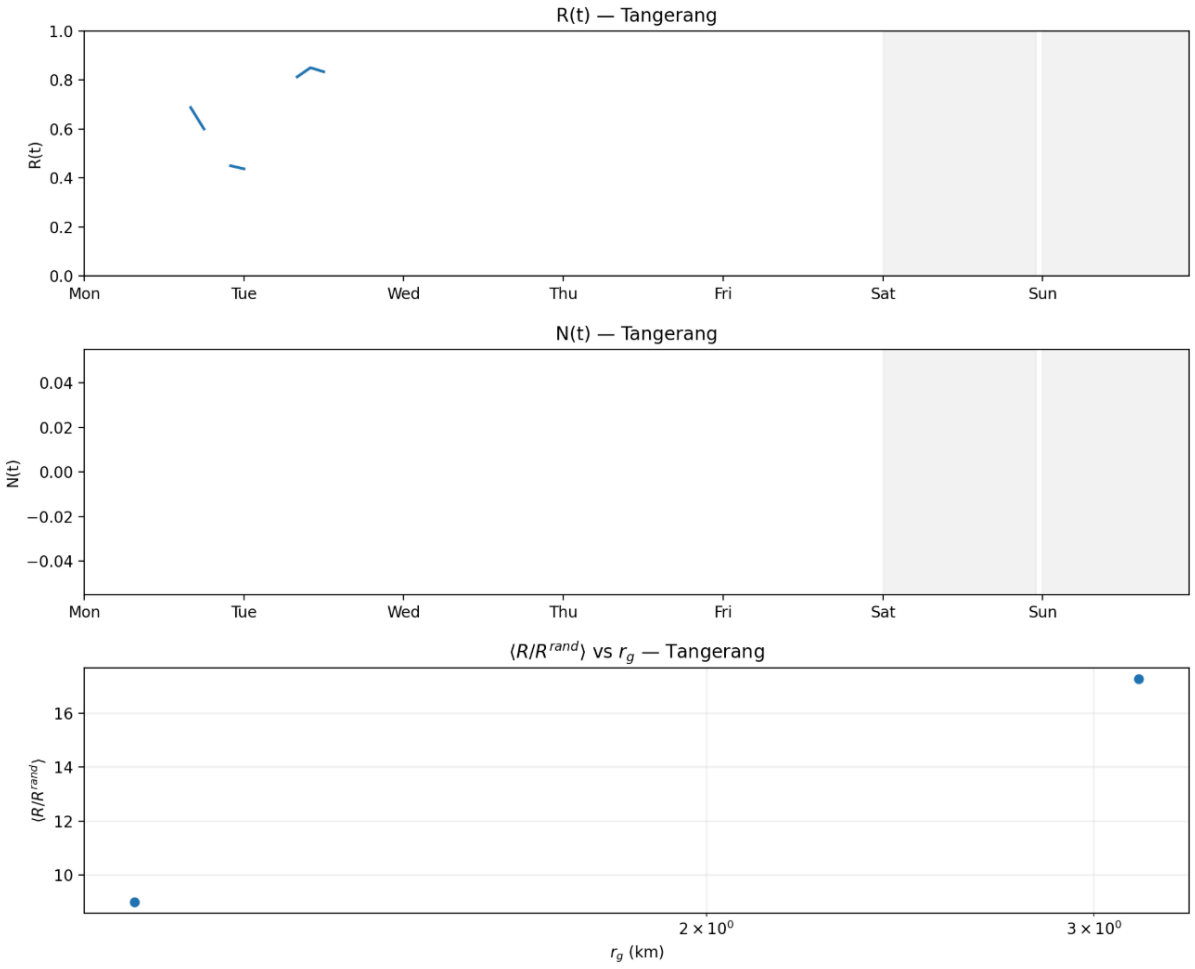
- **Sparsity (q):** Mean ~0.69, median ~0.72, showing moderate regularity in user trajectories.
- **Uncertainty entropy (S_unc):** Mean ~3.28, median ~2.95, indicating diverse but structured mobility.
- **Random entropy (S_rand):** Mean ~3.30, median = 3.0, very close to S_unc, suggesting limited randomness in movement patterns.
- **Theoretical predictability (Π_max):** Mean ~0.44, but median = 0.17, showing a **large variance** between users—some highly predictable, others more random.

- **Radius of gyration (R_g):** Mean ~4.59 km, median ~3.10 km, with a wide spread up to ~26 km, suggesting varied travel ranges across users.
- **Regularity (R):** Mean ~0.82, median ~0.83, showing strong temporal regularity in user movements.

Overall, Sydney users demonstrate **stable and regular mobility patterns**, with moderate predictability and a relatively broad spatial range compared to smaller cities.

Tangerang

Figure



Summary

```
{
  "city": "Tangerang",
  "tz": "Asia/Jakarta",
  "n_users_total": 1427,
  "n_users_valid": 3,
  "q": {
    "mean": 0.7328319126071935,
    "median": 0.7777777777777778,
    "p25": 0.7016229712858926,
    "p75": 0.7865137865137866,
    "min": 0.6254681647940075,
    "max": 0.7952497952497952,
    "count": 3
  },
  "S_unc": {
    "mean": 3.3266424641437893,
    "median": 3.121928094887362,
    "p25": 2.6867786311375923,
    "p75": 3.8641491125217717,
    "min": 2.2516291673878226,
    "max": 4.606370130156182,
    "count": 3
  },
  "S_rand": {
    "mean": 3.4499446971524157,
    "median": 3.169925001442312,
    "p25": 2.745926548164837,
    "p75": 4.0139529982849425,
    "min": 2.321928094887362,
    "max": 4.857980995127572,
    "count": 3
  },
  "Pi_max": {
    "mean": 1.0,
    "median": 1.0,
    "p25": 1.0,
    "p75": 1.0,
    "min": 1.0,
```

```
    "max": 1.0,
    "count": 3
  },
  "Rg_km": {
    "mean": 1.6036331752015263,
    "median": 1.0494731633015444,
    "p25": 0.6894151898563747,
    "p75": 2.2407711545966866,
    "min": 0.3293572164112052,
    "max": 3.4320691458918287,
    "count": 3
  },
  "R": {
    "mean": 0.96,
    "median": 1.0,
    "p25": 0.94,
    "p75": 1.0,
    "min": 0.88,
    "max": 1.0,
    "count": 3
  },
  "figure": "reports/figures/tangerang_fig3_combined.png"
}
```


Analyze

For Tangerang, we analyzed **1,427 users**, with only **3 valid users** retained after filtering, indicating very sparse data.

- **Sparsity (q):** Mean ~0.73, median ~0.78, showing relatively structured movement among the few retained users.
- **Uncertainty entropy (S_unc):** Mean ~3.33, with a broad range (2.25–4.61), reflecting variability in user mobility.
- **Random entropy (S_rand):** Mean ~3.45, median ~3.17, similar to S_unc, suggesting consistency even under randomized assumptions.
- **Theoretical predictability (Π_max):** Mean and median both **1.0**, indicating **extremely high predictability** in mobility patterns (likely due to the very

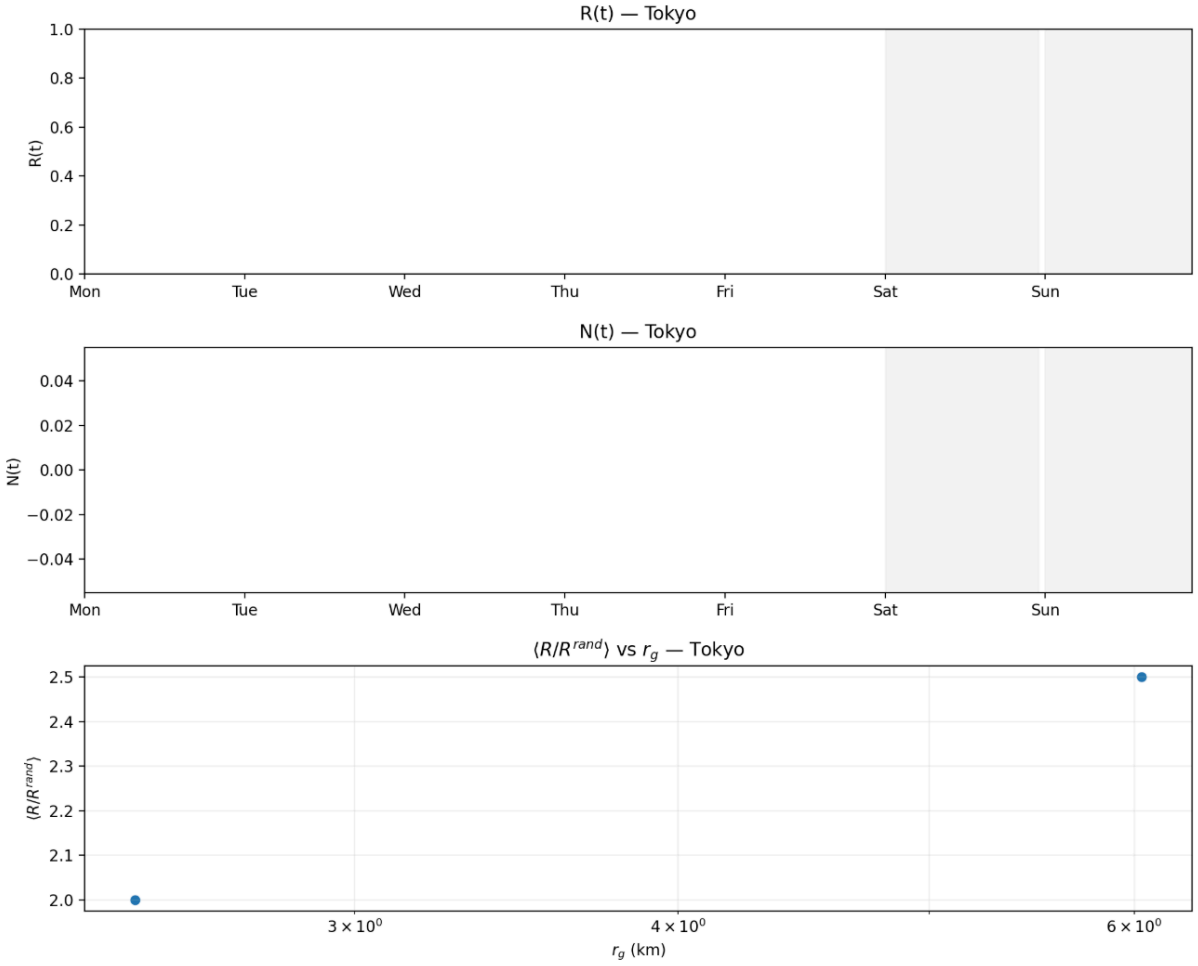
small valid sample).

- **Radius of gyration (R_g):** Mean ~1.60 km, median ~1.05 km, showing **short travel distances**, consistent with localized mobility.
- **Regularity (R):** Mean ~0.96, median = 1.0, showing extremely strong temporal regularity.

Overall, Tangerang shows **very predictable and regular movement**, but the conclusion is limited by the **small valid sample size (n=3)**, which may not generalize well.

Tokyo

Figure



Summary

```
{
  "city": "Tokyo",
  "tz": "Asia/Tokyo",
  "n_users_total": 761,
  "n_users_valid": 2,
  "q": {
    "mean": 0.12834810315642736,
    "median": 0.12834810315642736,
    "p25": -0.15871751468684658,
    "p75": 0.4154137209997013,
    "min": -0.4457831325301205,
    "max": 0.7024793388429752,
    "count": 2
  },
  "S_unc": {
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  "Pi_max": {
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    "p25": 3.3489830810573538,
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    "max": 6.316971045226531,
    "count": 2
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  "R": {
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    "p25": 0.42500000000000004,
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    "min": 0.4,
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    "count": 2
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  "figure": "reports/figures/tokyo_fig3_combined.png"
}
```


Analyze

For Tokyo, we analyzed **761 users**, but only **2 valid users** remained after filtering, making the dataset **extremely sparse** and conclusions highly unreliable.

- **Sparsity (q):** Mean ~0.13, with a wide range (–0.45 to 0.70), showing inconsistent movement patterns.
- **Uncertainty entropy (S_unc):** Mean ~2.45, reflecting relatively low movement diversity.
- **Random entropy (S_rand):** Identical to S_unc due to the very small sample size, offering little additional insight.

- **Theoretical predictability (Π_max):** Mean ~0.18, indicating **low theoretical predictability** of movement compared to other cities.
- **Radius of gyration (R_g):** Mean ~4.34 km, suggesting moderate travel distances despite the small sample.
- **Regularity (R):** Mean ~0.45, pointing to weak temporal regularity.

Overall, Tokyo's results suggest **low predictability and regularity**, but due to the **extremely small valid user count (n=2)**, these findings are not representative of the city and should be interpreted with caution.