

# GPS-enabled Smartphones

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JAN  
2017

# GLOBAL DIGITAL SNAPSHOT

KEY STATISTICAL INDICATORS FOR THE WORLD'S INTERNET, MOBILE, AND SOCIAL MEDIA USERS

TOTAL  
POPULATION



**7.476**  
BILLION

URBANISATION:  
**54%**

INTERNET  
USERS



**3.773**  
BILLION

PENETRATION:  
**50%**

ACTIVE SOCIAL  
MEDIA USERS



**2.789**  
BILLION

PENETRATION:  
**37%**

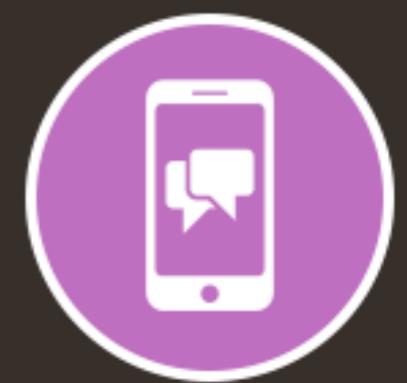
UNIQUE  
MOBILE USERS



**4.917**  
BILLION

PENETRATION:  
**66%**

ACTIVE MOBILE  
SOCIAL USERS



**2.549**  
BILLION

PENETRATION:  
**34%**

7

SOURCES: POPULATION: UNITED NATIONS; U.S. CENSUS BUREAU; INTERNET: INTERNETWORLDSTATS; ITU; INTERNETLIVESTATS; CIA WORLD FACTBOOK; FACEBOOK; NATIONAL REGULATORY AUTHORITIES; SOCIAL MEDIA AND MOBILE SOCIAL MEDIA: FACEBOOK; TENCENT; VKONTAKTE; LIVEINTERNET.RU; KAKAO; NAVER; NIKI AGHAEI; CAFEBAZAAR.IR; SIMILARWEB; DING; EXTRAPOLATION OF TNS DATA; MOBILE: GSMA INTELLIGENCE; EXTRAPOLATION OF EMARKETER AND ERICSSON DATA.

 **Hootsuite™**  **we  
are.  
social**

# All this technology is making us antisocial



# Social Media

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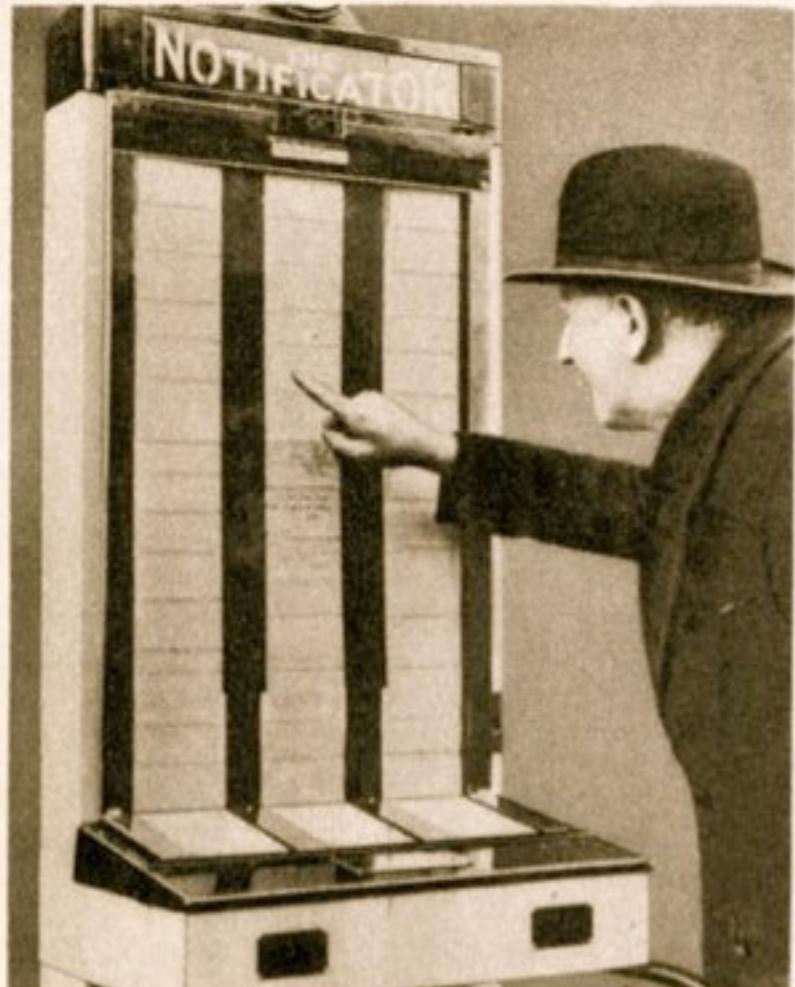
## SOCIAL MEOWDIA EXPLAINED



# Twitter

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## Robot Messenger Displays Person-to-Person Notes In Public



For a small sum Londoners may leave messages for friends in public places. When written on "notifier," message moves up behind window, remaining in view for two hours.

TO AID persons who wish to make or cancel appointments or inform friends of their whereabouts, a robot message carrier has been introduced in London, England.

Known as the "notifier," the new machine is installed in streets, stores, railroad stations or other public places where individuals may leave messages for friends.

The user walks up on a small platform in front of the machine, writes a brief message on a continuous strip of paper and drops a coin in the slot. The inscription moves up behind a glass panel where it remains in public view for at least two hours so that the person for whom it is intended may have sufficient time to observe the note at the appointed place. The machine is similar in appearance to a candy-vending device.

Source: Modern Mechanix (Aug, 1935)

twitter



# Anatomy of a Tweet

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# Anatomy of a Tweet

```
[u'contributors',
 u'truncated',
 u'text',
 u'in_reply_to_status_id',
 u'id',
 u'favorite_count',
 u'source',
 u'retweeted',
 u'coordinates',
 u'entities',
 u'in_reply_to_screen_name',
 u'in_reply_to_user_id',
 u'retweet_count',
 u'id_str',
 u'favorited',
 u'user',
 u'geo',
 u'in_reply_to_user_id_str',
 u'possibly_sensitive',
 u'lang',
 u'created_at',
 u'in_reply_to_status_id_str',
 u'place',
 u'metadata']
```

# Anatomy of a Tweet

---

```
[u'contributors',
 u'truncated',
 u'text',
 u'in_reply_to_status_id',
 u'id',
 u'favorite_count',
 u'source',
 u'retweeted',
 u'coordinates',
 u'entities',
 u'in_reply_to_screen_name',
 u'in_reply_to_user_id',
 u'retweet_count',
 u'id_str',
 u'favorited',
 u'user',  
    u'geo',
 u'in_reply_to_user_id_str',
 u'possibly_sensitive',
 u'lang',
 u'created_at',
 u'in_reply_to_status_id_str',
 u'place',
 u'metadata']
[u'follow_request_sent',
 u'profile_use_background_image',
 u'default_profile_image',
 u'id',
 u'profile_background_image_url_https',
 u'verified',
 u'profile_text_color',
 u'profile_image_url_https',
 u'profile_sidebar_fill_color',
 u'entities',
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 u'profile_sidebar_border_color',
 u'id_str',
 u'profile_background_color',
 u'listed_count',
 u'is_translator_enabled',
 u'utc_offset',
 u'statuses_count',
 u'description',
 u'friends_count',
 u'location',
 u'profile_link_color',
 u'profile_image_url',
 u'following',
 u'geo_enabled',
 u'profile_banner_url',
 u'profile_background_image_url',
 u'screen_name',
 u'lang',  
    u'profile_background_tile',
 u'favourites_count',
 u'name',
 u'notifications',
 u'url',
 u'created_at',
 u'contributors_enabled',
 u'time_zone',
 u'protected',
 u'default_profile',
 u'is_translator']
```

# Anatomy of a Tweet

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```
[u'contributors',
 u'truncated',
 u'text',
 u'in_reply_to_status_id',
 u'id',
 u'favorite_count',
 u'source',
 u'retweeted',
 u'coordinates',
 u'entities',
 u'in_reply_to_screen_name',
 u'in_reply_to_user_id',
 u'retweet_count',
 u'id_str',
 u'favorited',
 u'user',
 u'geo',
 u'in_reply_to_user_id_str',
 u'possibly_sensitive',
 u'lang',
 u'created_at',
 u'in_reply_to_status_id_str',
 u'place',
 u'metadata']

u"I'm at Terminal Rodovi\xcelrio de Feira de Santana
(Feira de Santana, BA) http://t.co/WirvdHwYMq

u'<a href="http://foursquare.com" rel="nofollow">
foursquare</a>'

[u'symbols',
 u'user_mentions',
 u'hashtags',
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 u'coordinates']
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# Geolocated Tweets

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# Geolocated Tweets

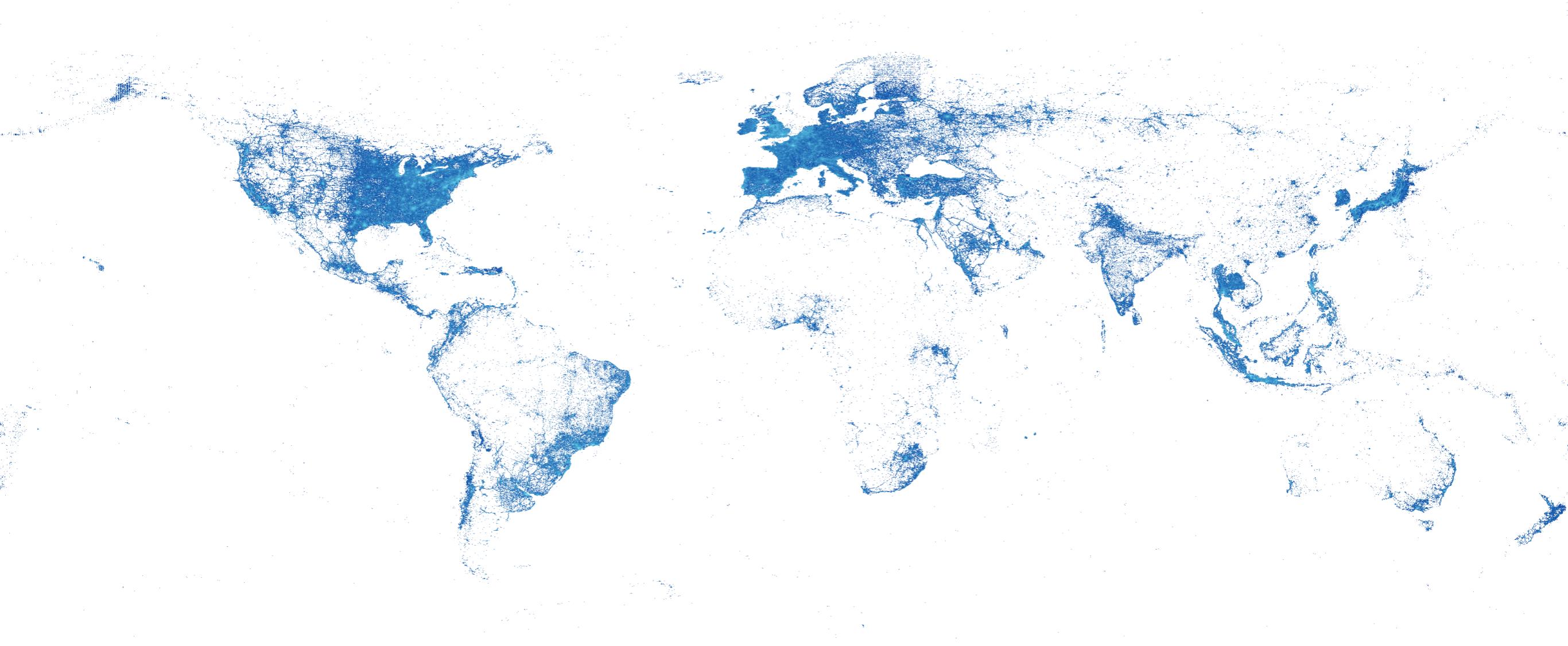
PLoS One 8, E61981 (2013)



**Bias** is a term used in statistics and psychology to describe a tendency to favor one outcome over another, often due to preexisting beliefs or information. It can manifest in various ways, such as confirmation bias, where individuals seek out information that supports their existing beliefs and ignore information that contradicts them. Another form of bias is selection bias, where researchers choose participants or data points that are more likely to support their hypothesis. In statistics, bias refers to the difference between the expected value of an estimator and the true value of the parameter being estimated. A biased estimator is one that consistently provides estimates that are not equal to the true value. This can occur due to factors such as sampling error, measurement error, or unrepresentative samples. In psychology, bias is often studied in the context of social cognition, where individuals may have unconscious biases based on gender, race, or other demographic factors. These biases can influence how people perceive and interpret information, leading to unfair treatment or discrimination. Addressing bias requires awareness and effort to counteract preexisting beliefs and biases, and to ensure that research and decision-making are based on objective and representative data.

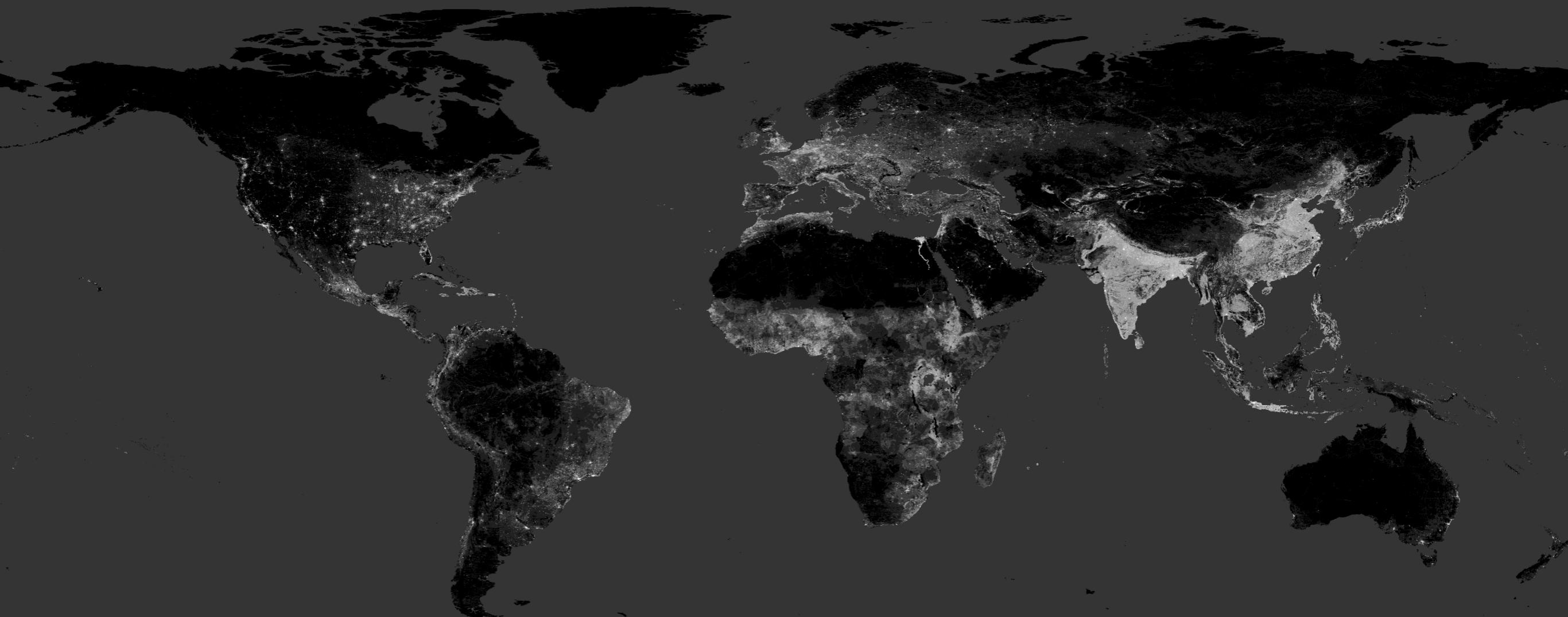
# GPS Coordinates

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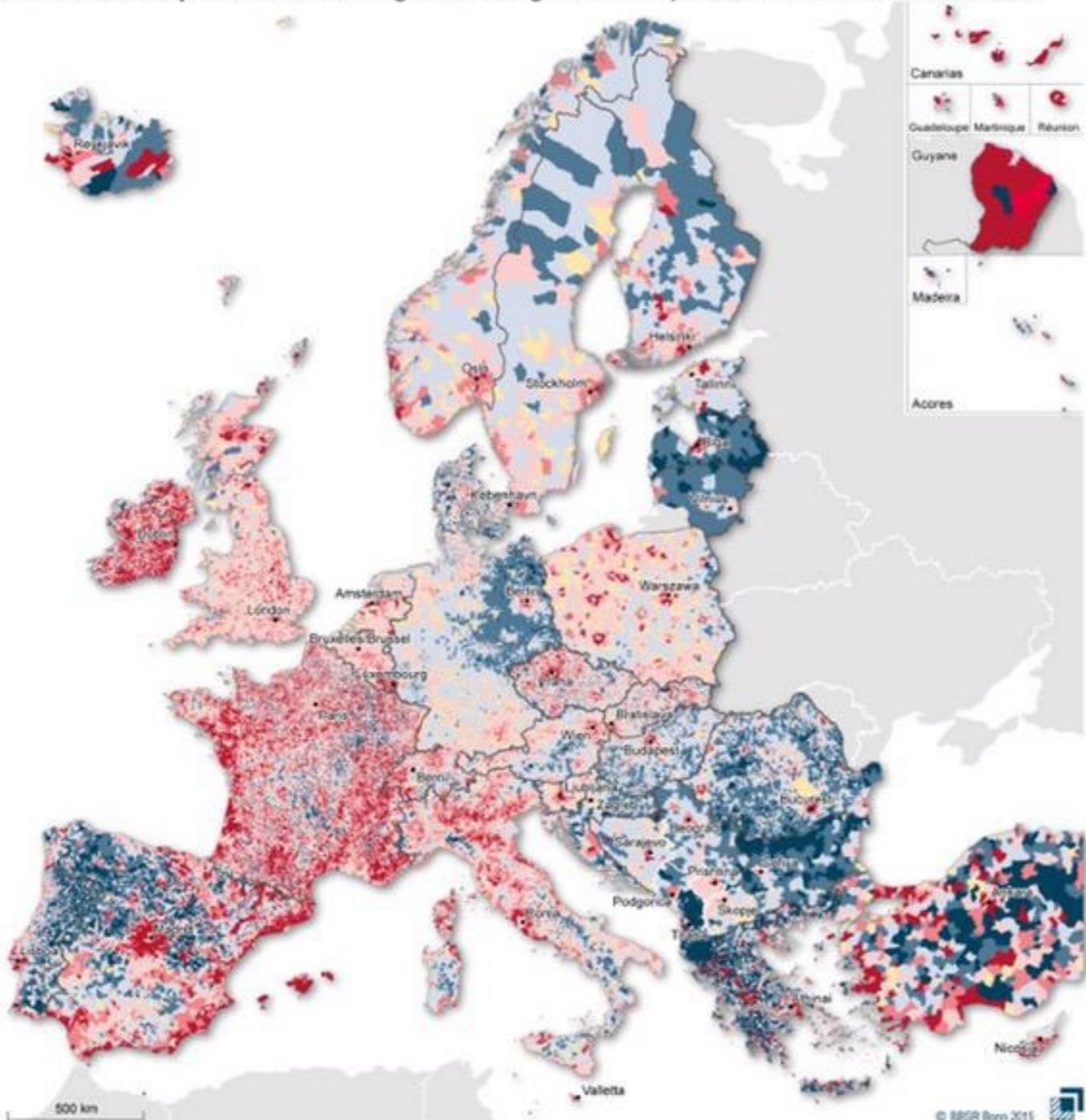
# World Population

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# Biases

Durchschnittliche jährliche Bevölkerungsentwicklung in den Europäischen Lokalen Gebietseinheiten



Durchschnittliche jährliche Bevölkerungsentwicklung von 2001-2011\* in % in den Gemeinden (LAU2)\*\*



\*Bevölkerungsdaten: Dezember 2001, 2011.  
\*\*LAU2: 2001: FR, FRA, 2009: IT, NL, PL, SL, MD; 2011:  
BA, 2007-2010: ME, 2003-2011: BE, 2007-2011  
Regierungsbezirke CH: 2007, 2010, HS: 2011, 2012  
\*\*Europa: Substaatseinheiten LAU2: BG, LT, ME, AM, TR, LAU1:  
Autonome Substaatseinheiten: LAU2: Äquivalente AL, PO, GL;  
LAU1 Äquivalente BA, K, R

© BEISER Bonn 2015  
Statistik Austria  
Geometrische Grundlage: GRI-Erfassung  
Regionen LAU2  
Bewohntang R: Birken, L: Bäder, N: Küsten-Wälder,  
T: Fichtenwald, V: Schneidt-Schweiz

## Smartphone Ownership Highest Among Young Adults, Those With High Income/Education Levels

% of U.S. adults in each group who own a smartphone

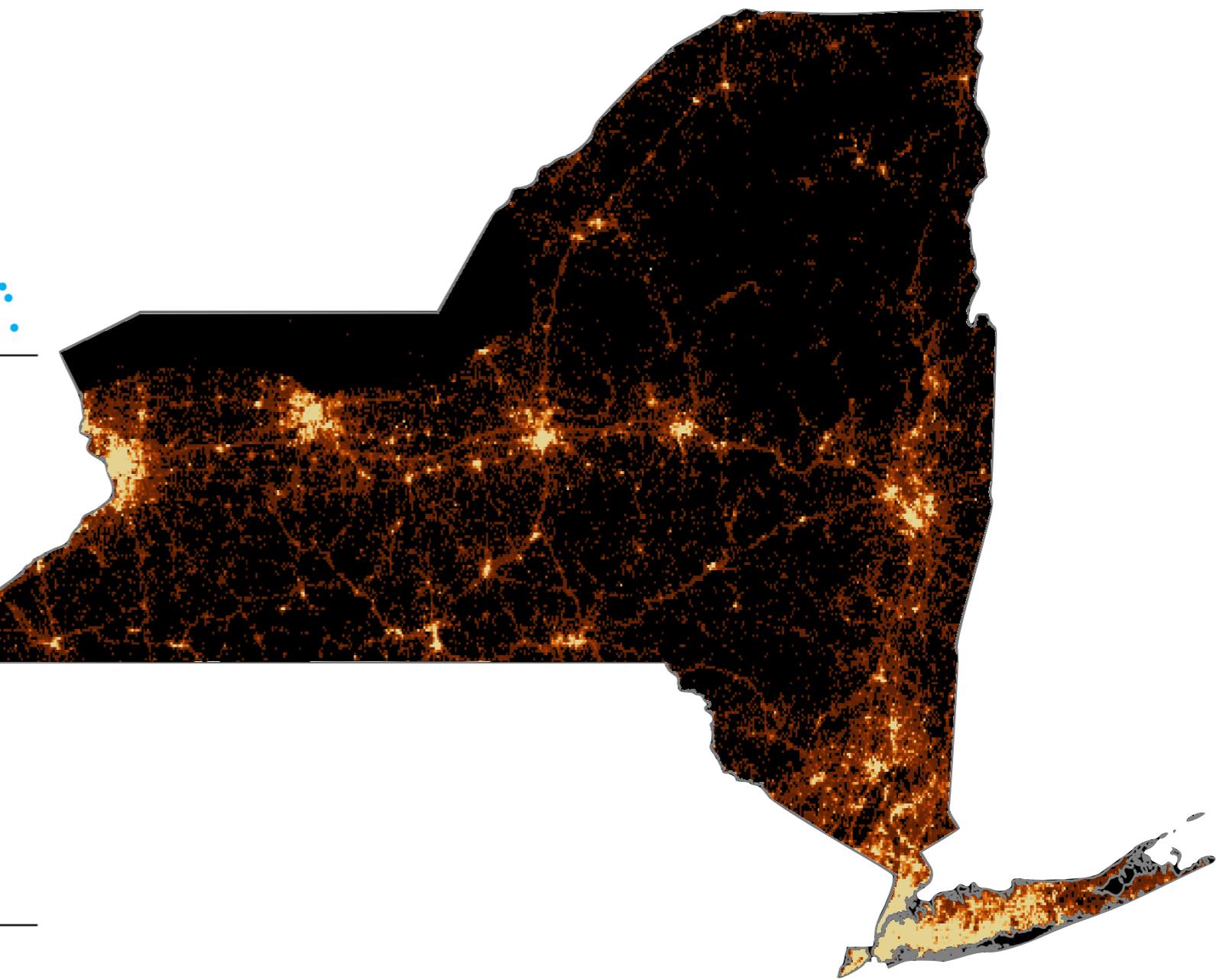
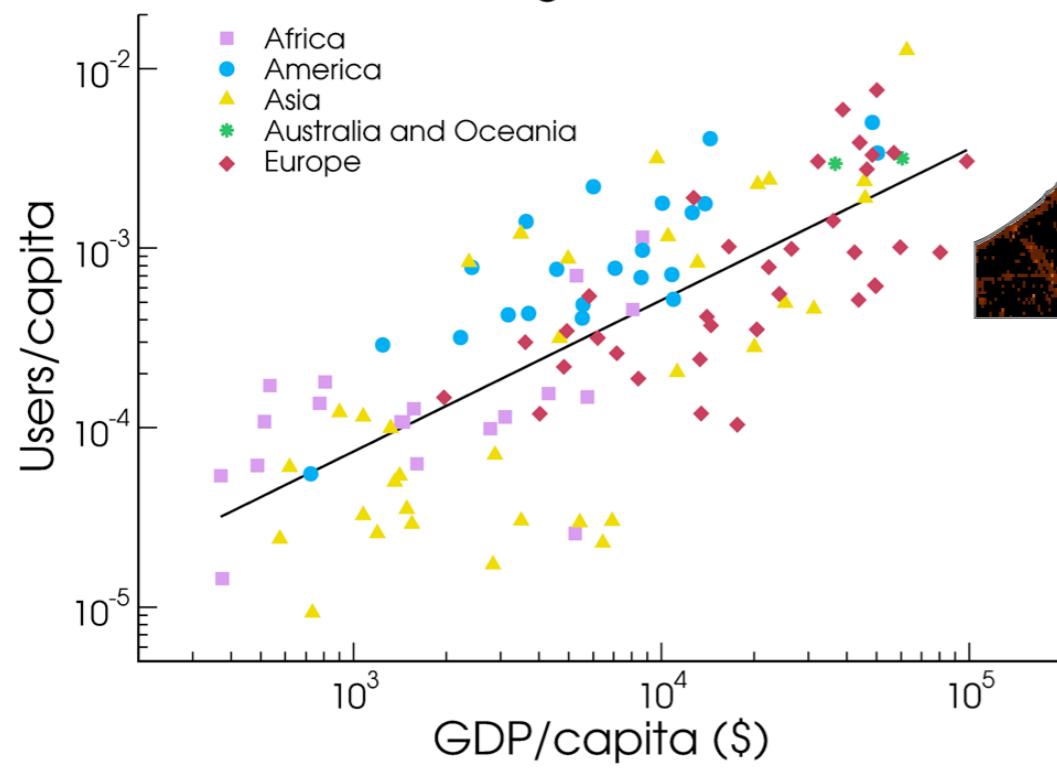
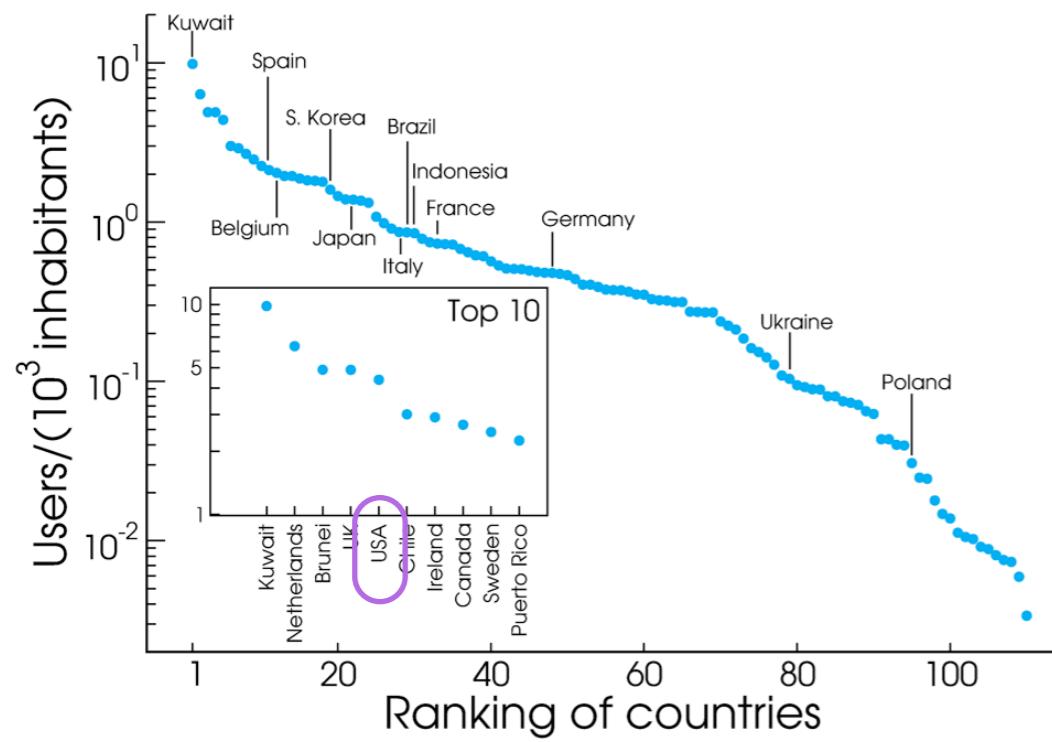
All adults	64%
Male	66
Female	63
18-29	85
30-49	79
50-64	54
65+	27
White, non-Hispanic	61
Black, non-Hispanic	70
Hispanic	71
HS grad or less	52
Some college	69
College+	78
Less than \$30,000/yr	50
\$30,000-\$49,999	71
\$50,000-\$74,999	72
\$75,000 or more	84
Urban	68
Suburban	66
Rural	52

Combined analysis of Pew Research Center surveys conducted Dec. 4-7 and Dec. 18-21, 2014.

PEW RESEARCH CENTER

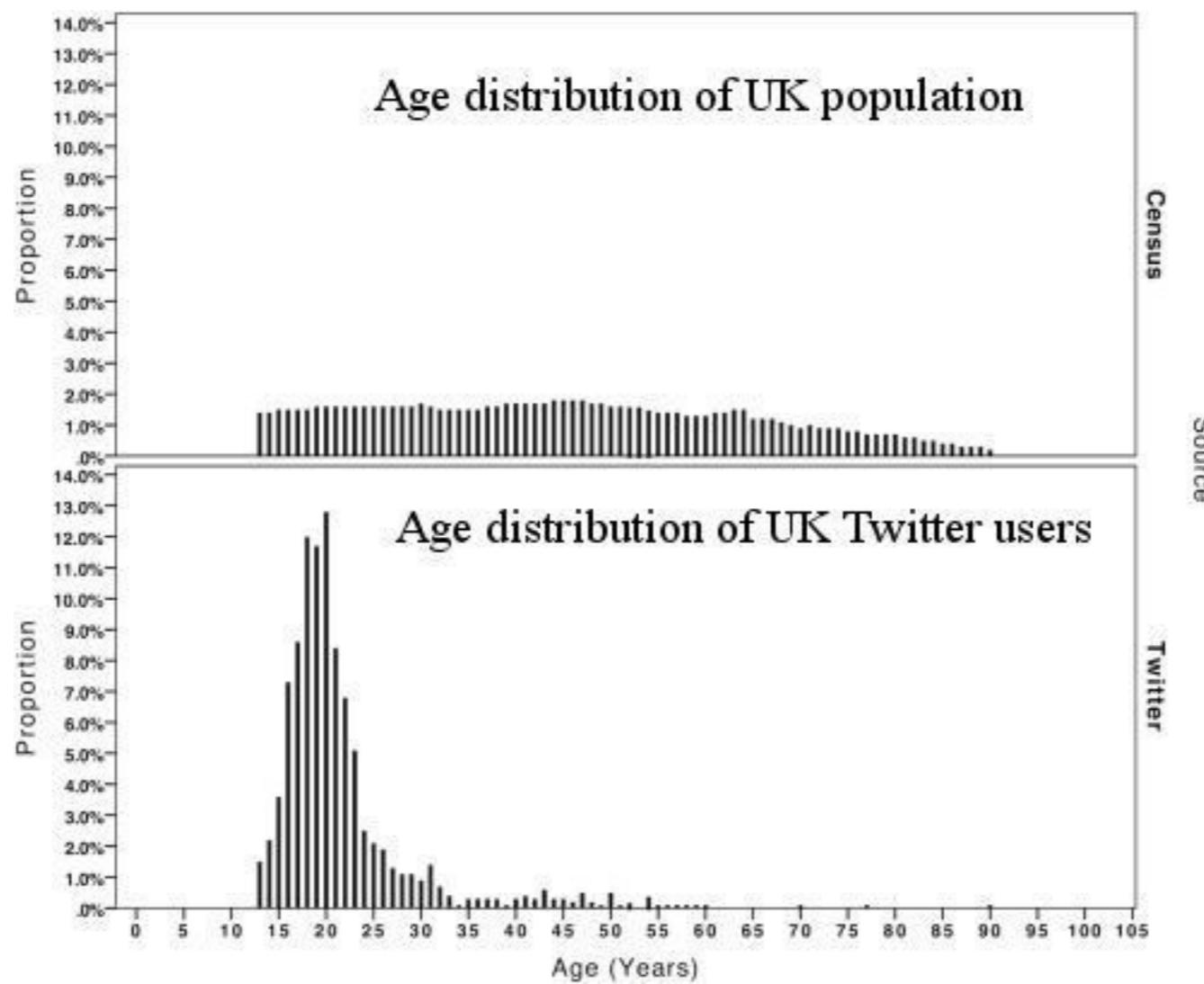
# Market Penetration

PLoS One 8, E61981 (2013)



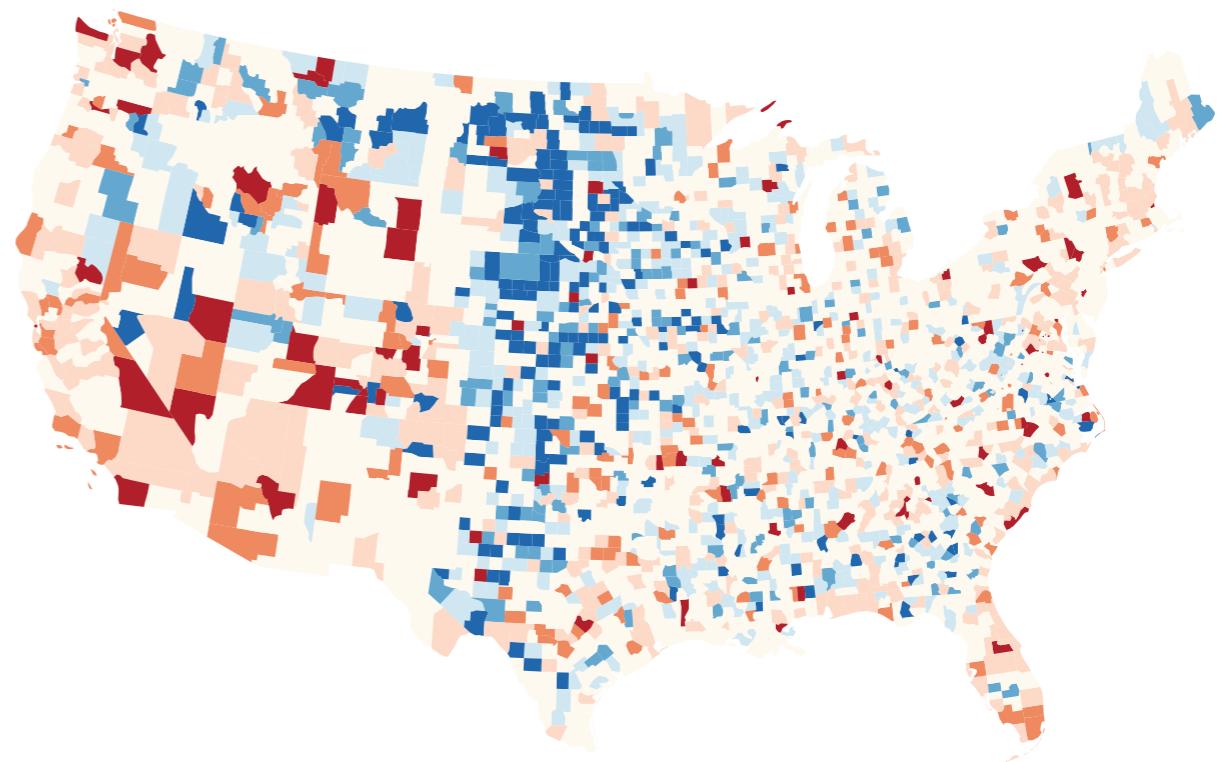
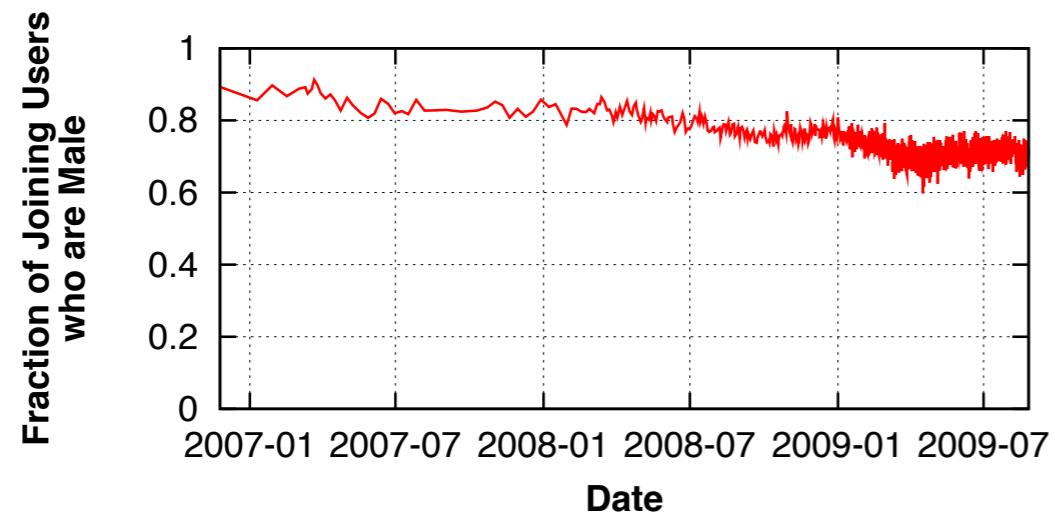
# Age Distribution

PLoS One 10, e0115545 (2015)

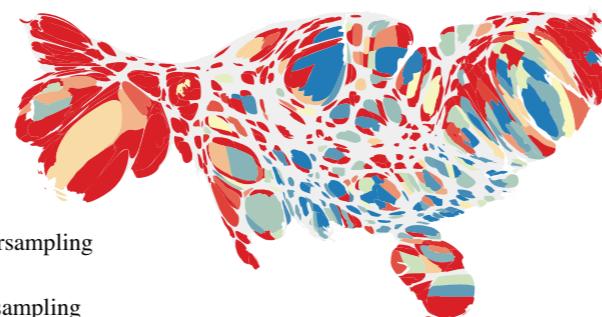


# Demographics

ICWSM'11, 375 (2011)



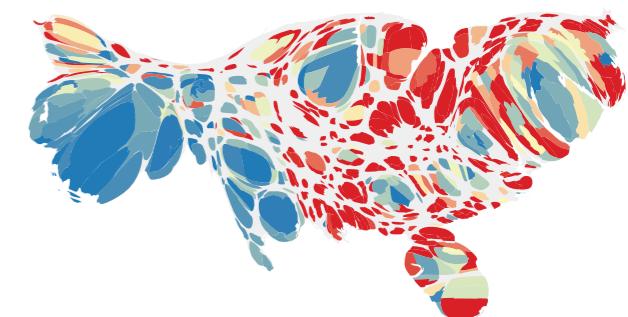
(a) Caucasian (non-hispanic)



(b) African-American



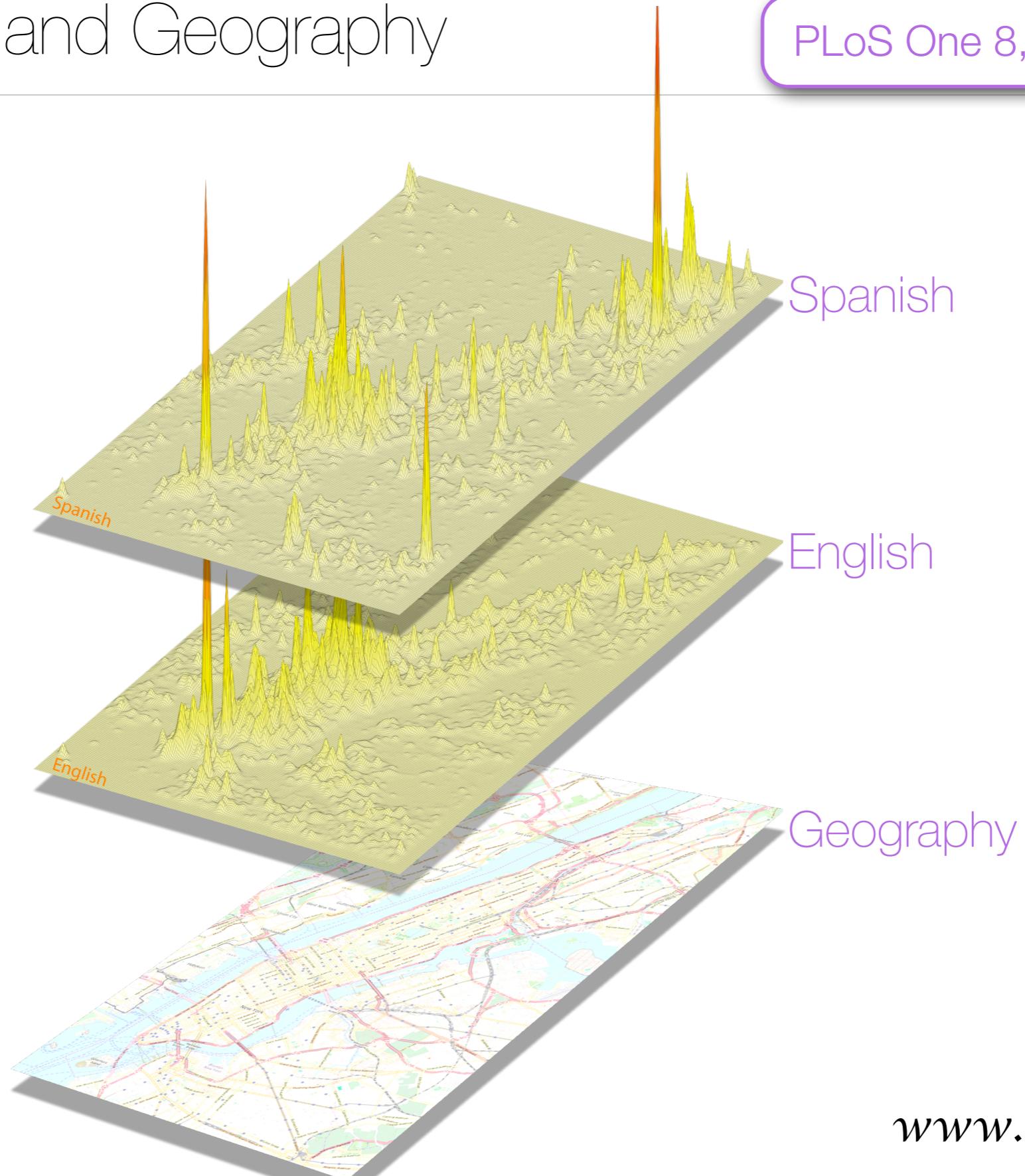
(c) Asian or Pacific Islander



(d) Hispanic

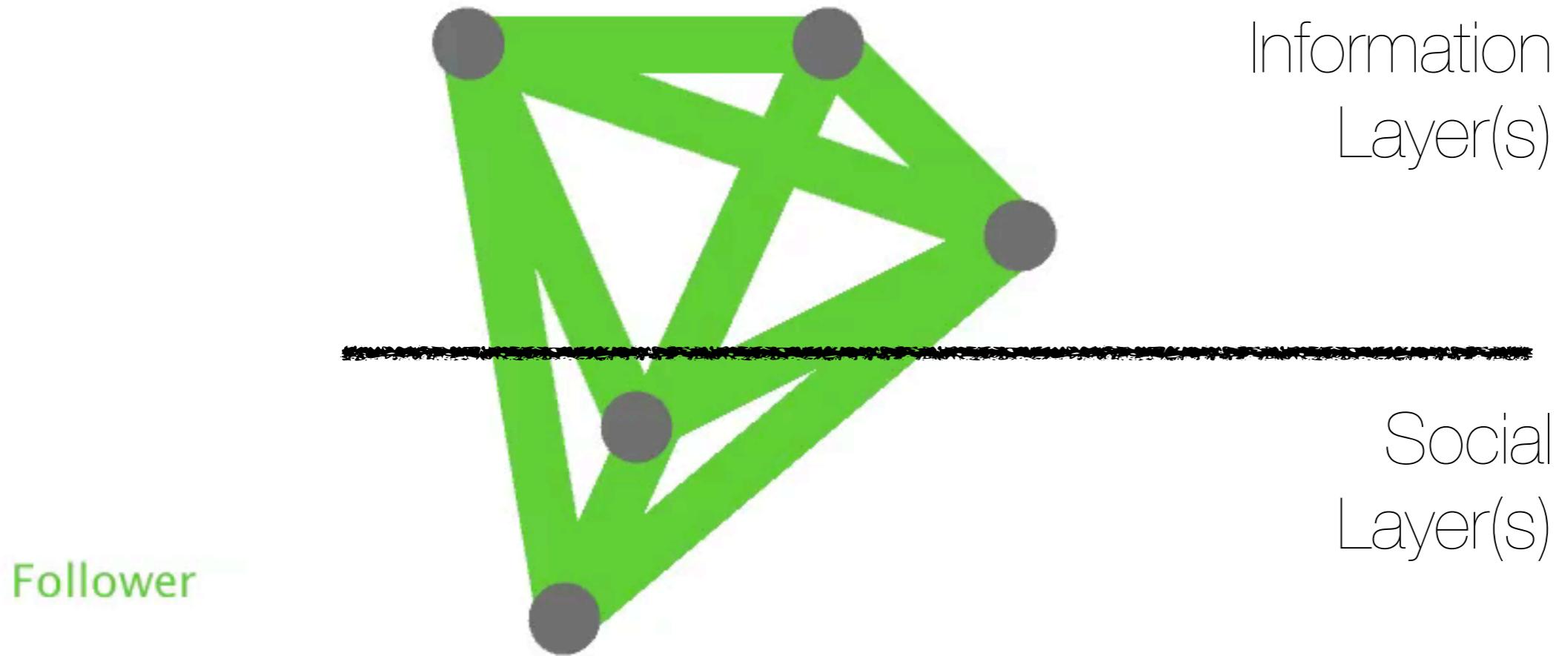
# Language and Geography

PLoS One 8, E61981 (2013)



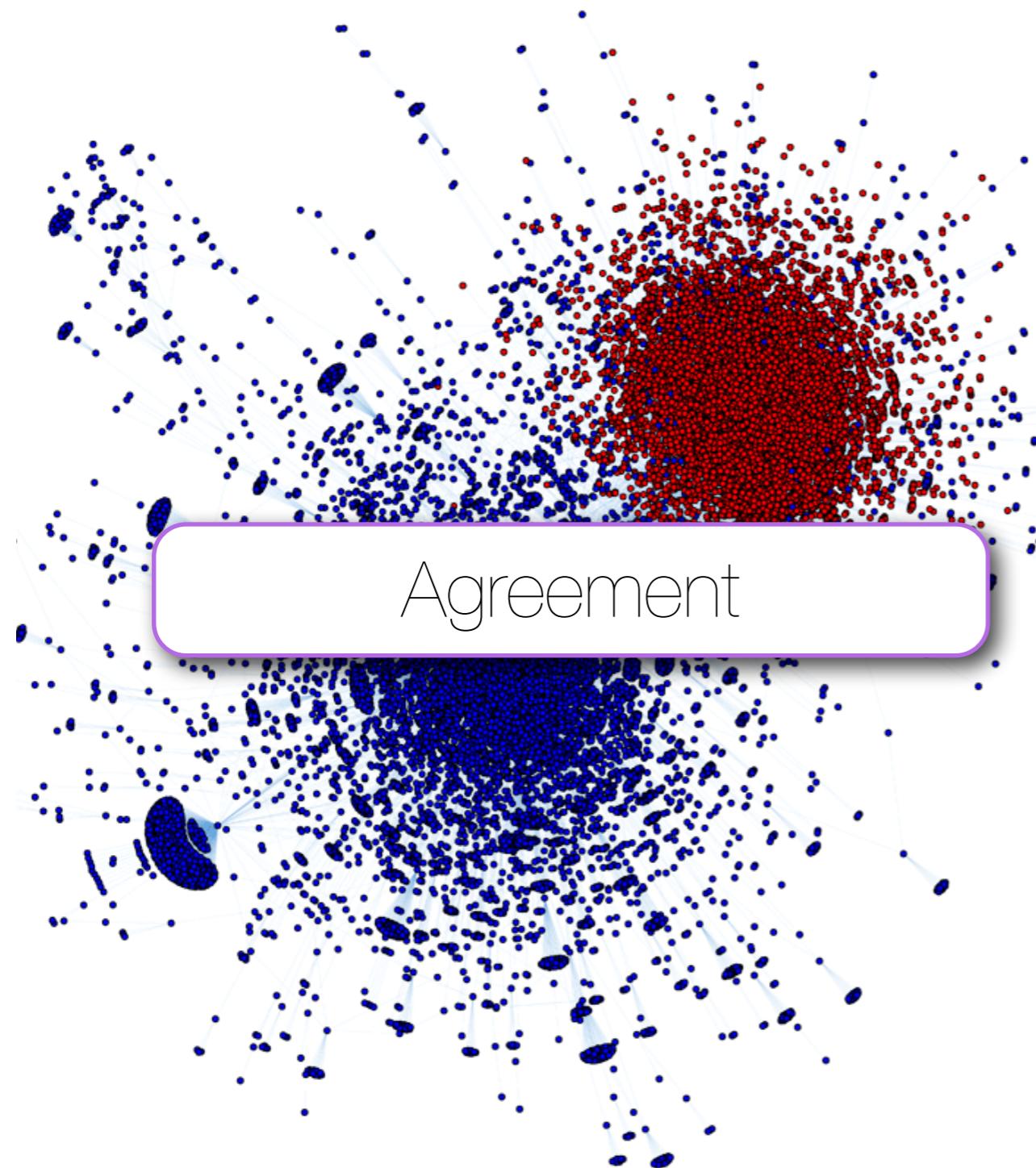
# Multilayer Network

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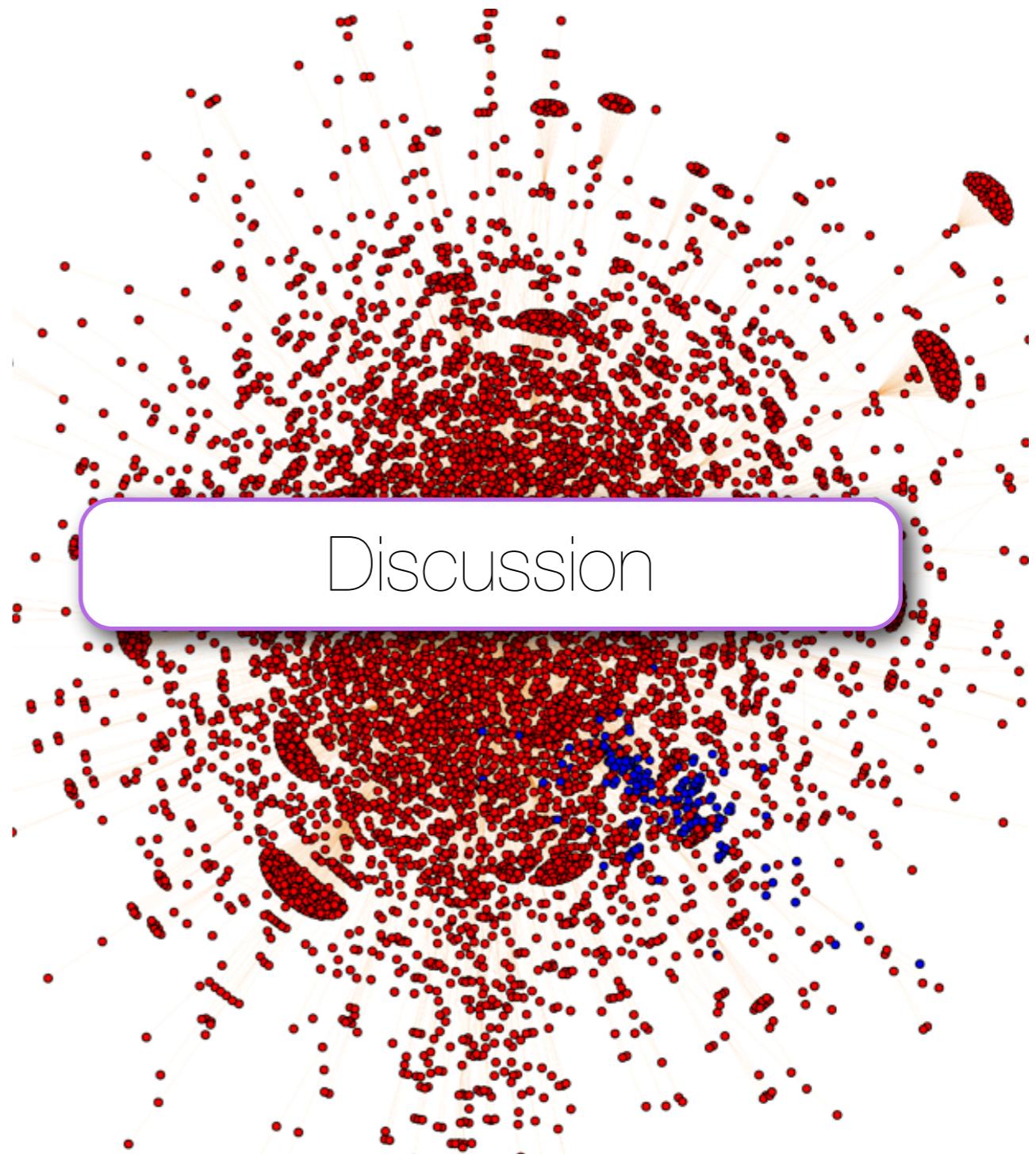


# Link Function

ICWSM'11, 89 (2011)



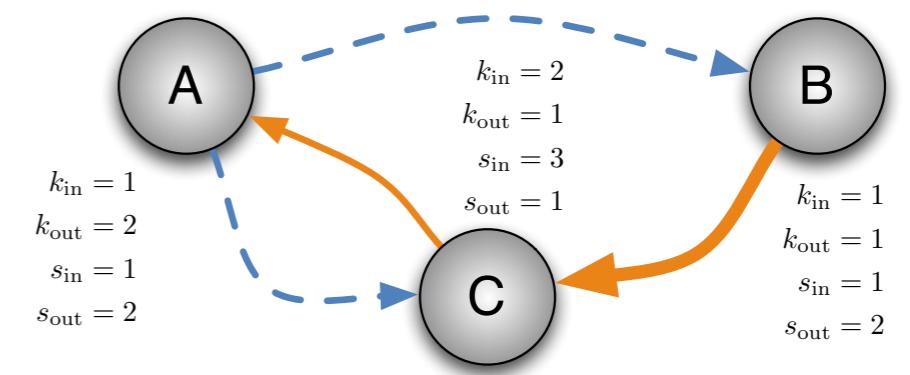
Agreement



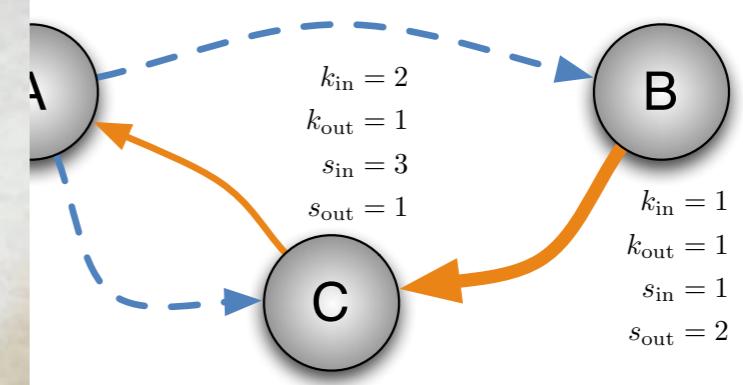
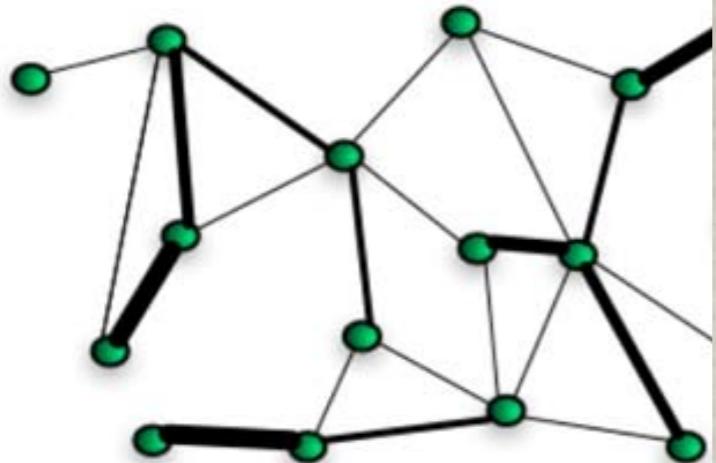
Discussion

# The Strength of Ties

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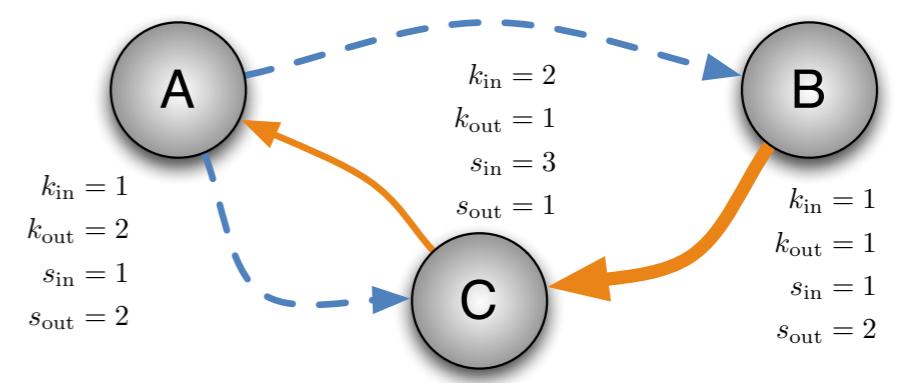


# The Strength of Weak Ties



Mark S. Granovetter  
Johns Hopkins University

## The Strength of Weak Ties (1973)



- Interviews to find out how individuals found out about job opportunities.
- Mostly from acquaintances or friends of friends
- "It is argued that the degree of overlap of two individuals social networks varies directly with the strength of their tie to one another"

Mark S. Granovetter  
Johns Hopkins University

# The Strength of Weak Ties (1973)

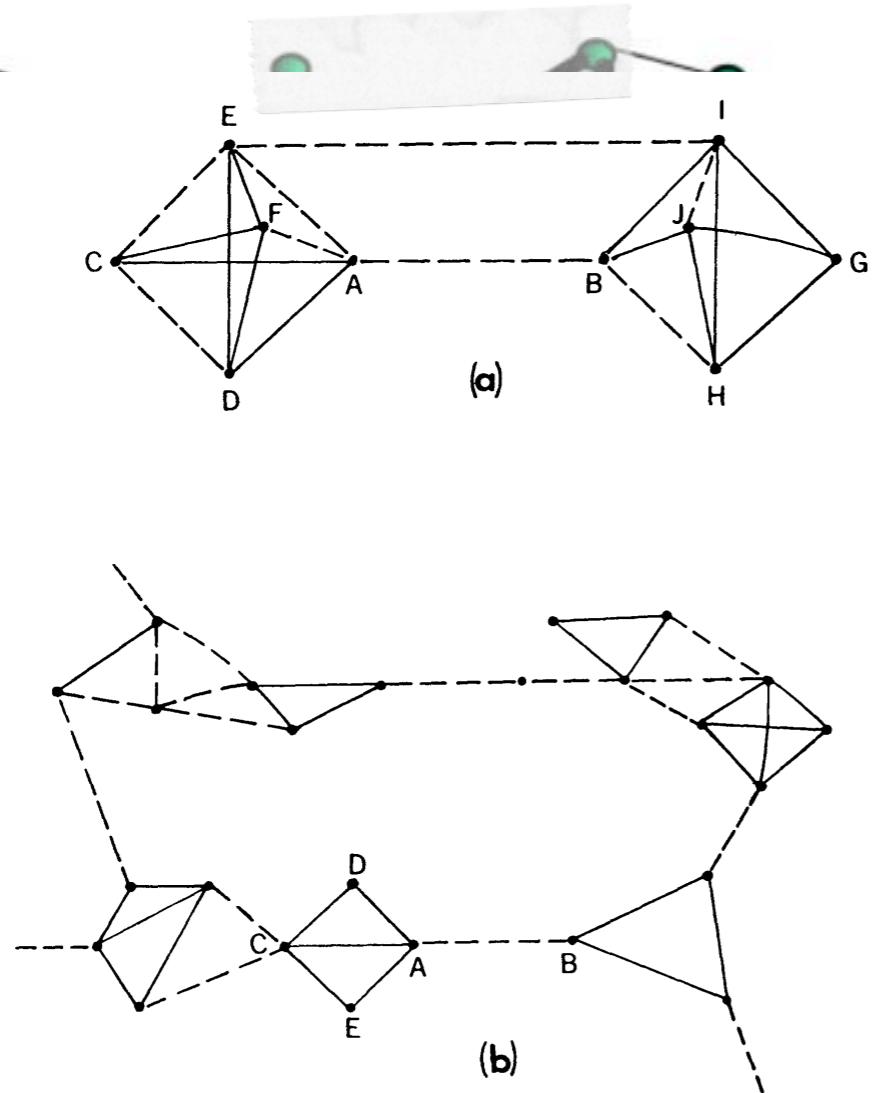
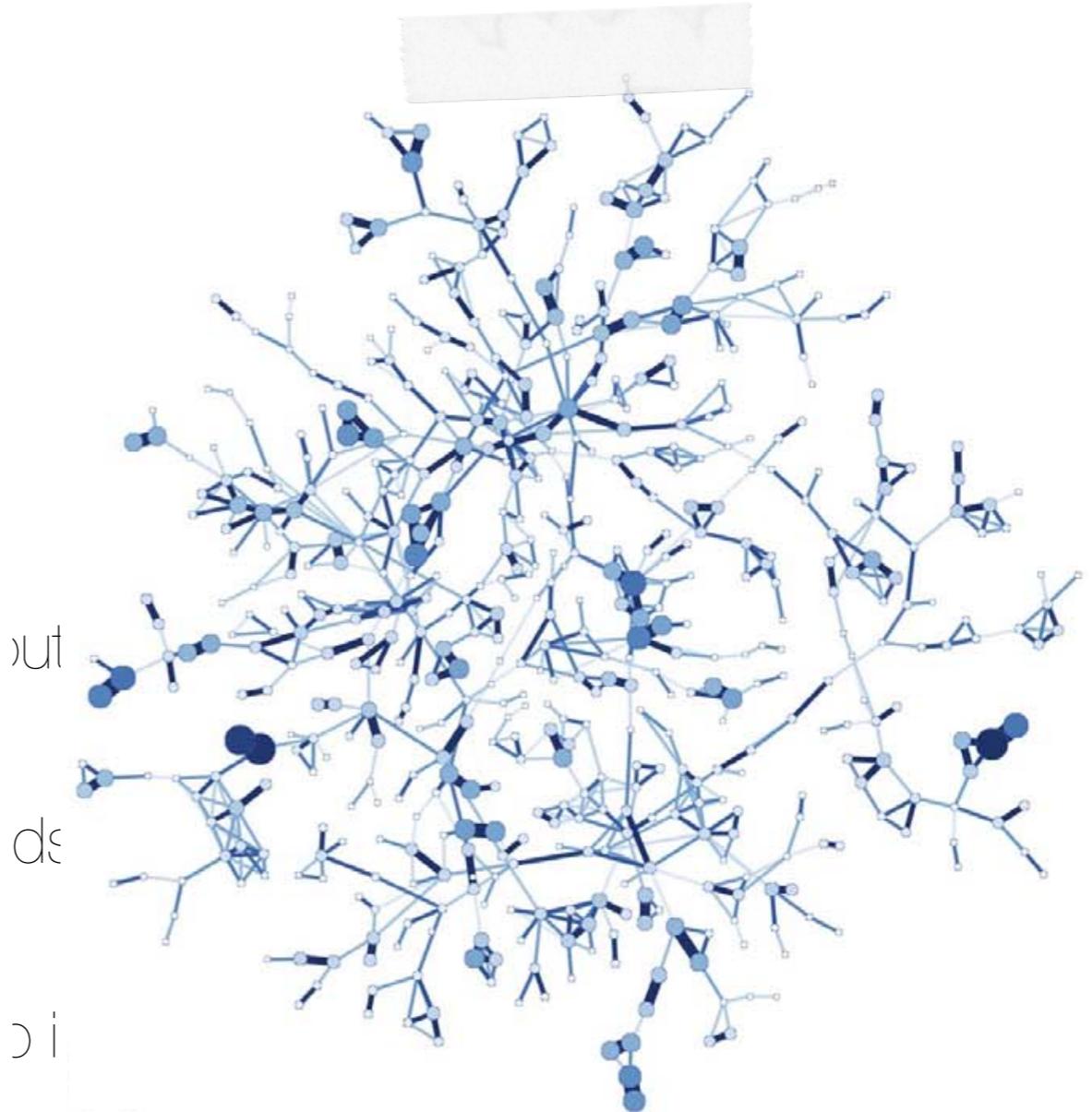
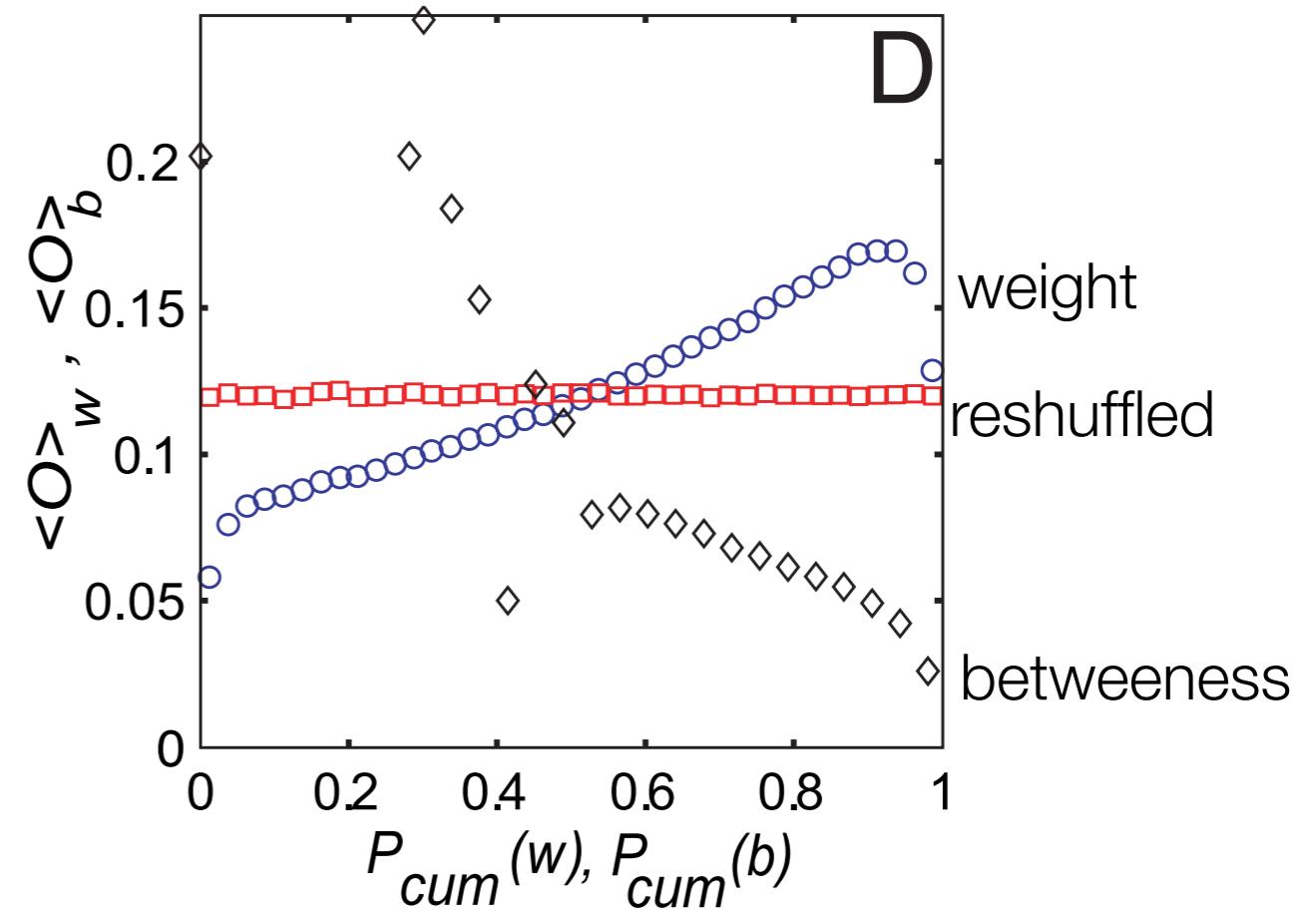
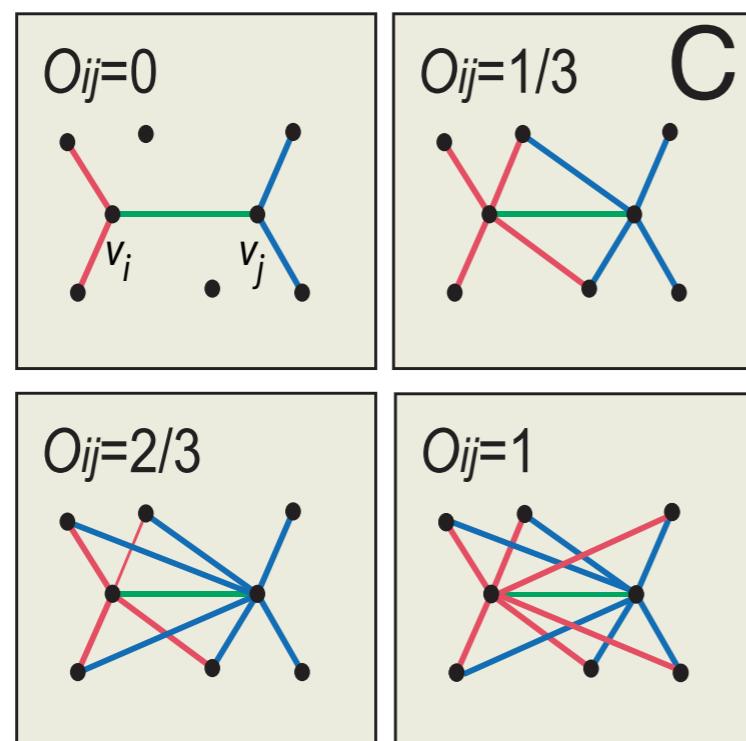


FIG. 2.—Local bridges. *a*, Degree 3; *b*, Degree 13. — = strong tie; - - - = weak tie.



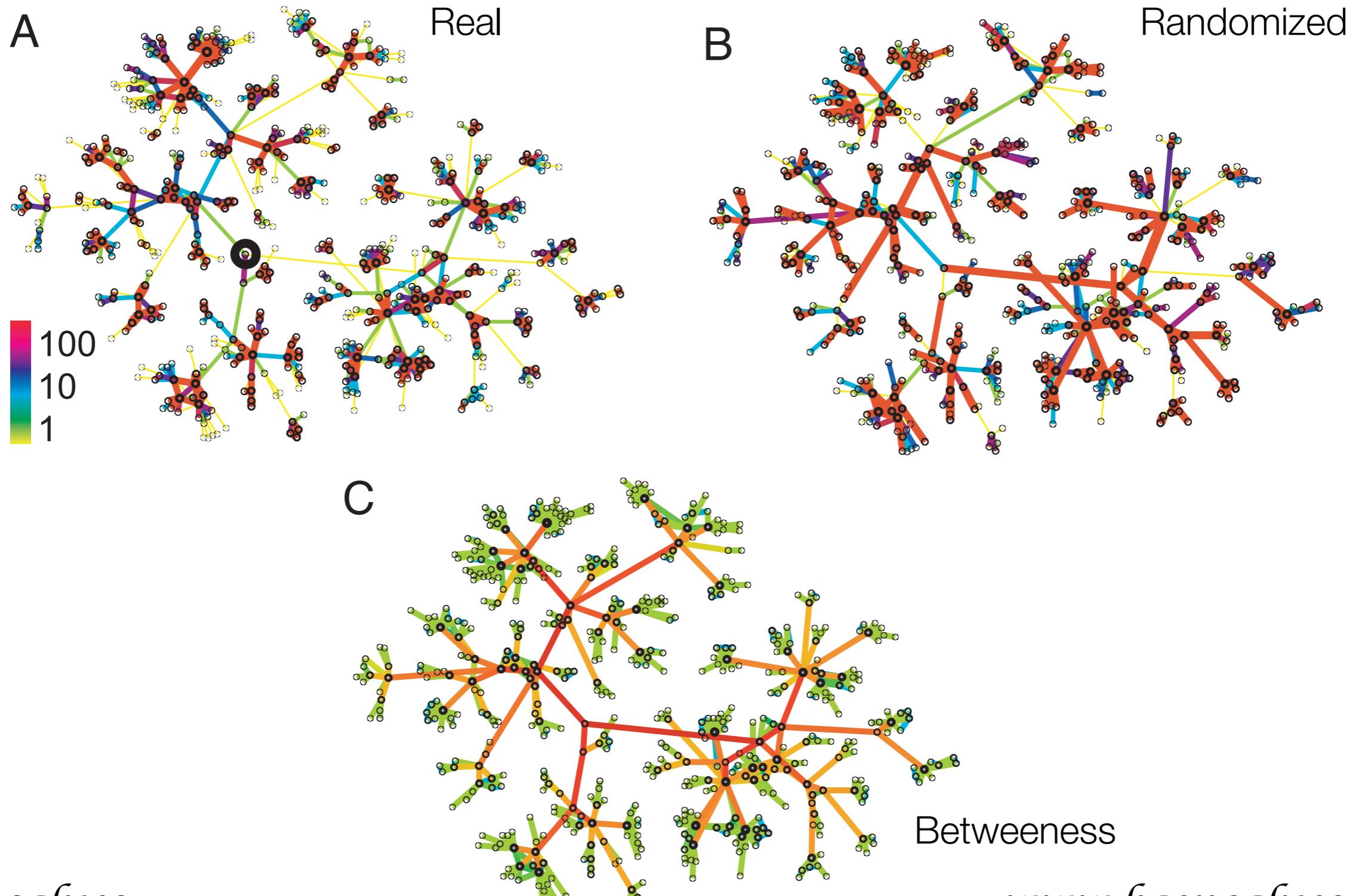
# Neighborhood Overlap

PNAS 104, 7333 (2007)



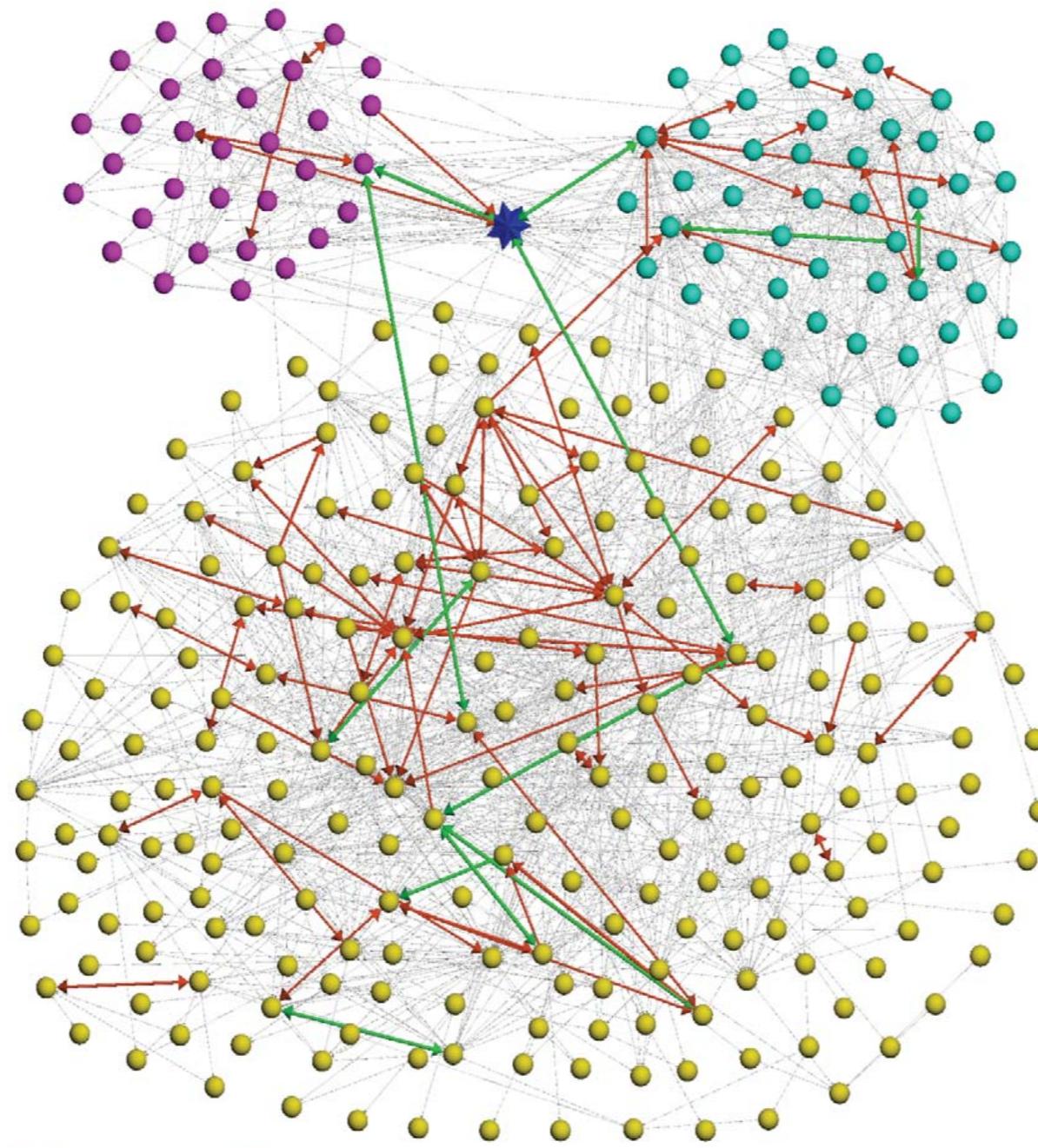
# Strong Ties have higher overlaps

PNAS 104, 7333 (2007)



# Network Structure

PLoS One 7, e29358 (2012)



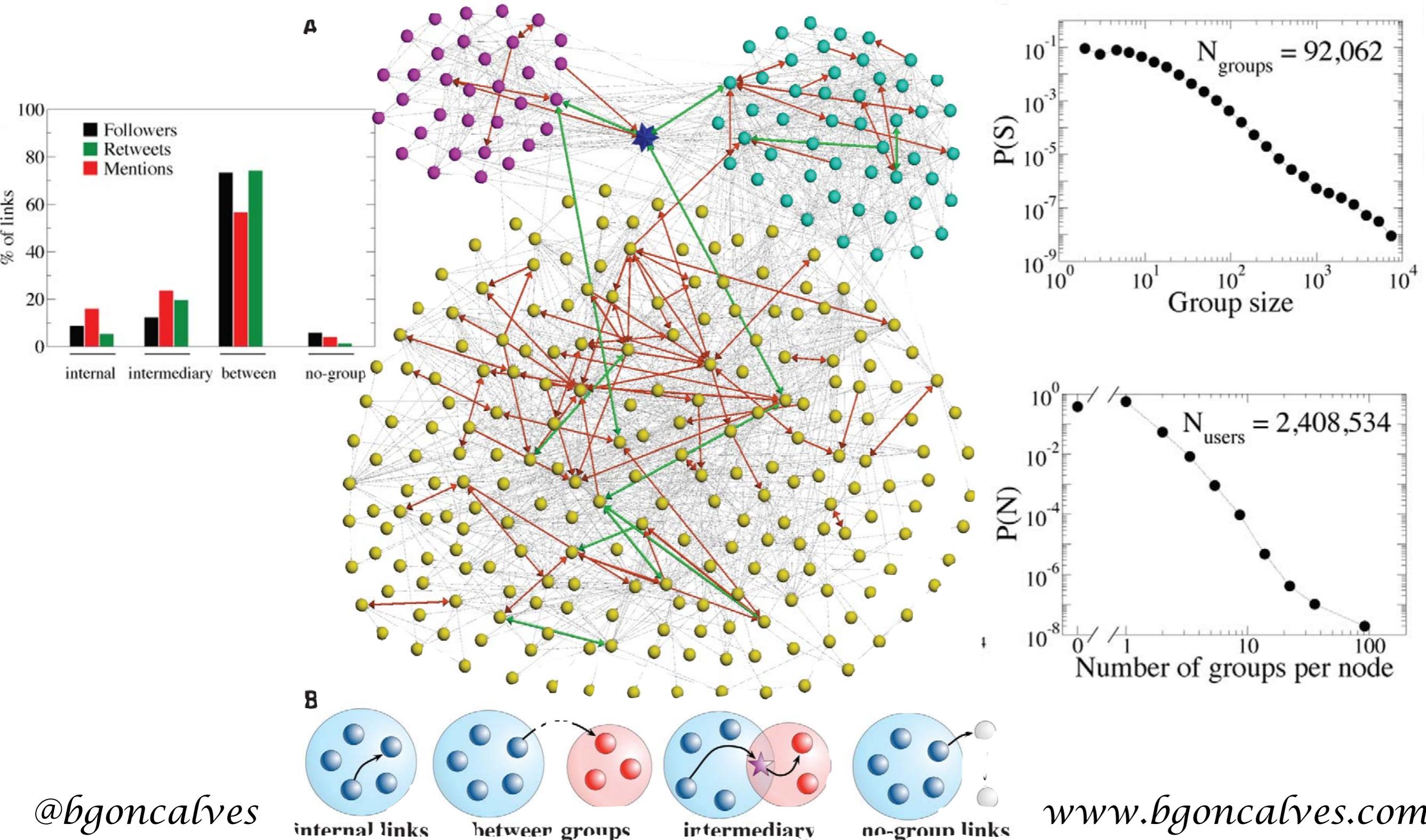
## Structural Holes and Good Ideas<sup>1</sup>

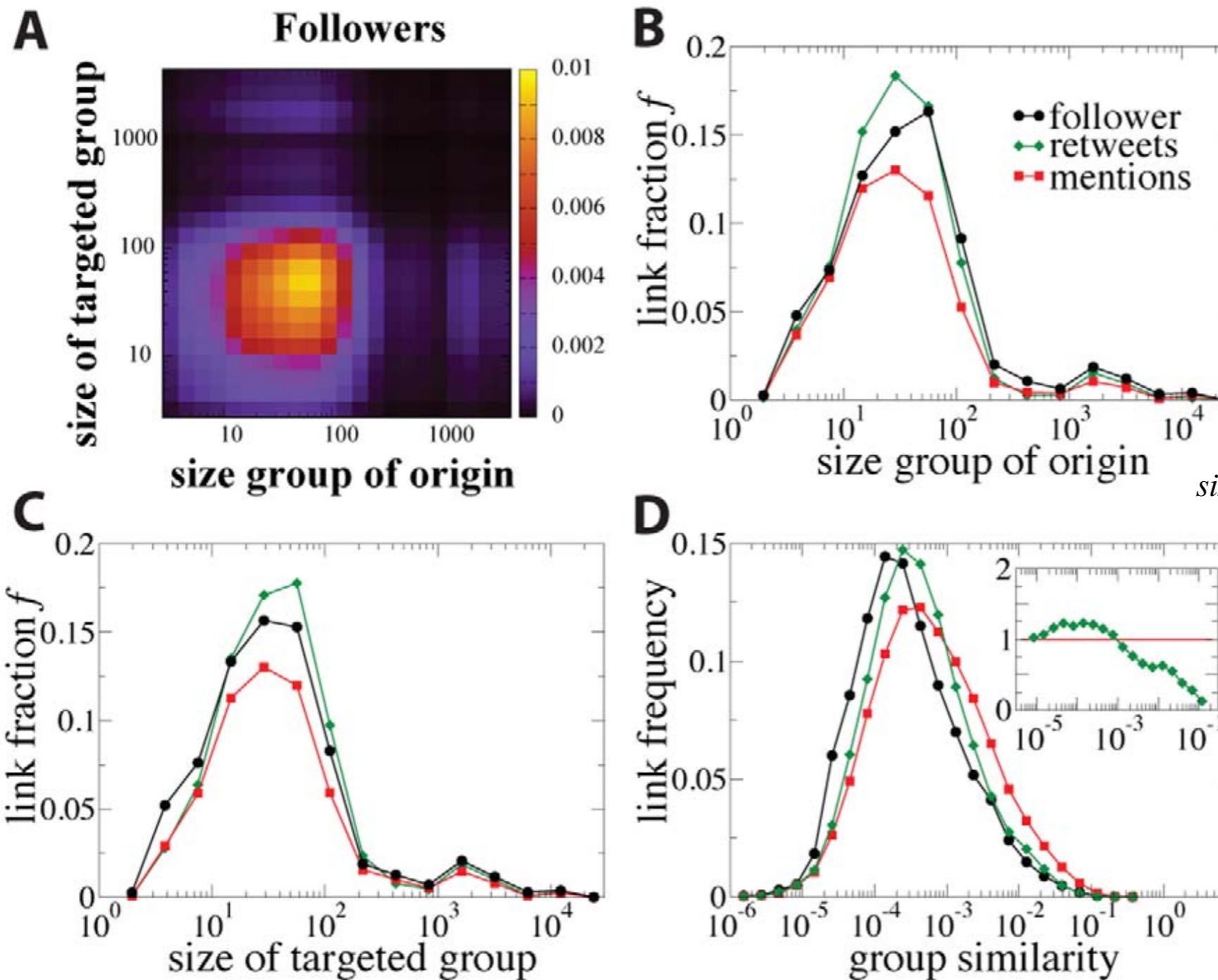
Ronald S. Burt  
*University of Chicago*

“People whose networks bridge the structural holes between groups have an advantage in detecting and developing rewarding opportunities. Information arbitrage is their advantage. They are able to see early, see more broadly, and translate information across groups.”

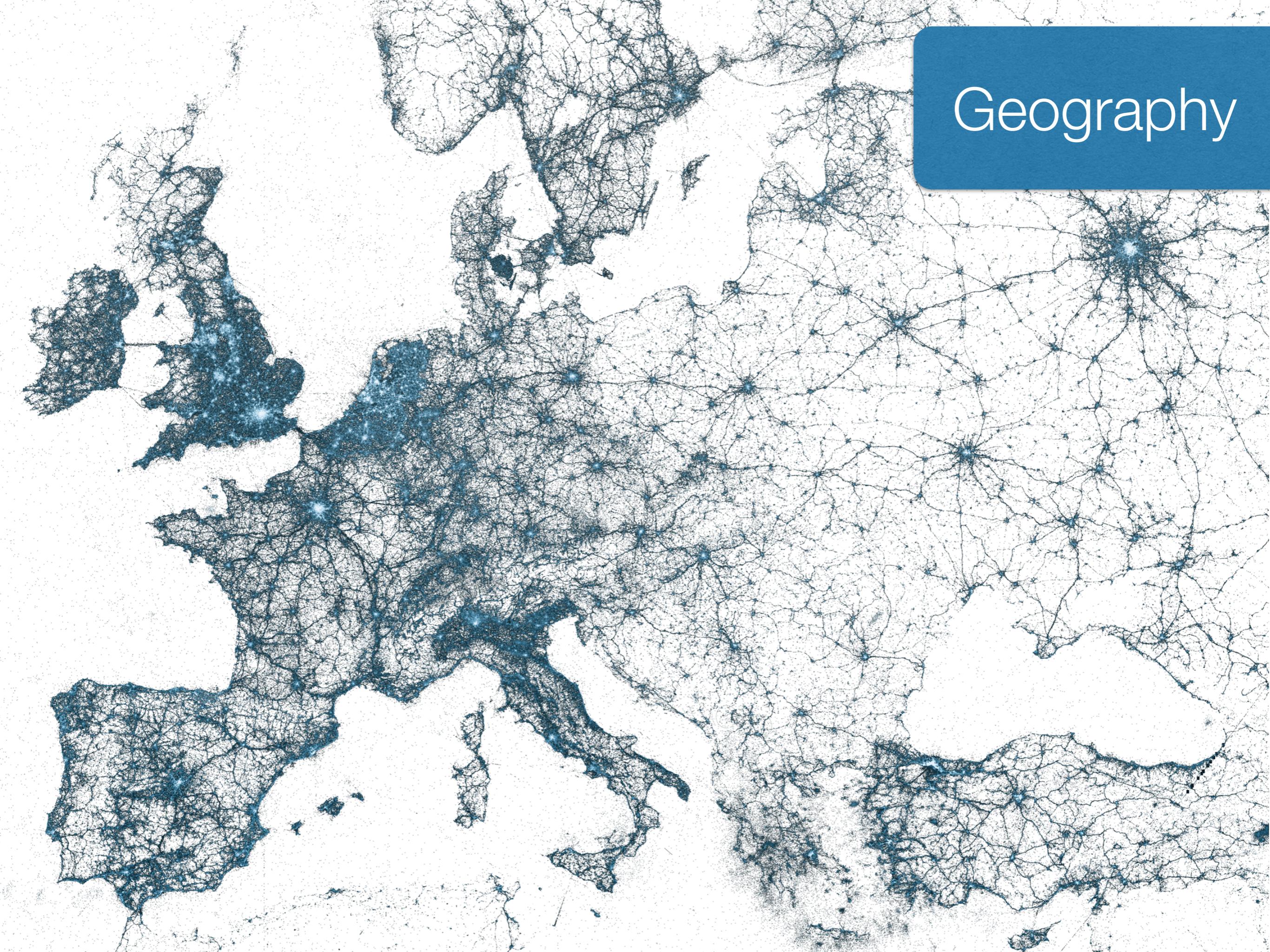
# Network Structure

PLoS One 7, e29358 (2012)





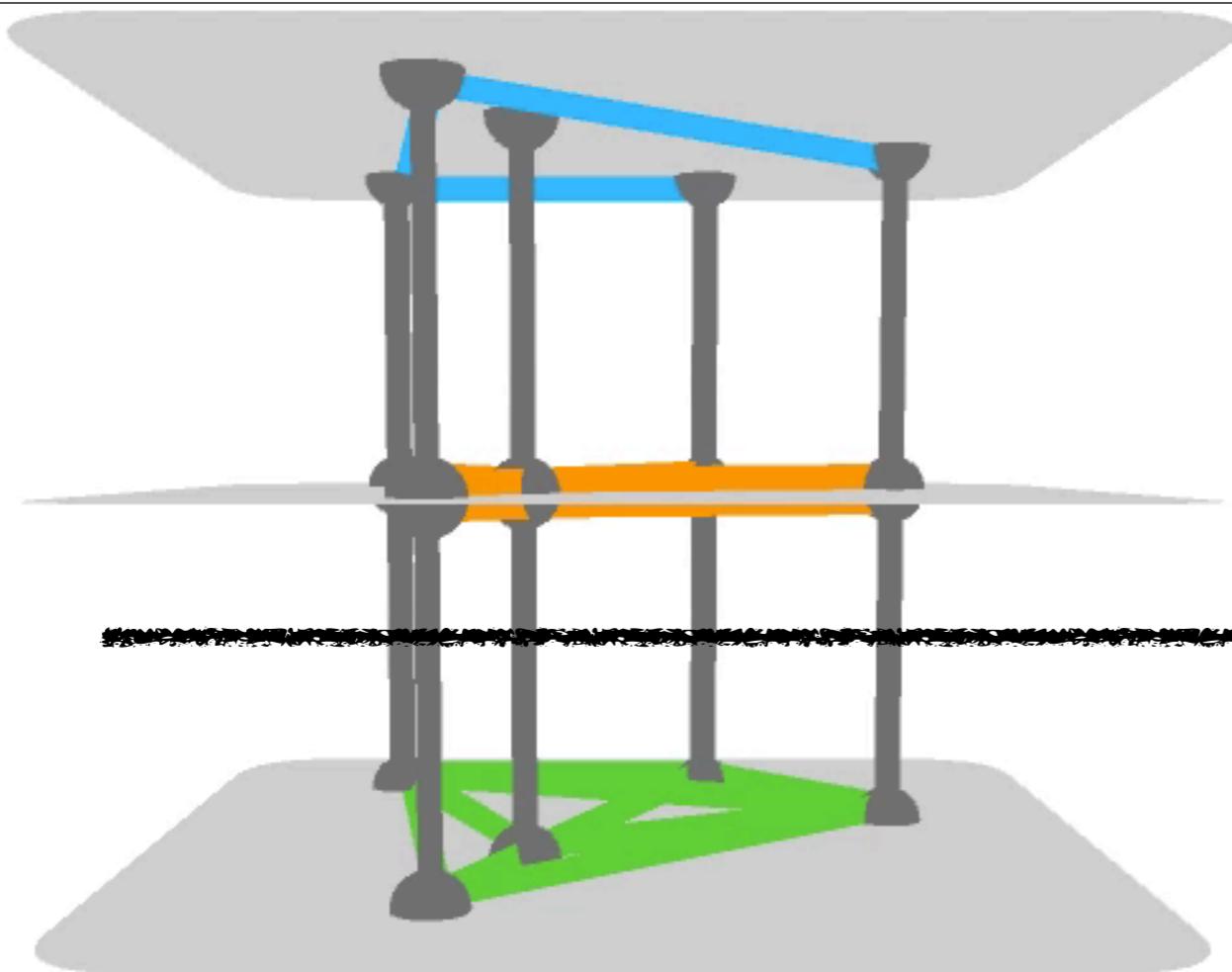
$$\text{similarity}(A, B) = \frac{|\cap \text{links of } A \text{ and } B|}{|\cup \text{links of } A \text{ and } B|}$$

A world map where every country's borders are represented by a dense web of blue lines and small dots. The density of the network varies by country, with higher connectivity shown in darker shades of blue. Major cities are marked with larger, glowing blue dots. The map illustrates the interconnectedness of the world's economies and networks.

# Geography

# Multilayer Network

Retweet



Information  
Layer(s)

Mention

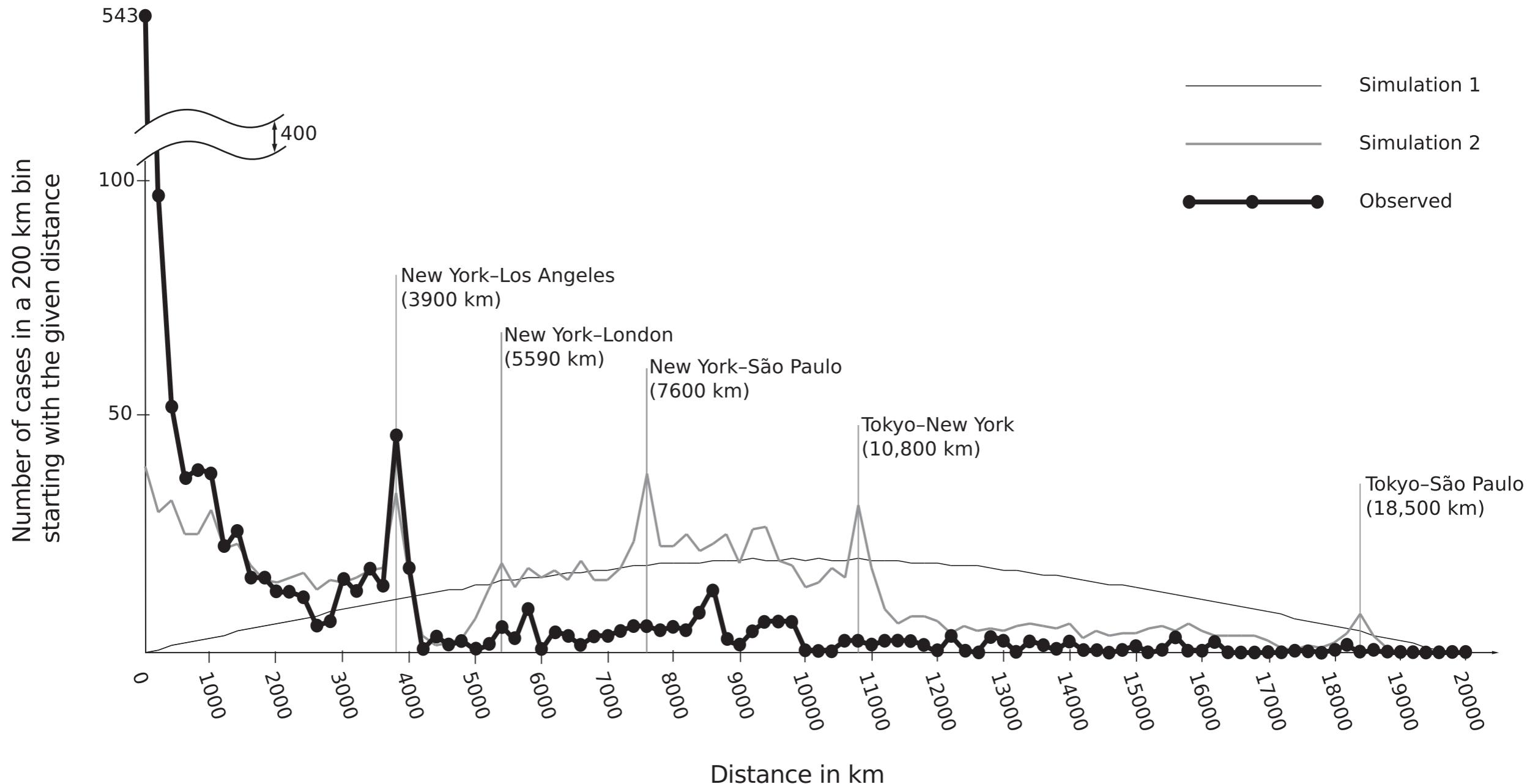
Social  
Layer(s)

Follower

Geographical  
Layer(s)

# Twitter Follower Distance

Social Networks 34, 73 (2012)



	Share of egos (%) <sup>a</sup>	Share of egos (%) for egos in dyads <sup>b</sup>	Share of alters (%) <sup>c</sup>	Percentage of domestic ties <sup>d</sup>	Percentage of domestic ties among non-local ties <sup>d</sup>
USA	48.5	45.7	54.5	91.6	89.3
Brazil	10.6	12.1	10.5	83.5	72.5
UK	7.6	8.3	7.6	50.6	33.3
Japan	5.5	6.5	6.3	92.1	86.0
Canada	3.7	3.8	2.9	33.3	23.1
Australia	2.7	2.7	1.9	50.0	32.0
Indonesia	2.6	1.8	1.2	60.0	25.0
Germany	2.1	1.8	1.3	62.9	58.8
Netherlands	1.4	1.4	1.2	66.7	22.2
Mexico	1.2	1.3	0.7	44.0	8.3

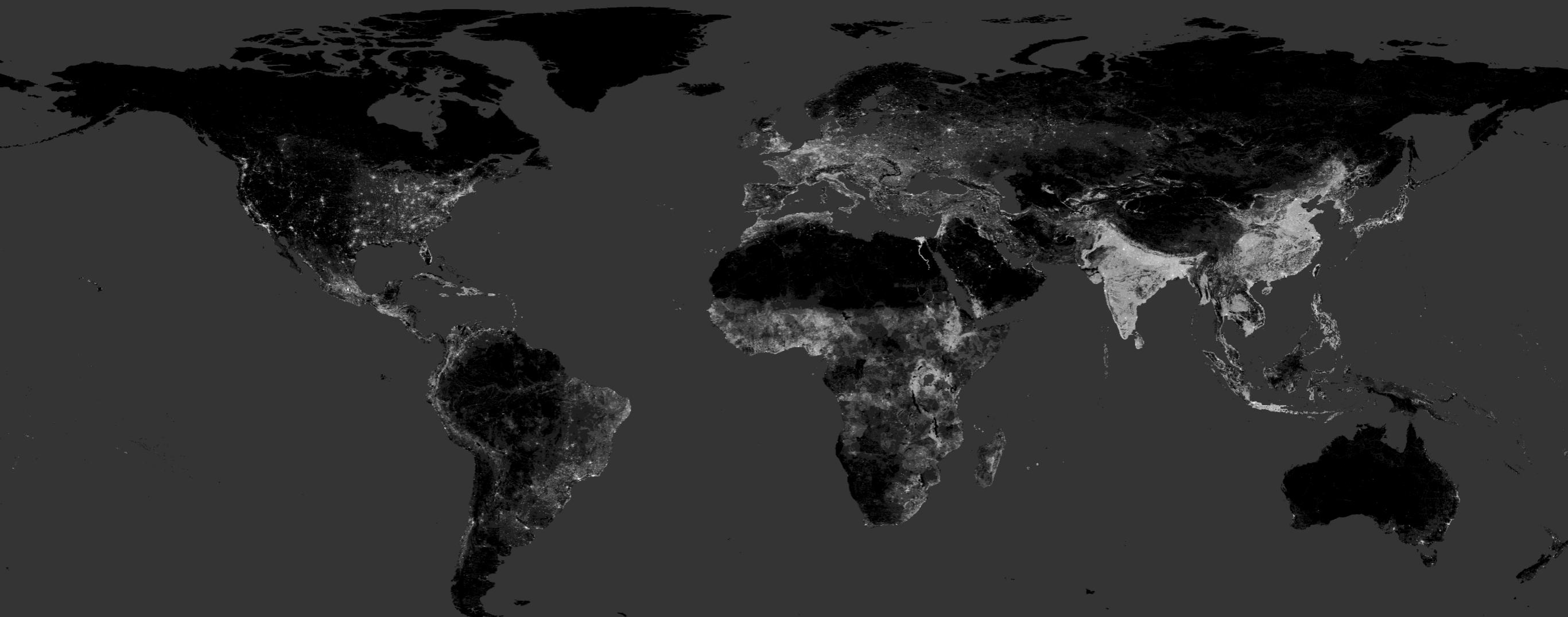
<sup>a</sup> Out of the 2852 egos located at the level of country or better.<sup>b</sup> Out of the egos included in 1953 dyads with both parties located at the level of country or better.<sup>c</sup> Out of the 1953 alters located at the level of country or better.<sup>d</sup> The number of ties with the ego and the alter in the given country as a share of all ties for egos in that country.

Rank	Cluster <sup>a</sup>	Share of egos (%) <sup>b</sup>	Share of egos (%) for egos in dyads <sup>c</sup>	Share of alters (%) <sup>d</sup>	Locality <sup>e</sup>
1	"New York"	8.5	8.3	10.2	54.3
2	"Los Angeles, CA"	5.1	5.6	10.4	53.3
3	"東京都" (Tokyo)	4.1	4.8	5.0	62.9
4	"London"	3.6	3.3	4.9	48.8
5	"São Paulo"	3.5	3.0	3.6	78.4
6	"San Francisco"	2.8	2.7	4.1	41.2
7	"New Jersey" <sup>f</sup>	2.5	2.8	2.1	20.0
8	"Chicago"	2.2	2.0	1.7	32.0
9	"Washington, DC"	2.1	2.8	2.6	34.3
10	"Manchester, UK"	1.9	2.0	1.1	30.8
11	"Atlanta"	1.7	2.1	2.1	46.2
12	"San Diego"	1.5	1.5	1.1	26.3
13	"Toronto, Canada"	1.3	1.1	1.5	42.9
14	"Seattle"	1.3	1.4	1.2	58.8
15	"Houston"	1.2	1.2	1.0	40.0
16	"Dallas, Texas"	1.2	1.0	1.4	61.5
17	"Rio de Janeiro"	1.2	1.0	1.1	30.8
18	"Boston, MA"	1.2	1.2	1.1	20.0
19	"Amsterdam"	1.1	1.1	0.9	50.0
20	"Jakarta, Indonesia"	1.1	0.6	0.3	42.9
21	"Austin, TX"	1.0	1.0	1.3	50.0
22	"Sydney"	0.9	1.0	0.8	38.5
23	"Orlando, Florida"	0.9	1.0	0.6	16.7
24	"Phoenix, AZ"	0.8	0.7	0.6	11.1
25	"兵庫" (Hyōgo) <sup>g</sup>	0.8	1.0	1.0	25.0

<sup>a</sup> Each cluster is labeled with the name most frequently used for locations assigned to the cluster.<sup>b</sup> Out of the 2167 egos located with precision of <25,000 km<sup>2</sup>.<sup>c</sup> Out of the 1259 egos included in dyads with both parties located with precision of <25,000 km<sup>2</sup>.<sup>d</sup> Out of the 1259 alters included in dyads with both parties located with precision of <25,000 km<sup>2</sup>.<sup>e</sup> Defined as the share of local of ties among all ties for egos in a cluster.<sup>f</sup> Centered between Philadelphia and Trenton, NJ and includes all locations identified as just "New Jersey".<sup>g</sup> Centered near the boundary between Hyōgo and Osaka prefectures, in the Kansai region of Japan.

# World Population

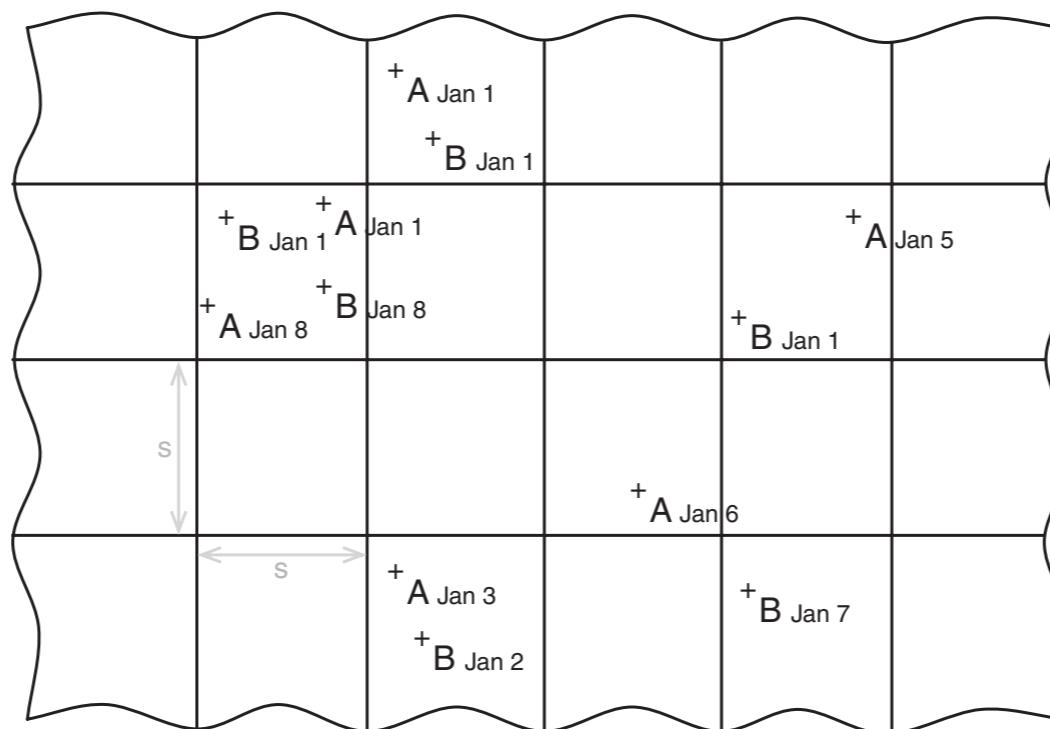
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# Co-occurrences and Social Ties

PNAS 107, 22436 (2010)

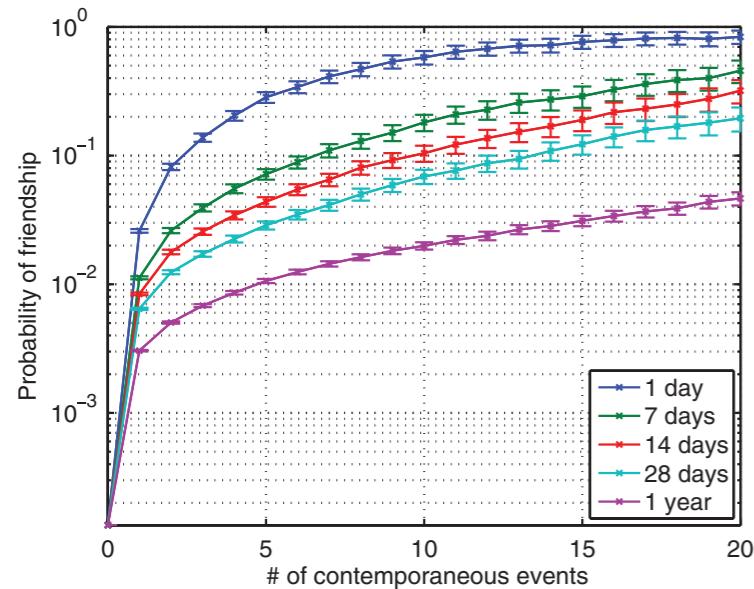
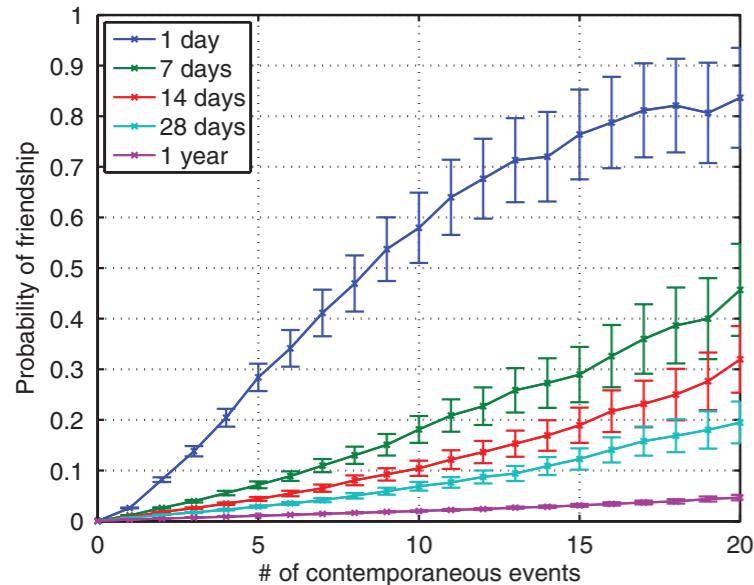
- Geotagged Flickr Photos
- Divide the world into a grid



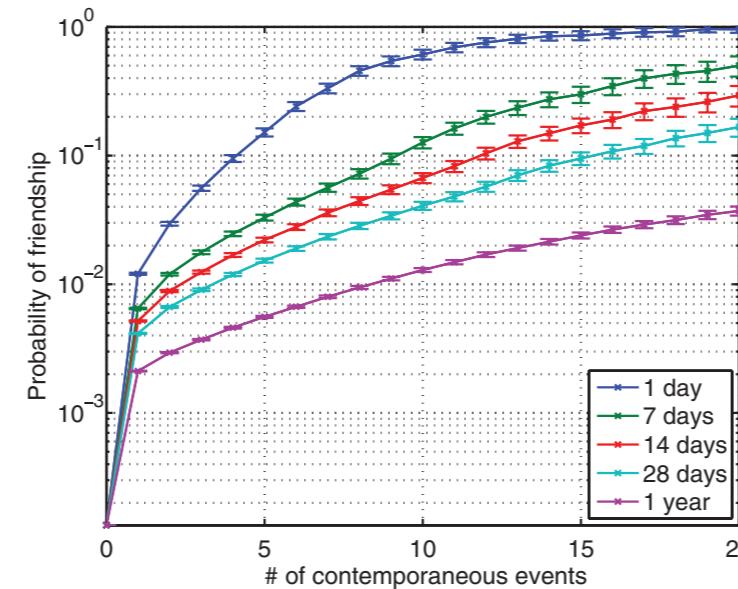
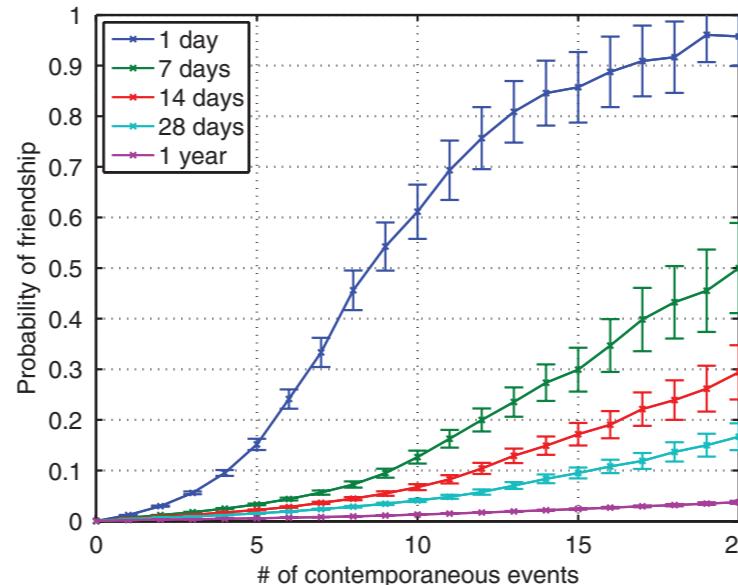
Count number of cells on which two individuals were within a given interval

# Co-occurrences and Social Ties

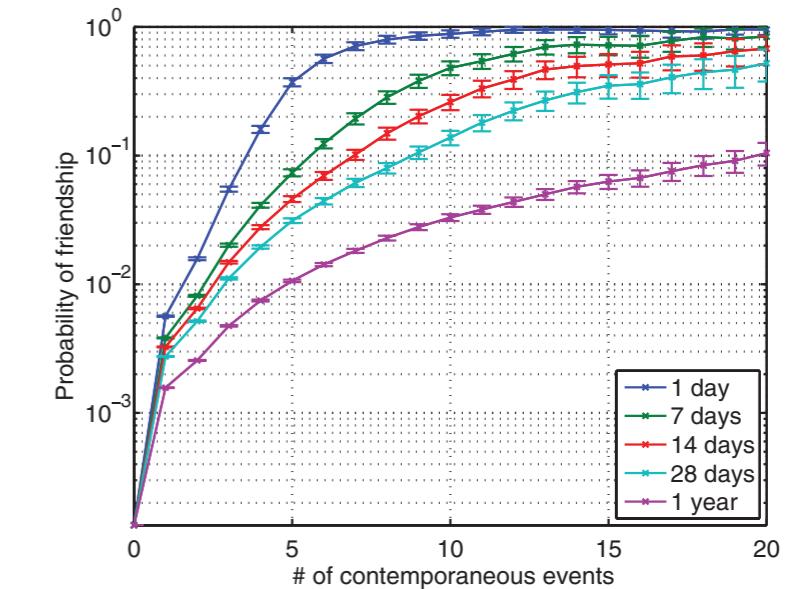
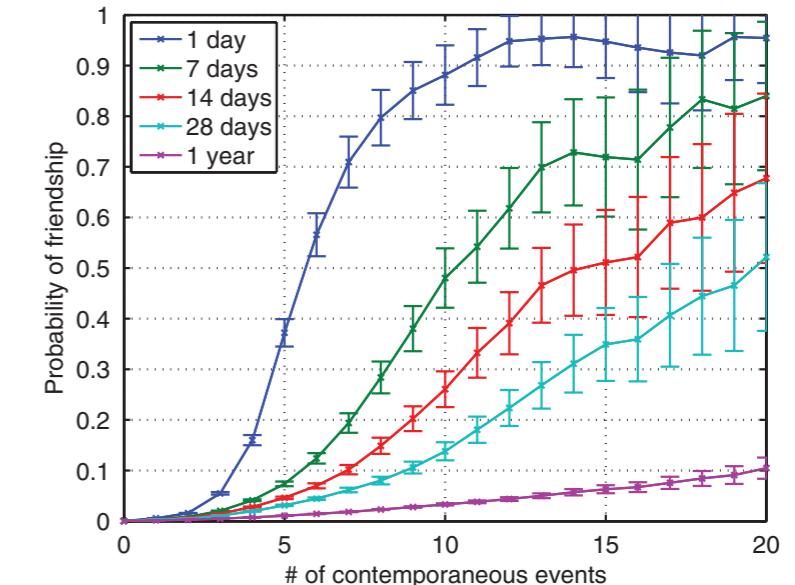
PNAS 107, 22436 (2010)



A  $s = 0.001^\circ$



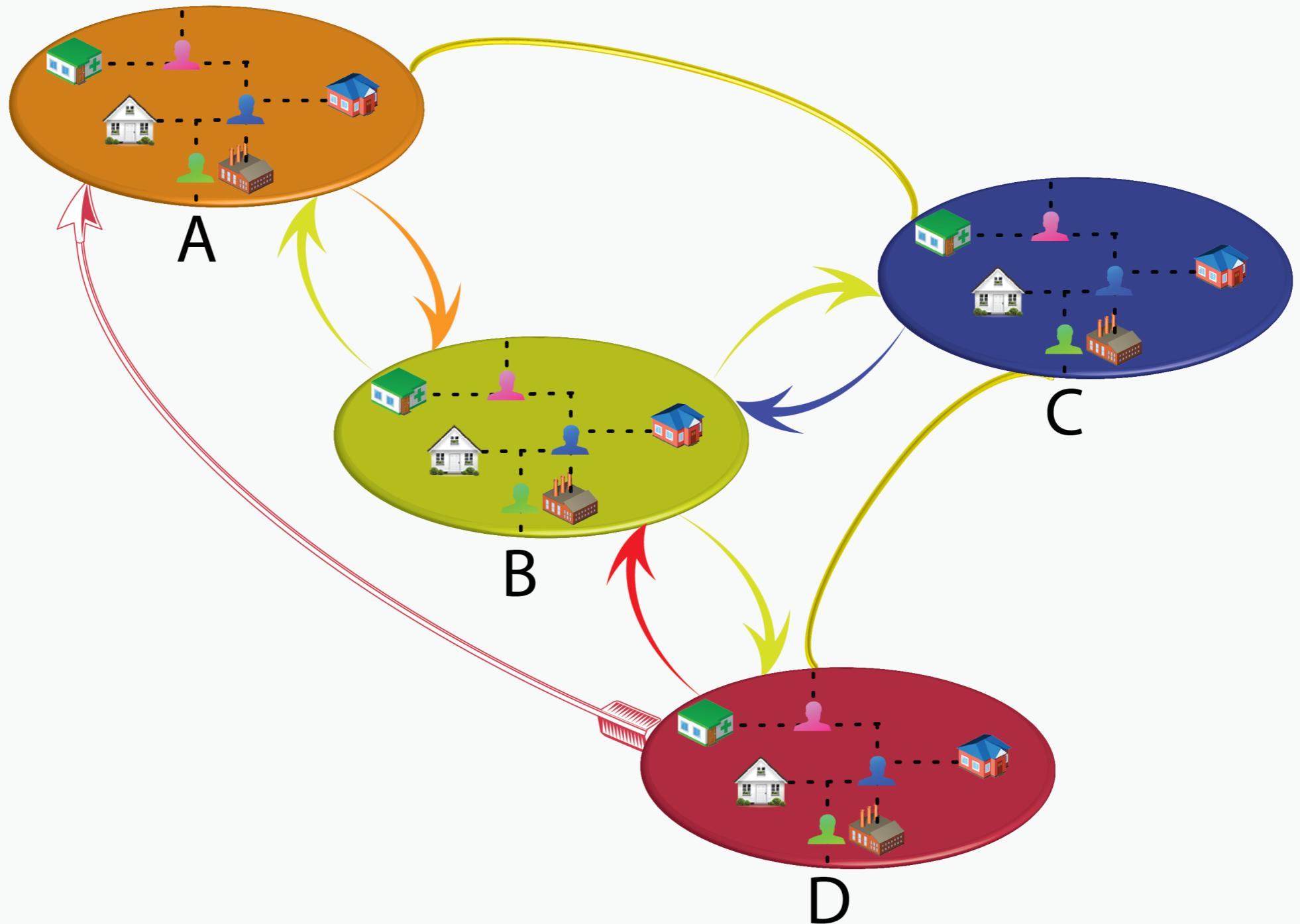
B  $s = 0.01^\circ$



C  $s = 0.1^\circ$

# Mobility

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# Airline Flights

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NATS

# Commuting

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@bgoncalves

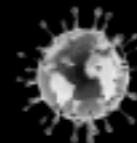
<http://youtube.com/watch?v=FqkinE8khZs>

Subscribe:  
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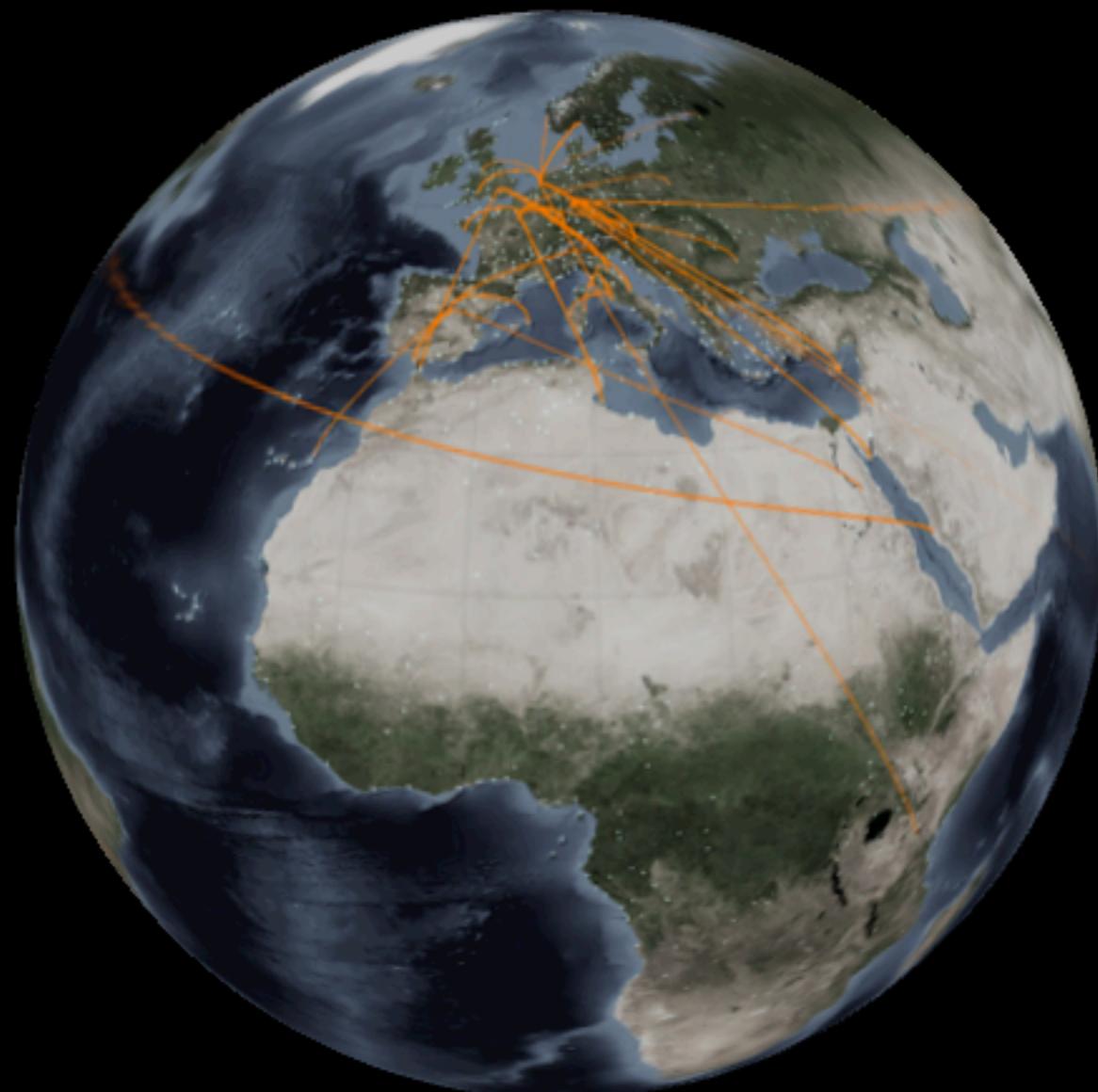
[www.bgoncalves.com](http://www.bgoncalves.com)

# Realistic Epidemic Spreading

PNAS 106, 21484 (2009)



GLEaMviz.org



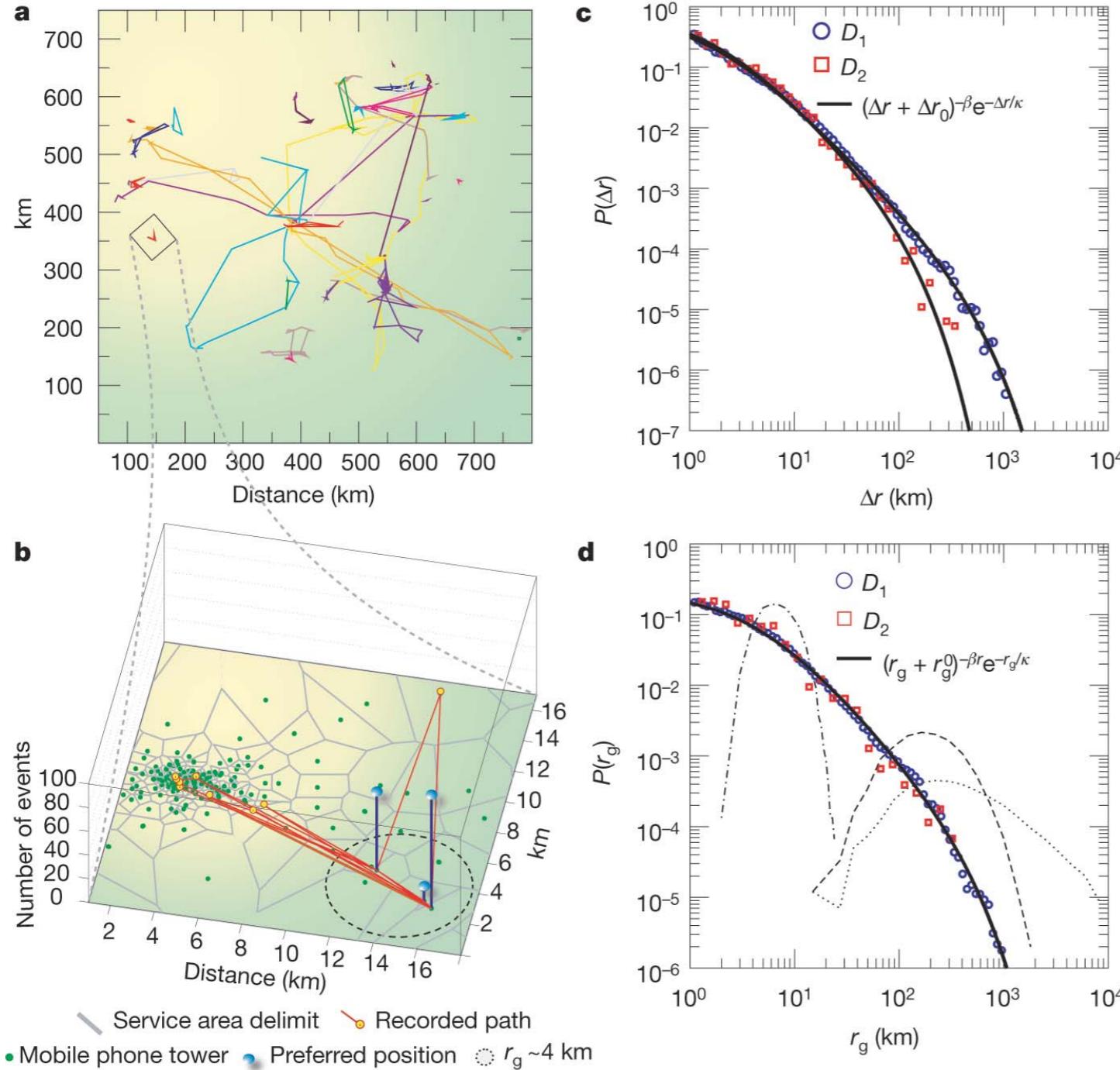
Jun 23, 2009

<https://www.youtube.com/watch?v=YAf1aXCvwU>

 MoBS

# Human Mobility

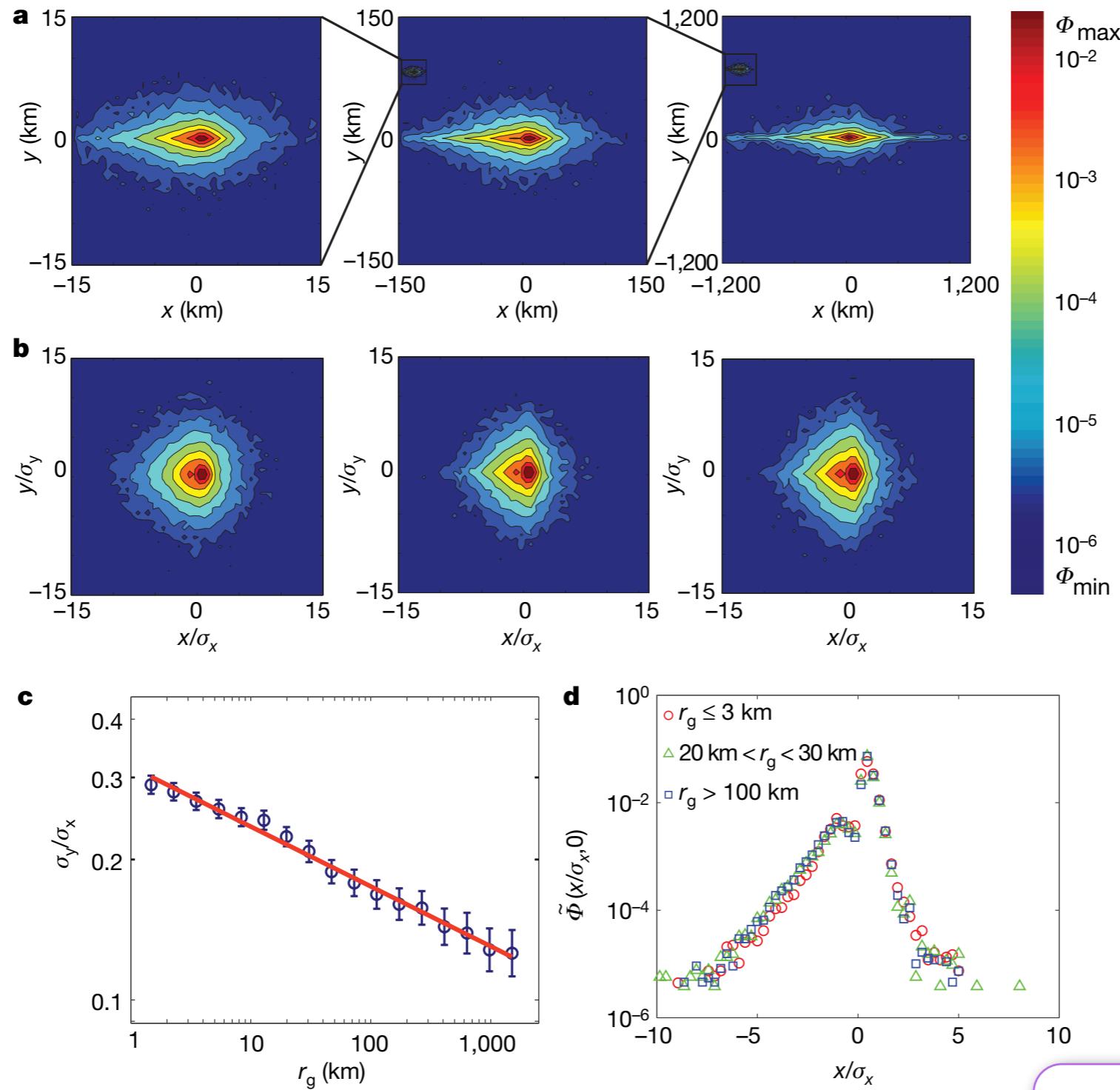
Nature 453, 779 (2008)

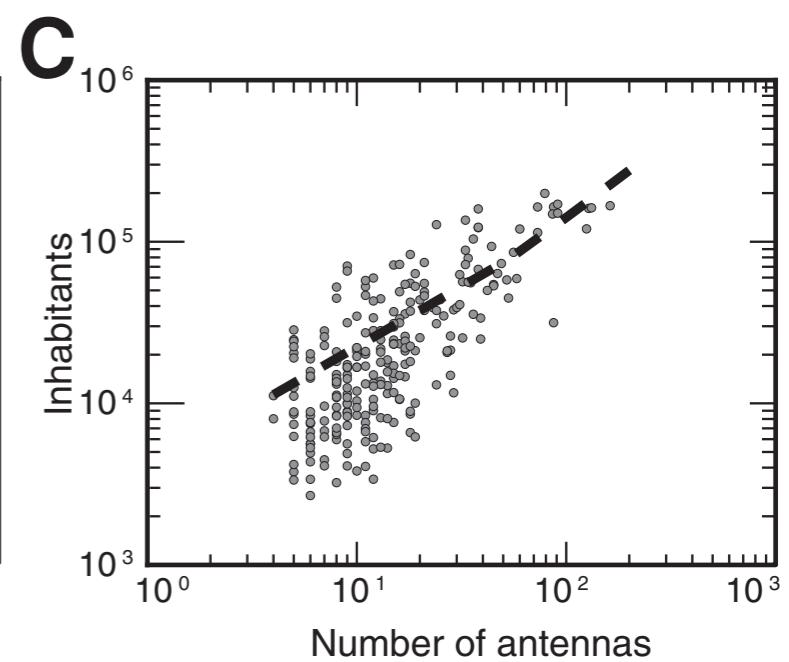
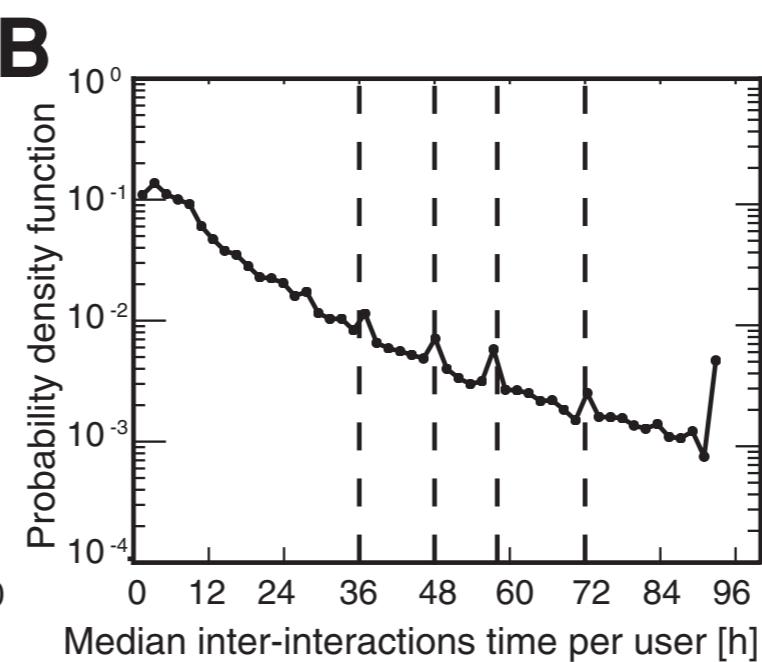
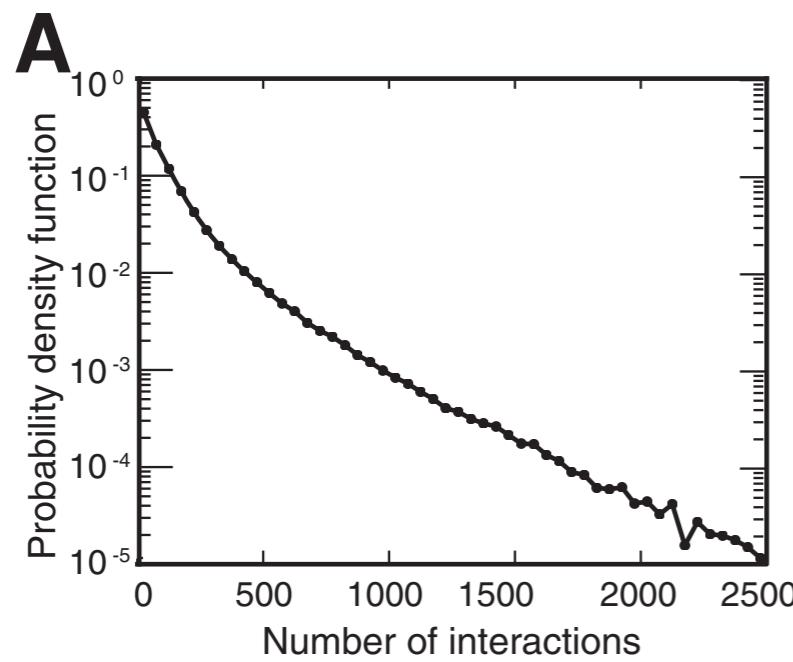
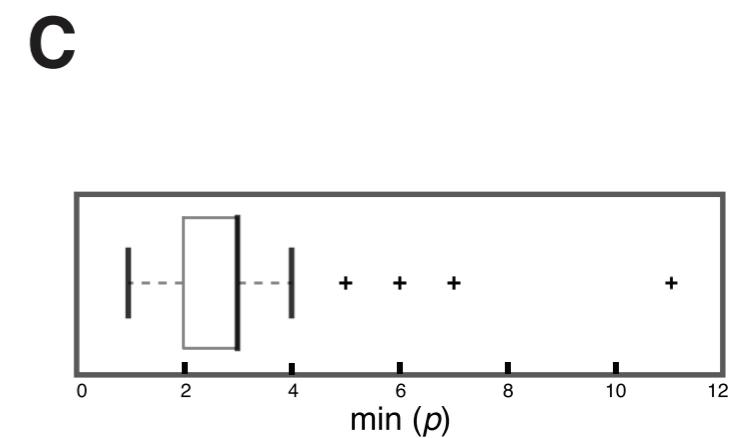
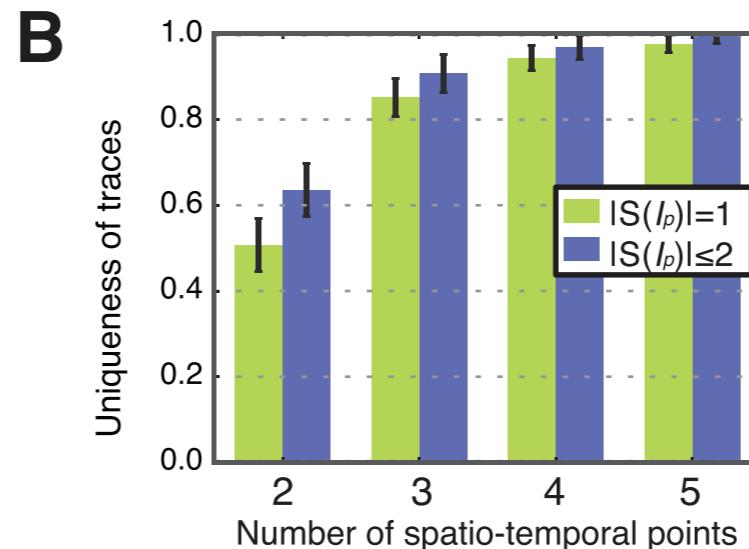
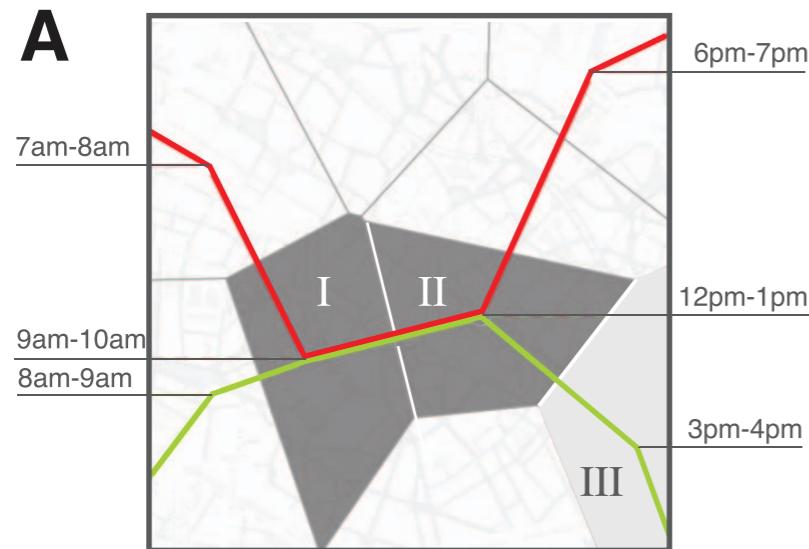


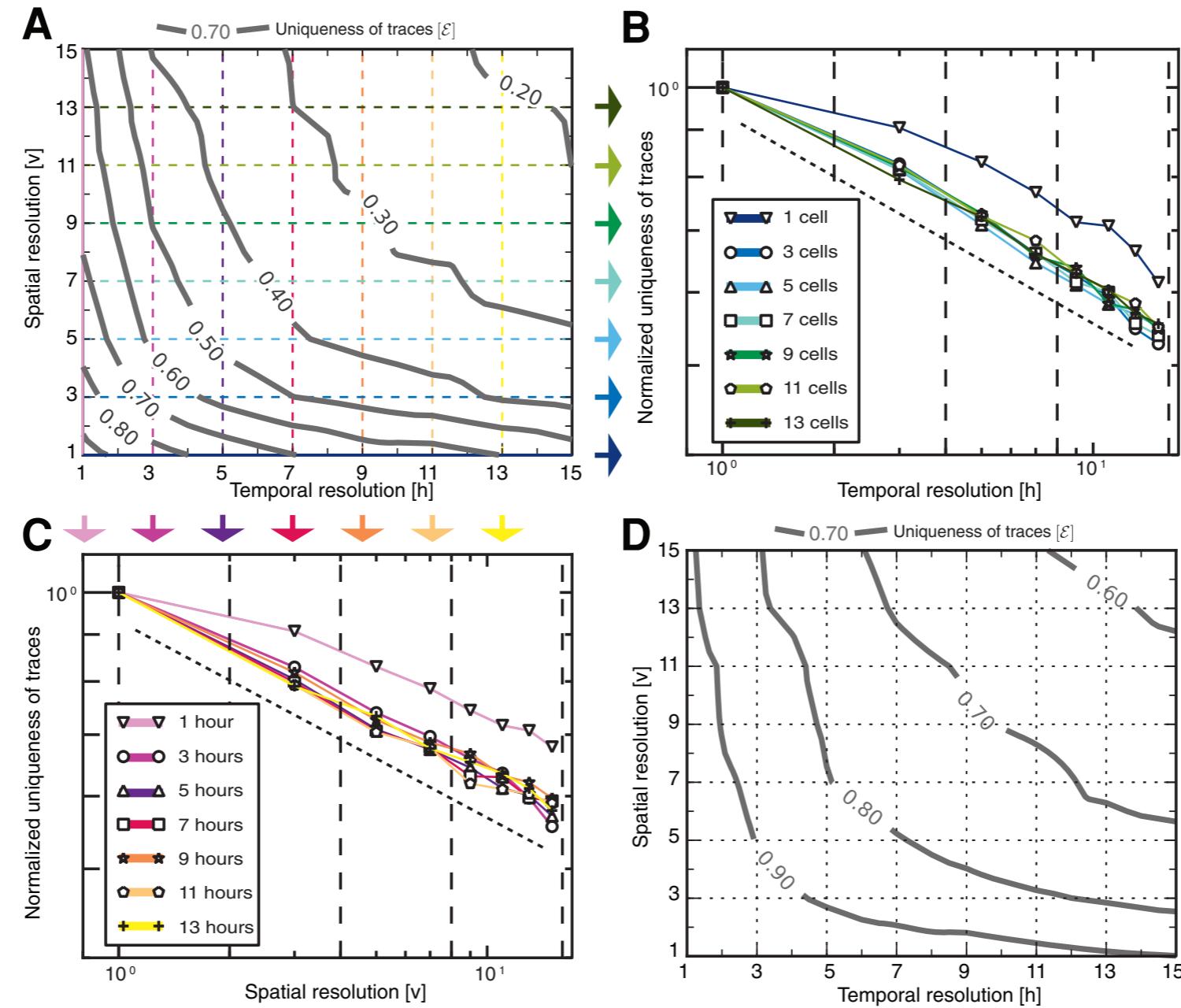
$$P(\Delta r) = (\Delta r + \Delta r_0)^{-\beta} \exp(-r_g/\kappa)$$

# Human Mobility

Nature 453, 779 (2008)



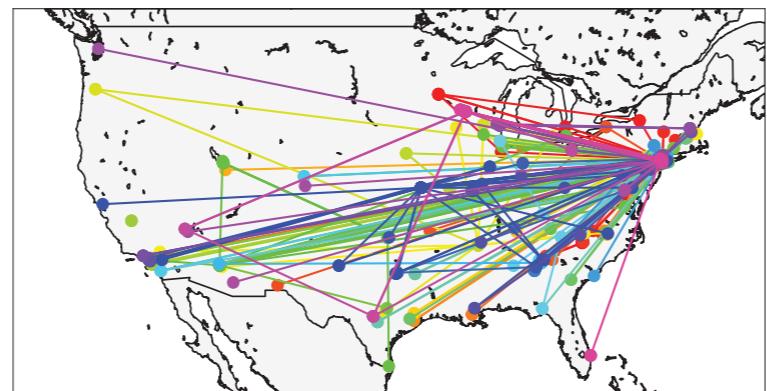
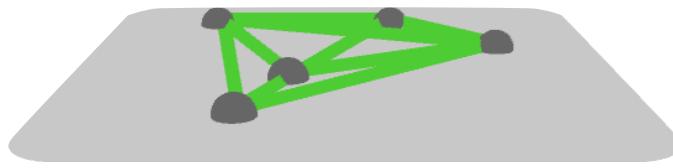




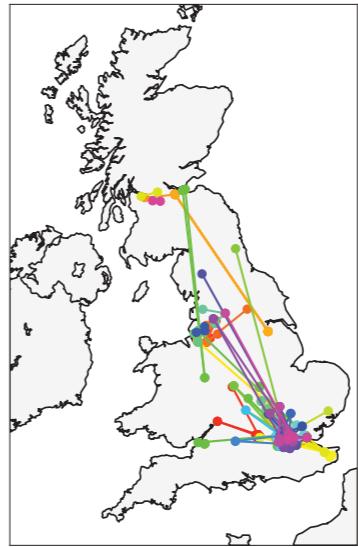
# Mobility and Social Networks

PLoS One 9, E92196 (2014)

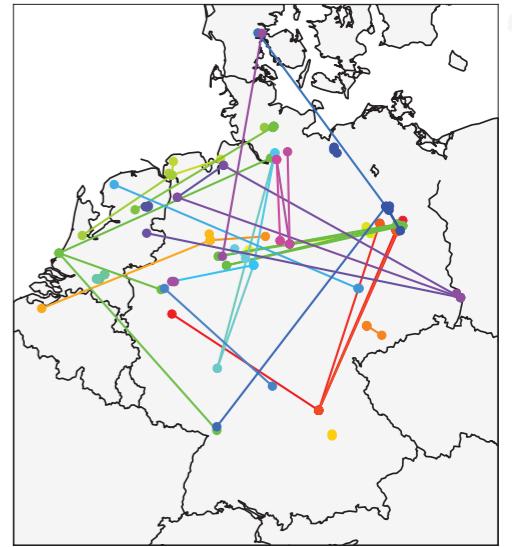
**Social networks (ego networks) in geographical space**



(D) US

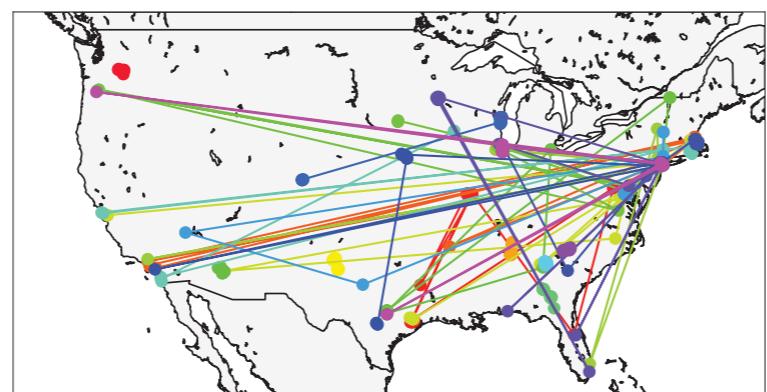


(E) UK

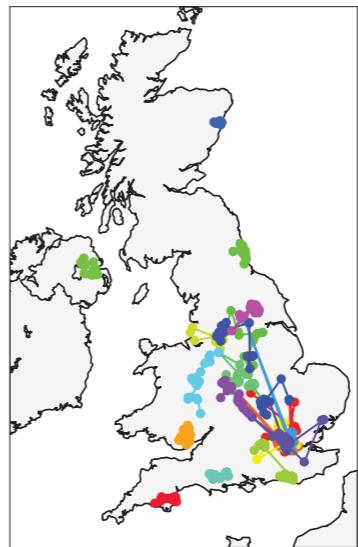


(F) DE

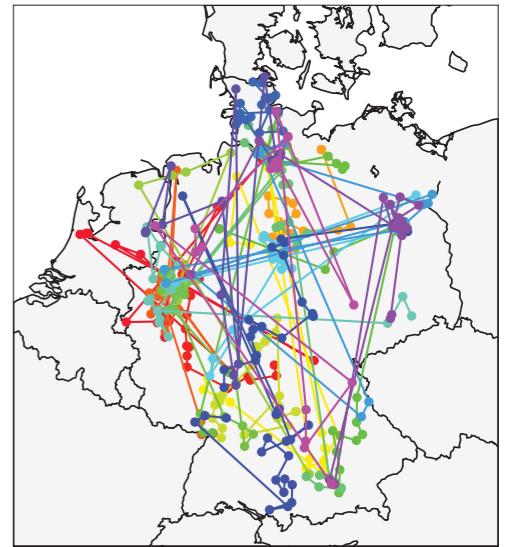
**Mobility patterns**



(A) US



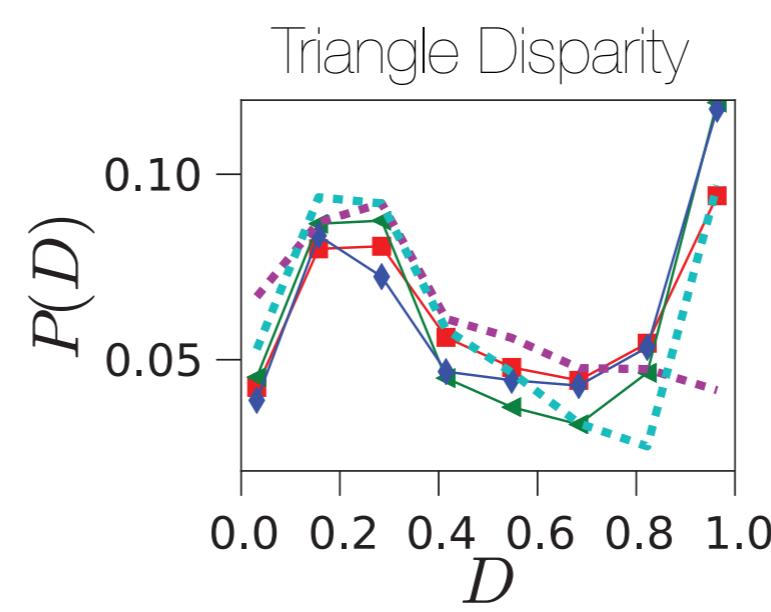
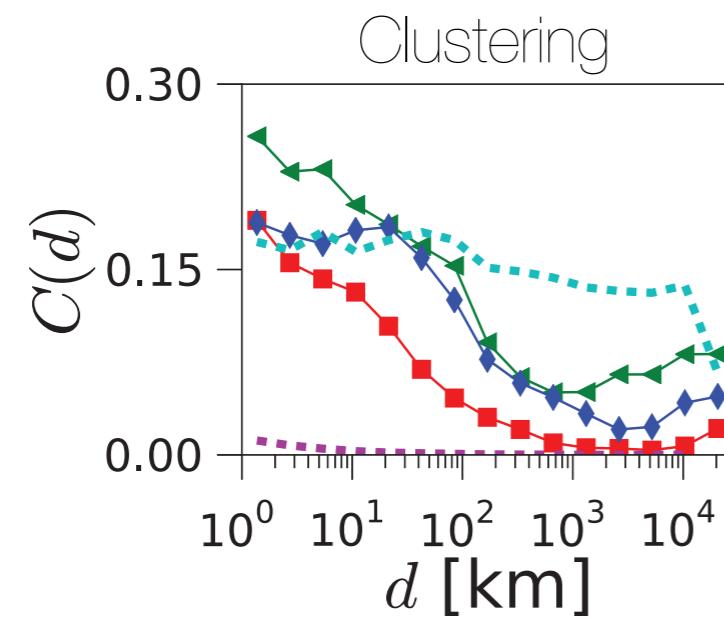
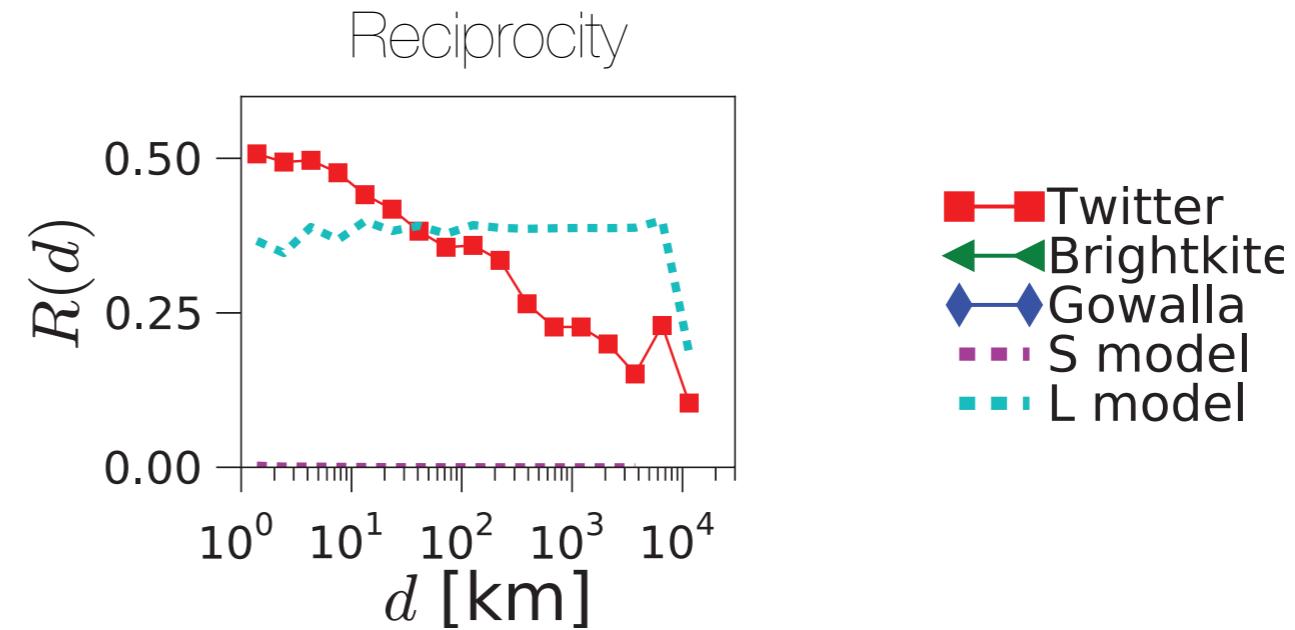
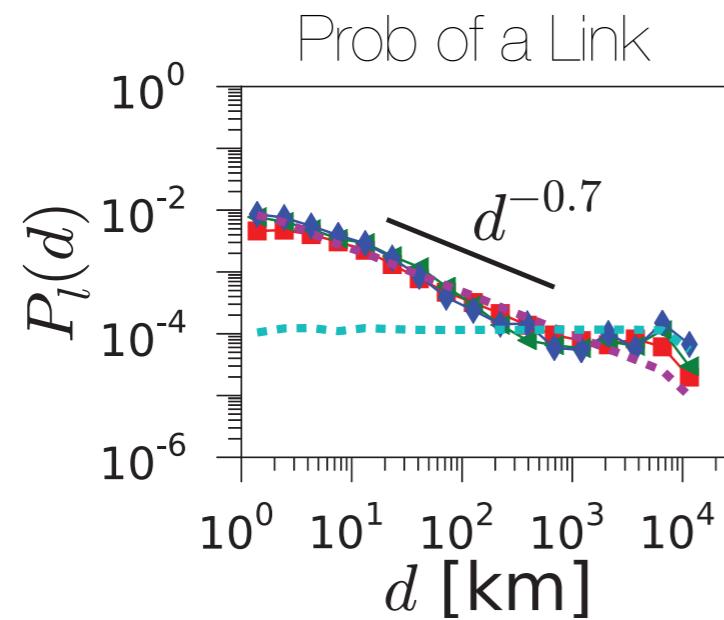
(B) UK



(C) DE

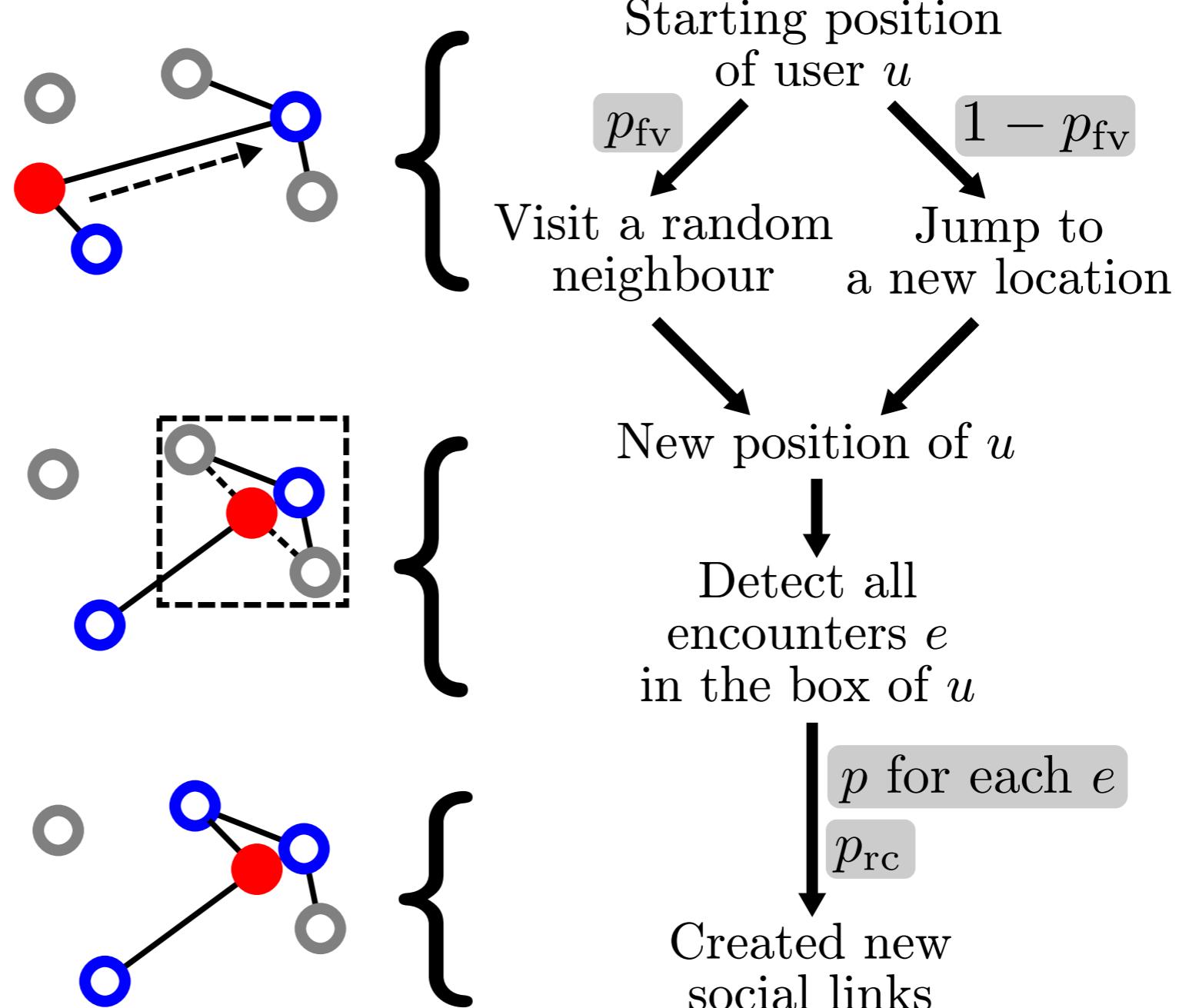
# Geo-Social Properties

PLoS One 9, E92196 (2014)



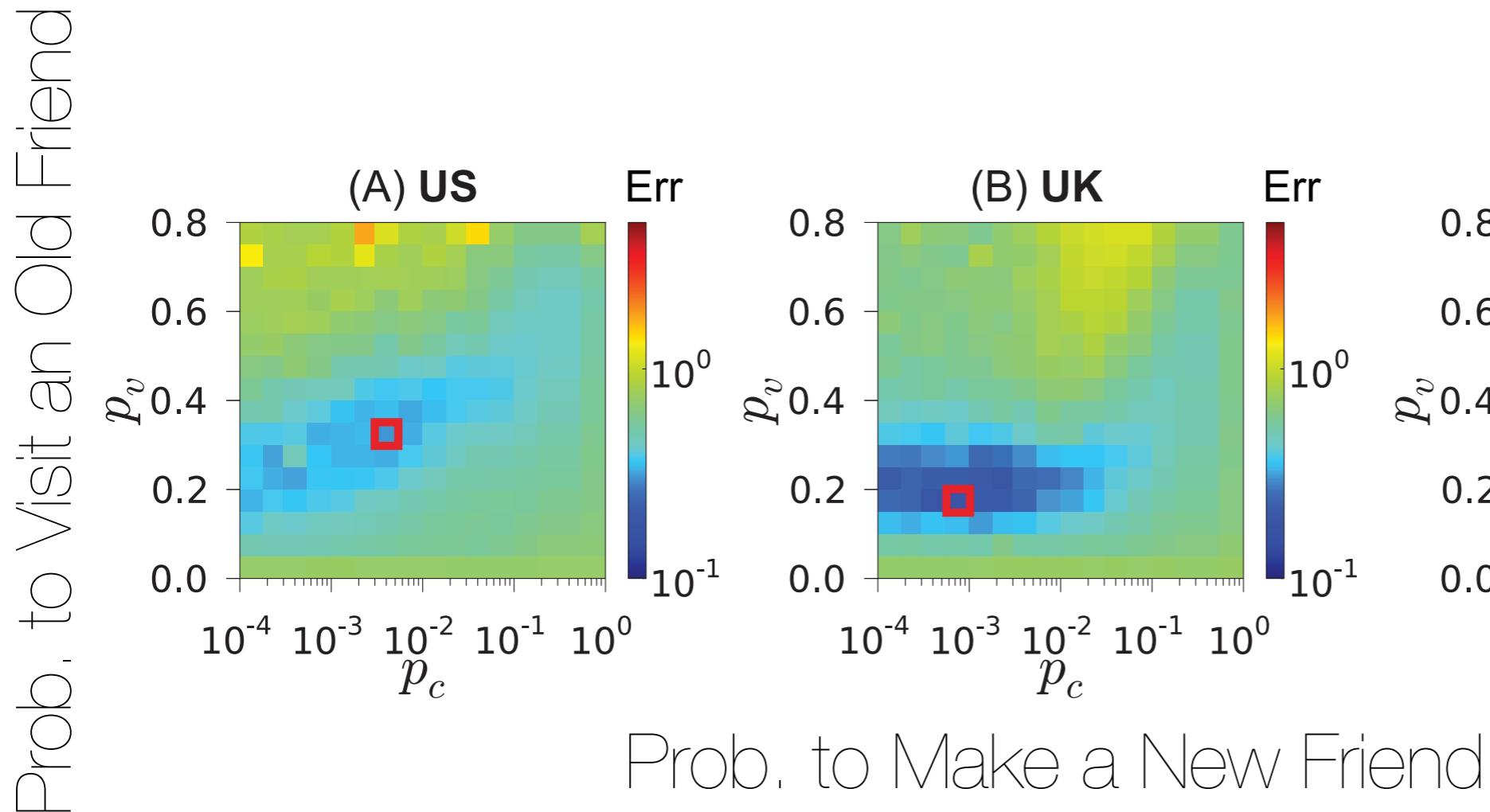
# Geo-Social Model

PLoS One 9, E92196 (2014)



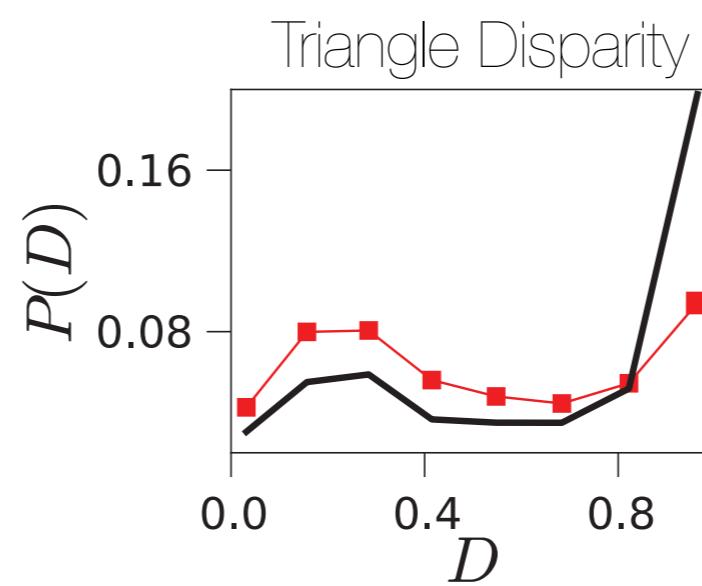
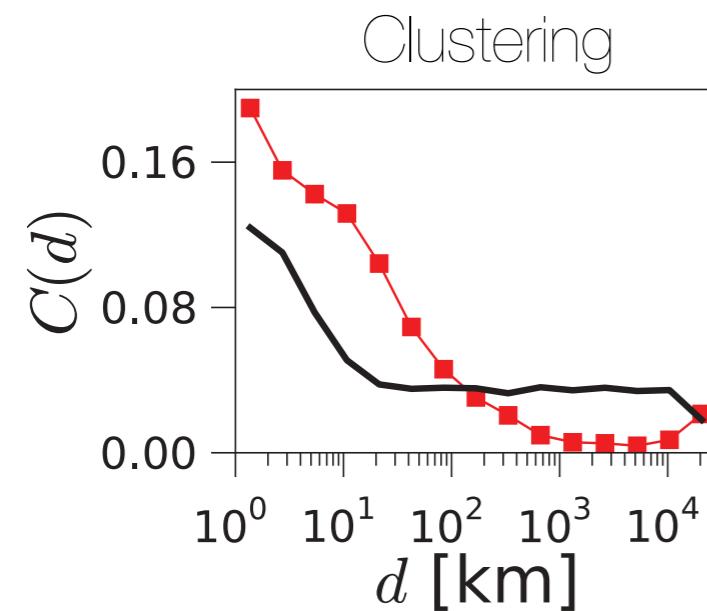
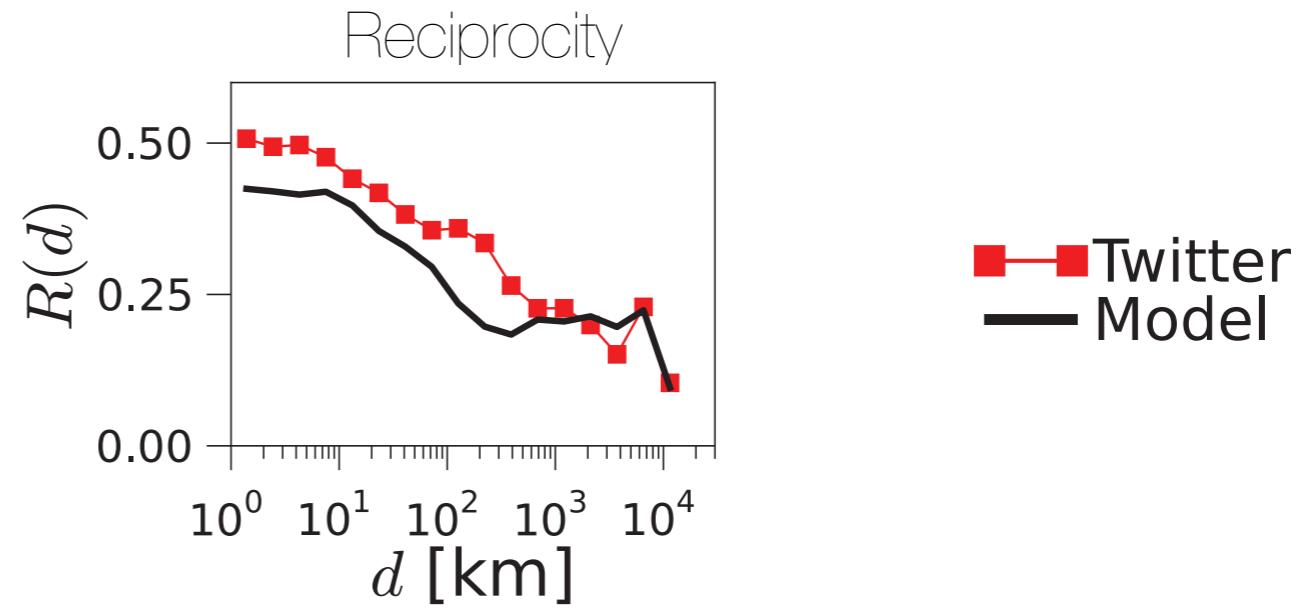
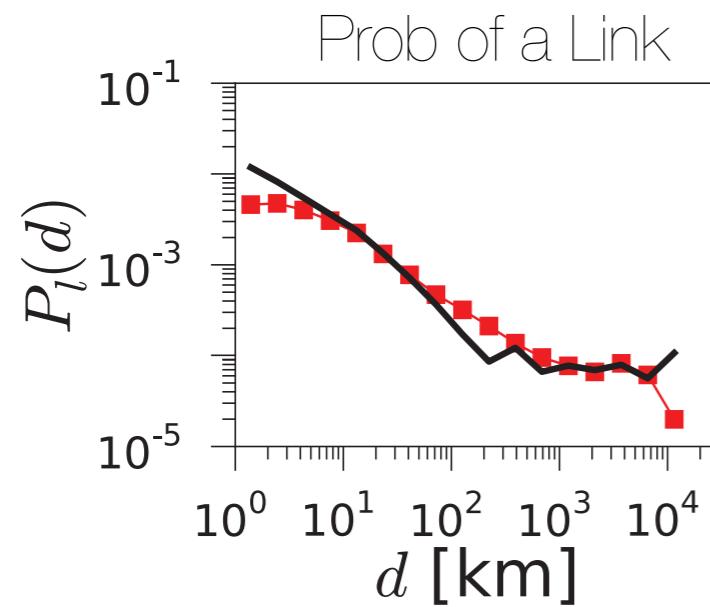
# Model Fitting

PLoS One 9, E92196 (2014)



# Model Results

PLoS One 9, E92196 (2014)

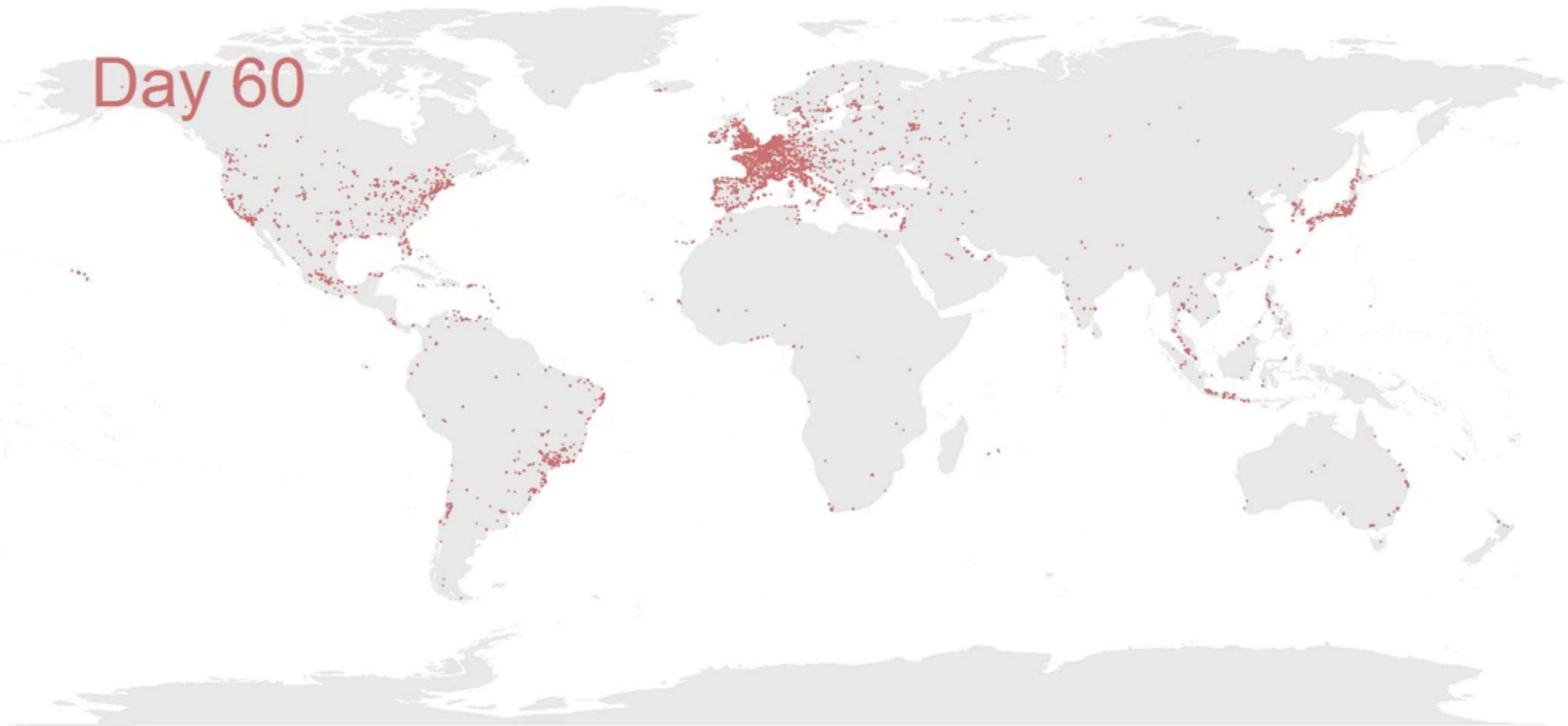


$$D = 6 \left[ \frac{d_1^2 + d_2^2 + d_3^2}{(d_1 + d_2 + d_3)^2} - \frac{1}{3} \right]$$

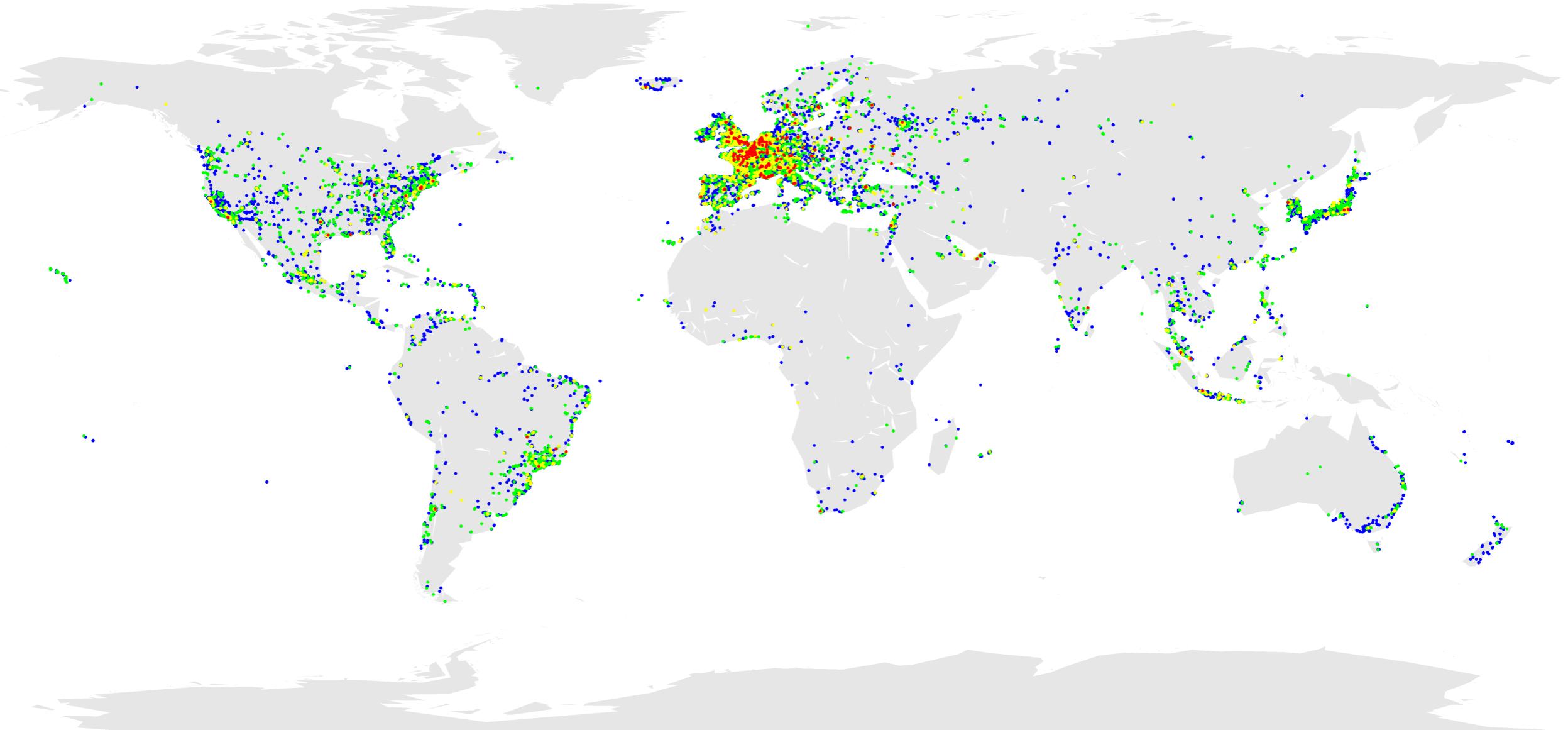
# Human Diffusion

J. R. Soc. Interface 12, 20150473 (2015)

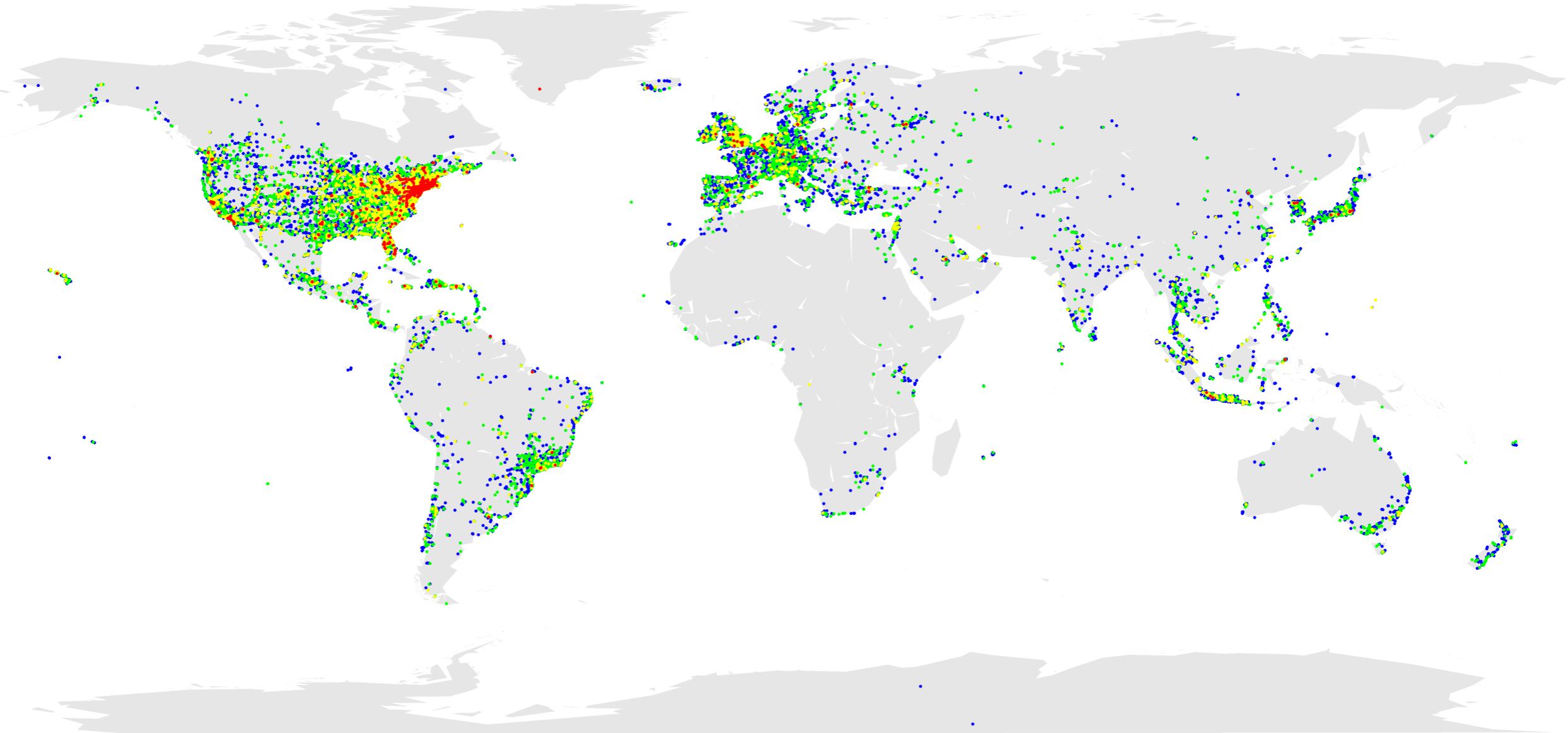
Day 60



## Starting from Paris

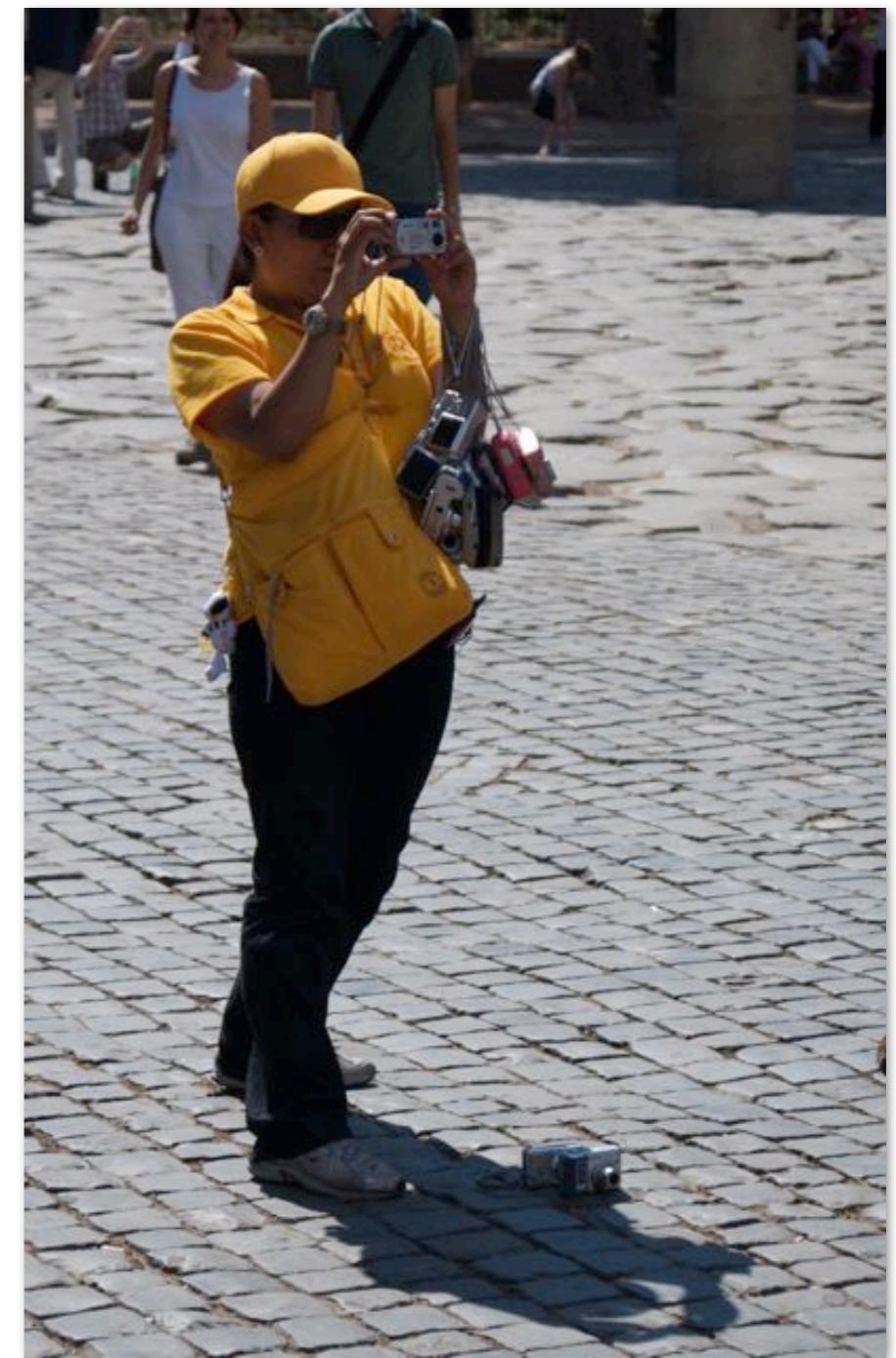


## Starting from New York



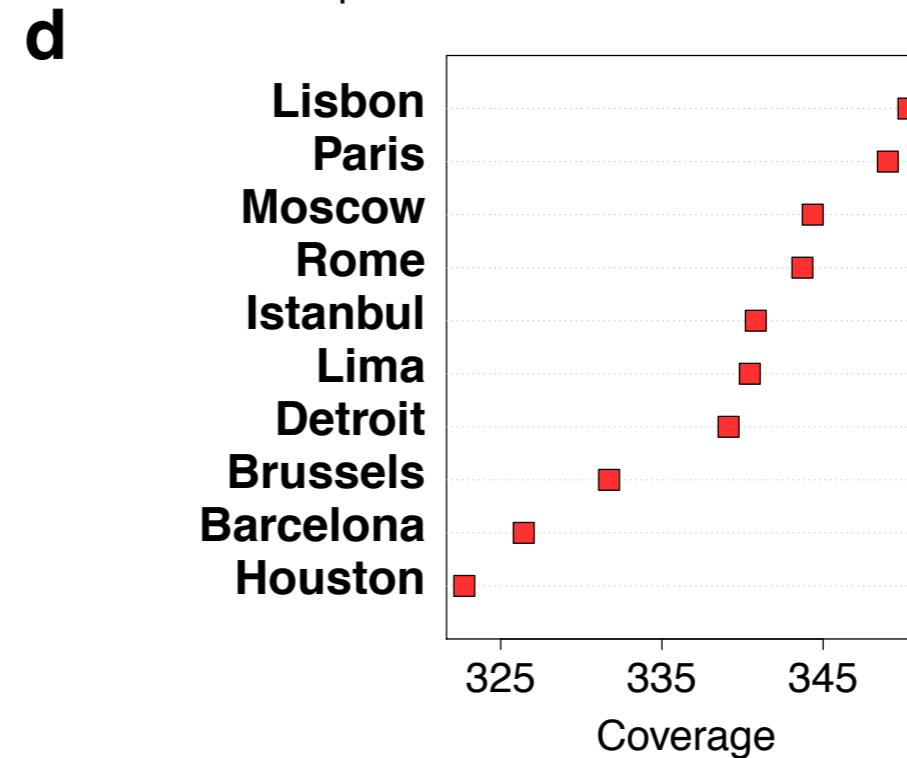
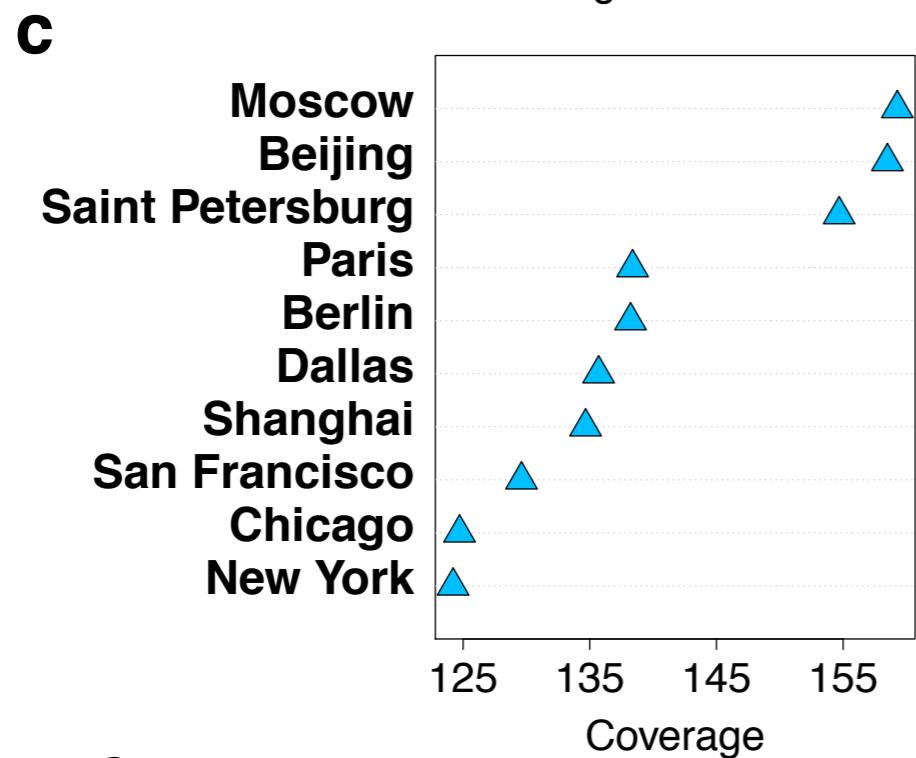
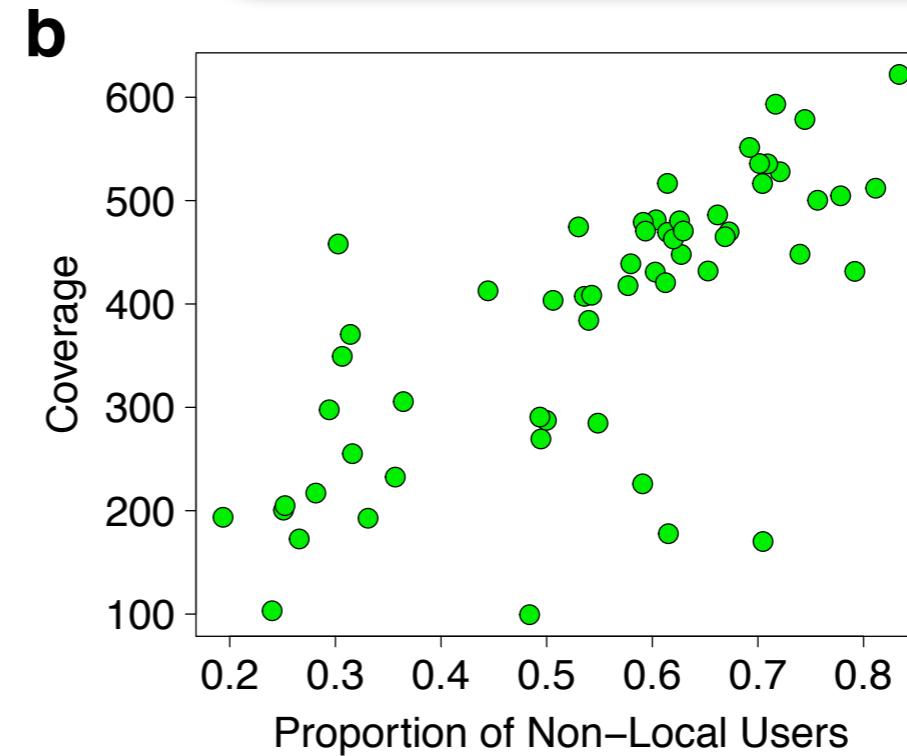
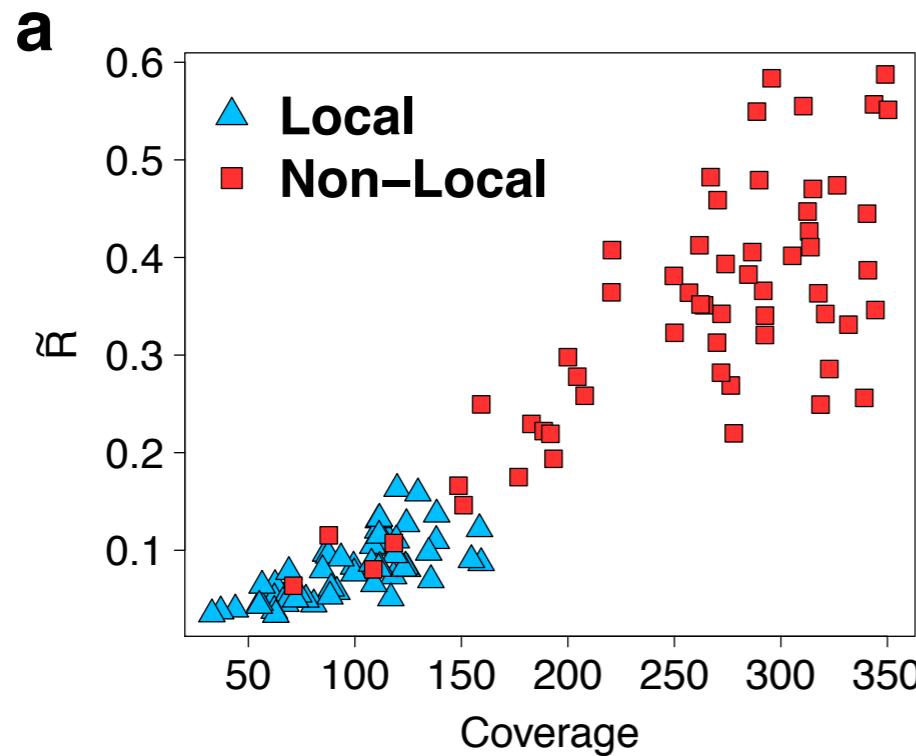
# Residents and Tourists

J. R. Soc. Interface 12, 20150473 (2015)



# Residents and Tourists

J. R. Soc. Interface 12, 20150473 (2015)



# City Communities

J. R. Soc. Interface 12, 20150473 (2015)

