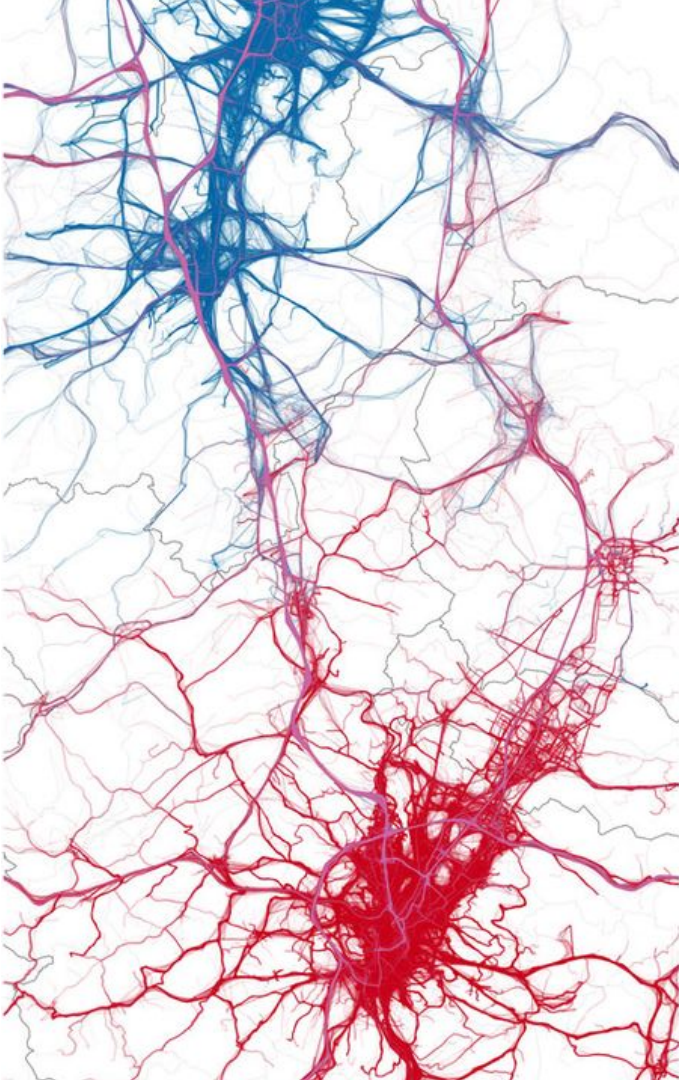




**Consiglio Nazionale
delle Ricerche**



Introduction to GSA

geography

Geospatial Analytics

The science of **extracting insights from data with a geographic dimension**. It develops methods to model spatial relationships, detect patterns, and support decision-making in urban planning, transportation, environment, health.

movements

Human Mobility

The study of how individuals and populations **move through space and time**, uncovering the mechanisms, patterns, and impacts of movements on society.

Geospatial Analytics

- How are spatial phenomena distributed across a region?
- What spatial patterns (clusters, hotspots) can be detected?
- How do environmental, socioeconomic variables correlate geographically?
- How do spatial networks (roads, rivers, utilities) structure connectivity and flows?
- How do land-use and spatial distributions change over time (urban growth, deforestation, climate impacts)?

Human Mobility

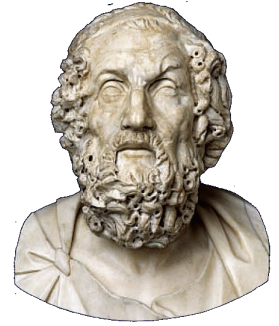
- How, why, and when do individuals move through space and time?
- What statistical regularities (e.g., trip length distributions) characterize mobility?
- How do people choose routes and destinations?
- How does urban form shape movement patterns?
- How do mobility patterns impact congestion or inequality?
- How can we model, predict, or simulate mobility at different scales (commutes, tourism, migration)?

Geospatial analytics is about spatial data and patterns.

Human mobility zooms in on movement behaviors and their consequences.

Historical Examples

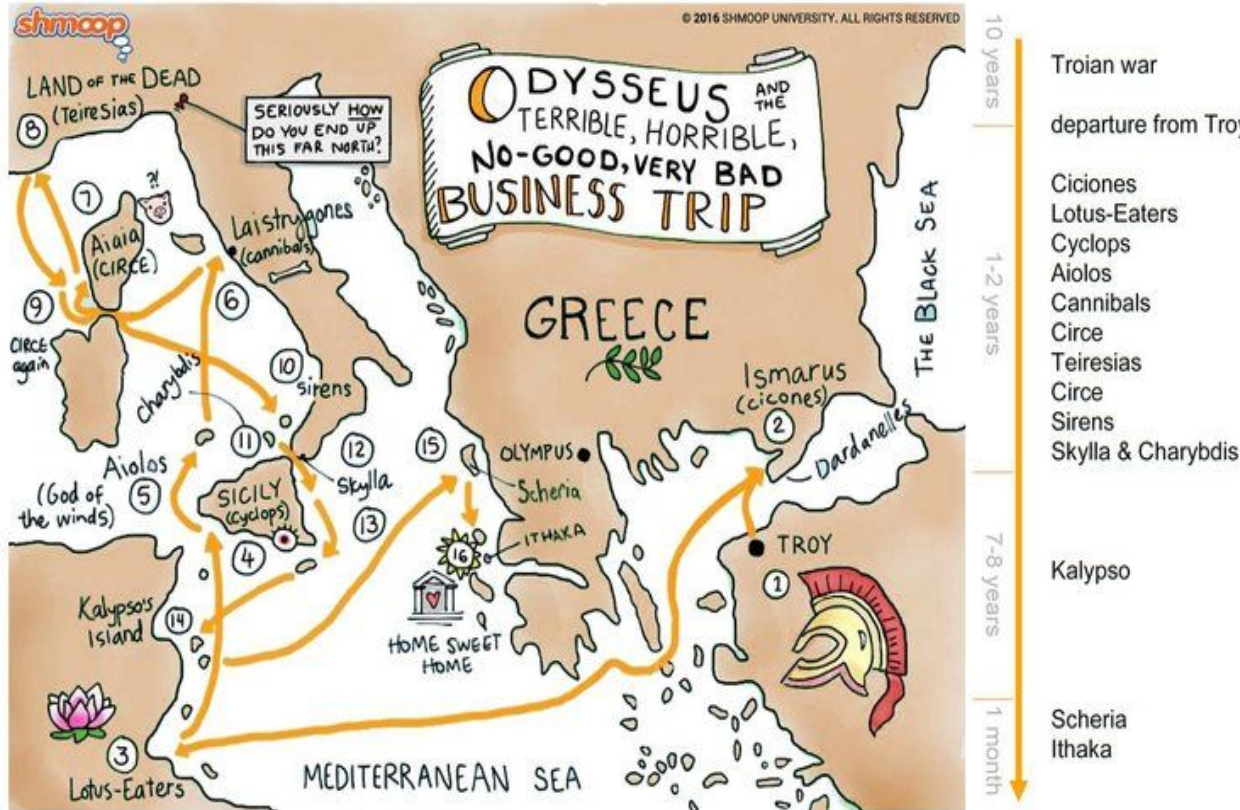
The Odyssey is the story of...a trajectory



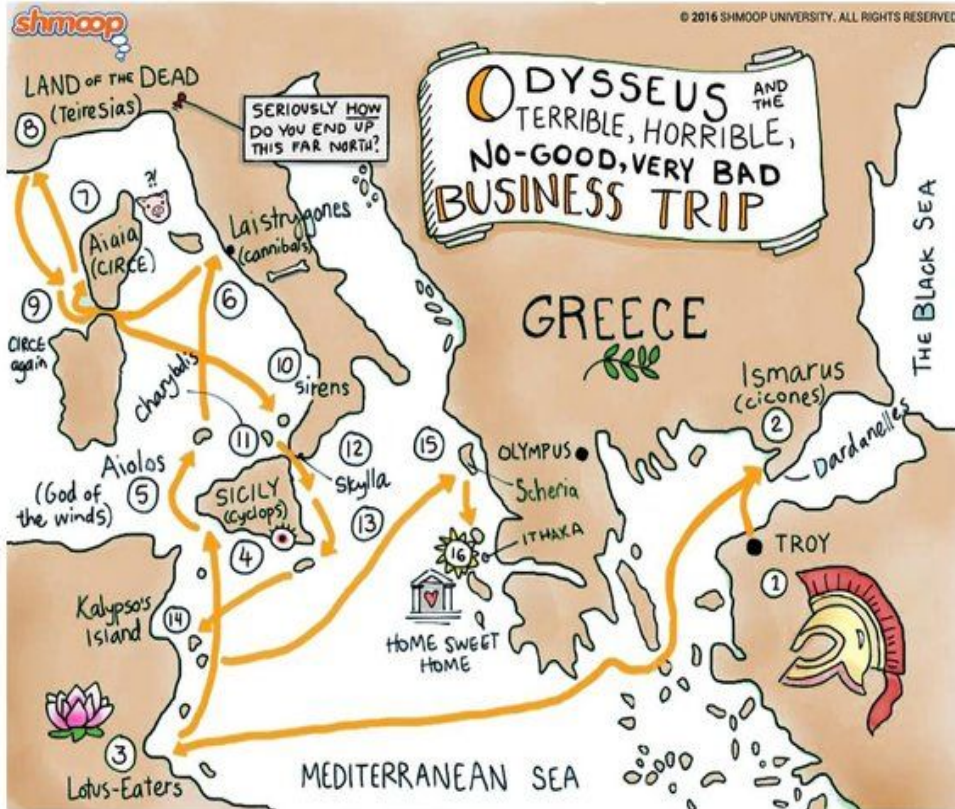
"A man who has been through bitter experiences and travelled far enjoys even his sufferings after a time"

Homer, Odyssey

interactive map



The Odyssey is the story of...a trajectory



10 years	Troian war
	departure from Troy
1-2 years	Ciciones
	Lotus-Eaters
	Cyclops
	Aiolos
	Cannibals
	Circe
	Teiresias
	Circe
	Sirens
	Skylla & Charybdis
7-8 years	Kalypso
1 month	Scheria
	Ithaka

*"ma misi me per l'alto mare aperto
sol con un legno e con quella compagna
picciola da la qual non fui disertò.
L'un lito e l'altro vidi infin la Spagna,
fin nel Morrocco, e l'isola d'i Sardi,
e l'altre che quel mare intorno bagna."*

Dante's Inferno, Canto XXVI

interactive map



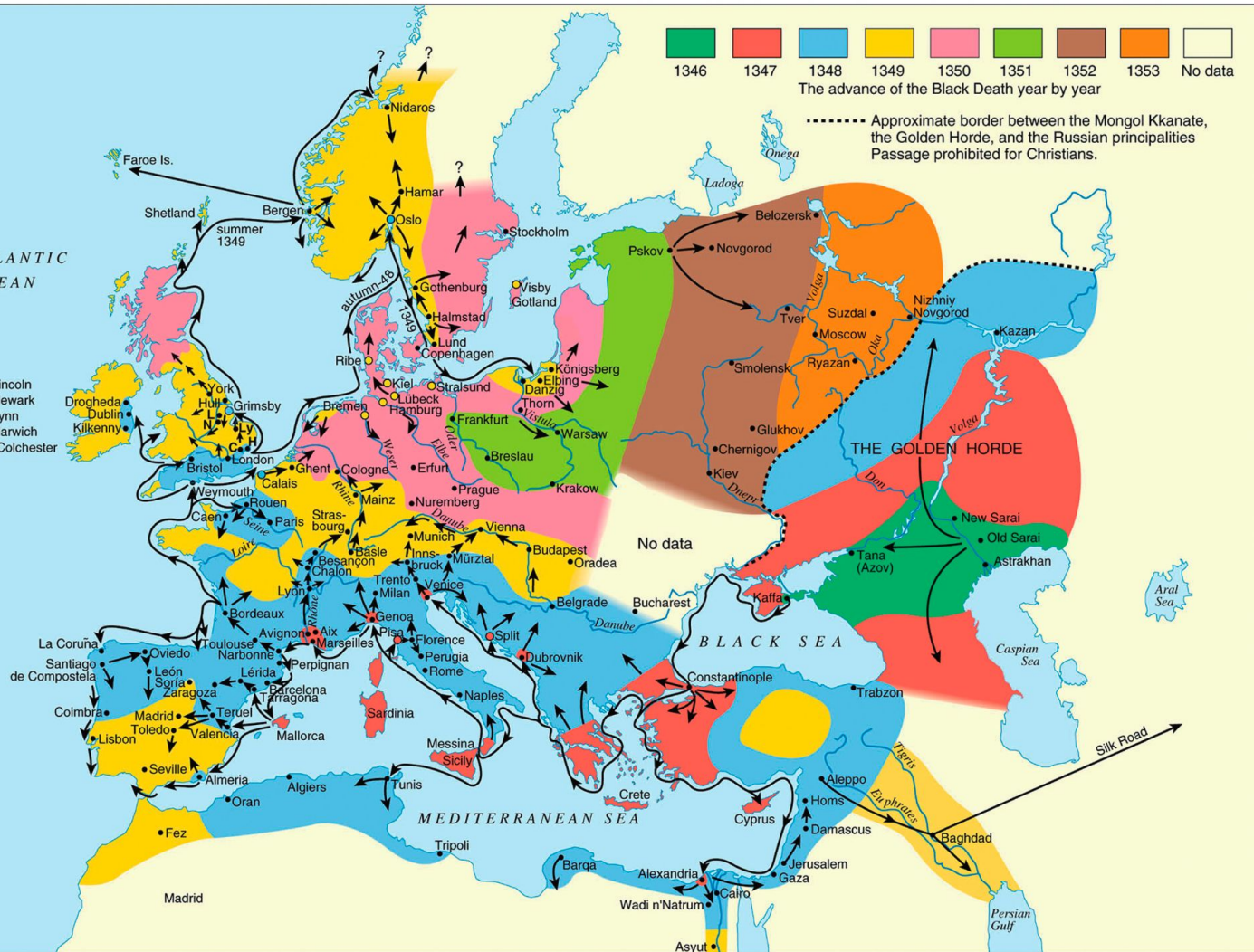


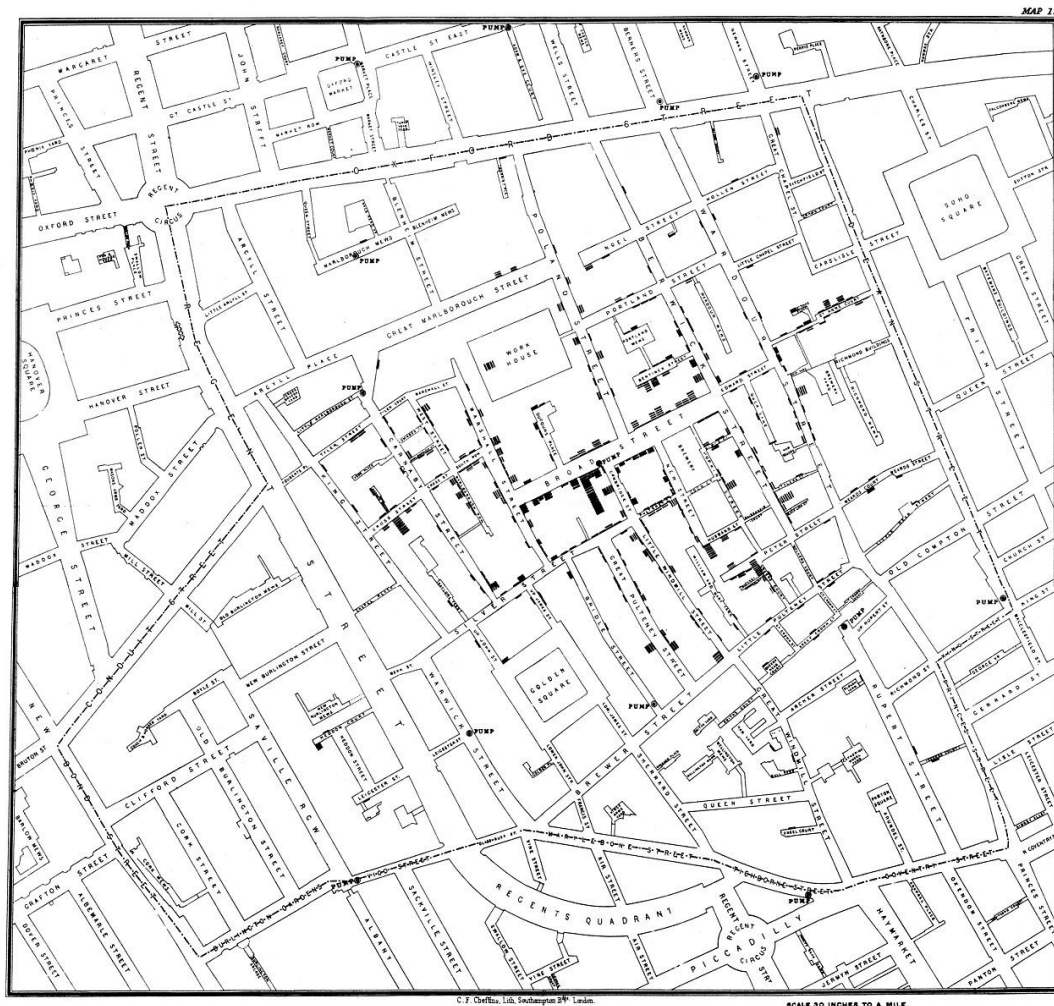
Spread of the Black Death (1346–1353)

L = Lincoln
N = Newark
Ly = Lynn
H = Harwich
C = Colchester



----- Approximate border between the Mongol Kkanate, the Golden Horde, and the Russian principalities
Passage prohibited for Christians.





John Snow and the Broad Street cholera outbreak (1854)





From wikicommons
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John Snow and the Broad Street cholera outbreak (1854)



Predicting criminals' trajectory

1930s



IDENTIFICATION ORDER NO. 1227 May 24, 1933.		DIVISION OF INVESTIGATION U. S. DEPARTMENT OF JUSTICE WASHINGTON, D. C.	
WANTED MRS. BOY THORNTON, alias BONNIE BARROW, MRS. CLYDE BARROW, BONNIE PARKER.		WANTED CLYDE CHAMPION BARROW, alias CLYDE BARROW, BOY BARKY, JACK BALE, ELDON WILLIAMS, CLYDE WILLIAMS.	
DESCRIPTION Age, 29 years (1903); Height, 5 feet, 5 inches; Weight, 100 pounds; Build, slender; Hair, brown, wavy; originally blonde; Eyes, blue; Complexion, fair; Scar on neck, bullet wound left foot next to little toe; bullet in left knee; burn scar on right leg from hip to knee; Peculiarities, walks with both knees slightly buckled.		DESCRIPTION Age, 28 years; Height, 5 feet, 7 inches, bare feet; Weight, 150 pounds; Build, medium; Hair, dark brown, wavy; reported dyed black; Eyes, hazel; Complexion, light; Scar on neck, bullet and scar with "D.B.B." on right forearm; scar; girl's bust, left inner forearm; bullet wound through both legs just above knees.	
RELATIVES: Ray Thornton, husband, Texas State Penitentiary Mrs. J. T. (Emma) Parker, mother, 1216 South Lamar St., Dallas, Texas Mrs. Billie Parker Nease, sister, 1216 South Lamar St., Dallas, Texas Robert (Buster) Parker, brother, Cleburne, Texas Billie Gonzalez, half-sister, Harwood, Garza County, Texas.		RELATIVES: Harry Barrow, father, Rural Route 6, Dallas, Texas Mrs. Celia Barrow, mother, Rural Route 6, Dallas, Texas L. C. Barrow, brother, County Jail, Dallas, Texas Marta Barrow, sister, Rural Route 6, Dallas, Texas Mrs. Artie Winkler, sister, Tanager Hotel Apartments, Dallas, Texas Mrs. Billie Conner, sister, Tanager Hotel Apartments, Dallas, Texas Mrs. Joe Buckner, aunt, Marshallville, Texas Mrs. Della Briggs, aunt, Dallas, Texas Frank Barrow, uncle, Garza, Garza County, Texas Joe Barrow, uncle, Streetman, Texas P. Brown, cousin, Marshallville, Texas Bertha Graham, cousin, Tyler, Texas Clara Lathrop, cousin, San Angelo, Texas Dorothy Lathrop, cousin, San Angelo, Texas.	
CRIMINAL RECORD Arrested sheriff's office, Kaufman, Texas, June 18, 1933; charge, burglary; released.		CRIMINAL RECORD Criminal record and fingerprints can be obtained from Identification Order No. 1217, issued October 29, 1933.	

Bonny & Clyde

Predicting criminals' trajectory

1930s



The Bonny & Clyde task force





EDITORIAL

**JONES HAPPY--
FREE NOW FROM
CLYDE'S ANGER**

Youngster's Last Show Was
Entertainment in His House

Newsp Washington,

HOPES FOR FREEDOM

Under Indemnity for Deeds
Killing, Not Seen Chance
of Liberty Release

Washington, D. C., June 11.—(AP)—A young man, who was arrested in connection with the killing of a woman, was today released from custody on a \$10,000 bond. The man, who is known as Clyde, was released on the condition that he would remain in the United States and not attempt to flee the country. He was released on the condition that he would remain in the United States and not attempt to flee the country. He was released on the condition that he would remain in the United States and not attempt to flee the country.

[illegible]

GOD HAVE MERCY
ON HIS SOUL
JOBS MOTHER

The following version of the gun fight was given by Frank Hunter:

Tracking the movements of dissidents

1970s-1980s



- Stasi sprayed a **radioactive solution** on the floors of the rooms where suspected dissidents met
- The solution adhered to dissidents' shoes, allowing agents to **track who attended a meeting** there
- Agents wore portable Geiger counters that activate when a suspected dissident was nearby

NewScientist



The Big Data era







Digital Footprints of Human Activity



Shopping
patterns

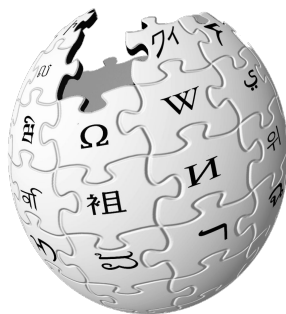
Digital Footprints of Human Activity



Shopping
patterns

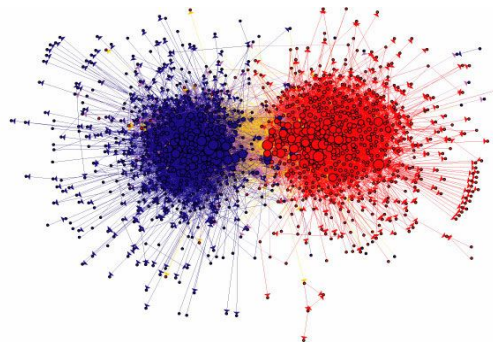


Opinions



WIKIPEDIA
The Free Encyclopedia

Social Ties

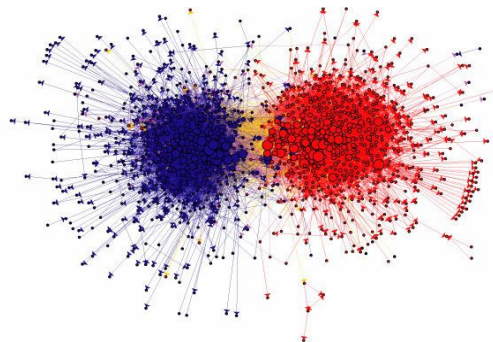


Digital Footprints of Human Activity

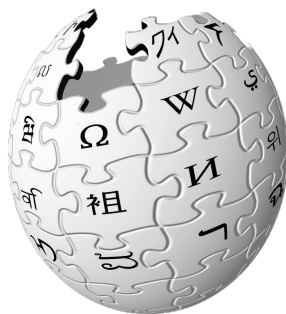


Shopping
patterns

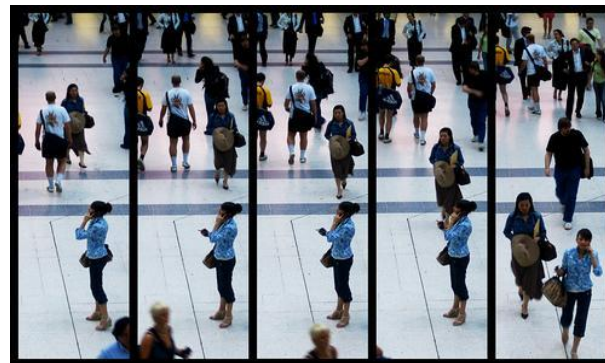
Social Ties



Opinions

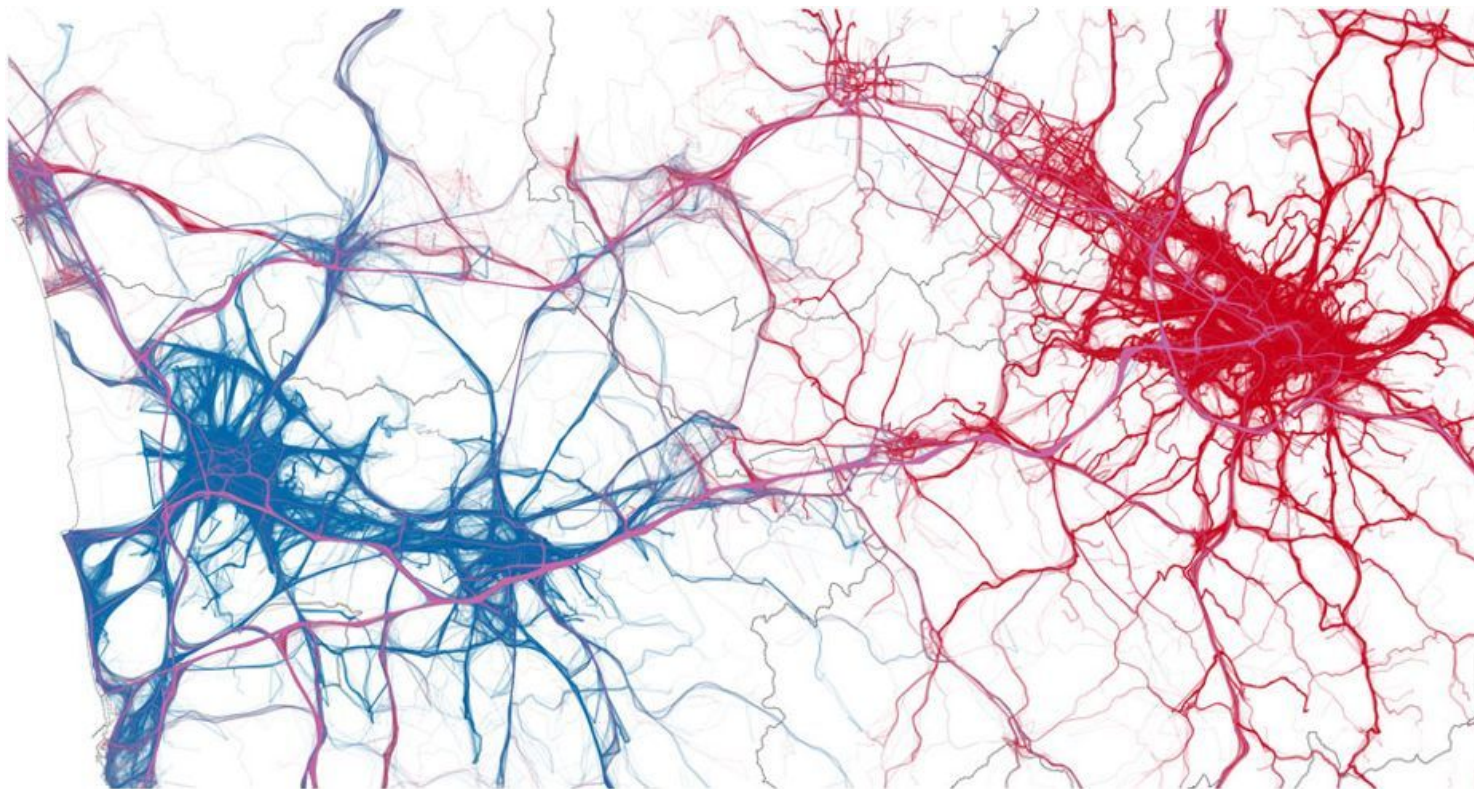


Movements



Digital Footprints of Human Activity

- **Volume:** the incredible amounts of data generated each second
- **Velocity:** speed at which vast amounts of data are being generated, collected and analyzed
- **Variety:** the different types of data we can now use
- **Veracity:** quality or trustworthiness of the data
- **Value:** the worth of the data being extracted



Pappalardo et al., Returners and Explorers dichotomy in Human Mobility, Nature Communications 6, 8166 (2015).
<https://doi.org/10.1038/ncomms9166>





The rest of the city rises and leaves the house to begin a new day.
And our insight around driving behaviour increases second by second, minute by minute.

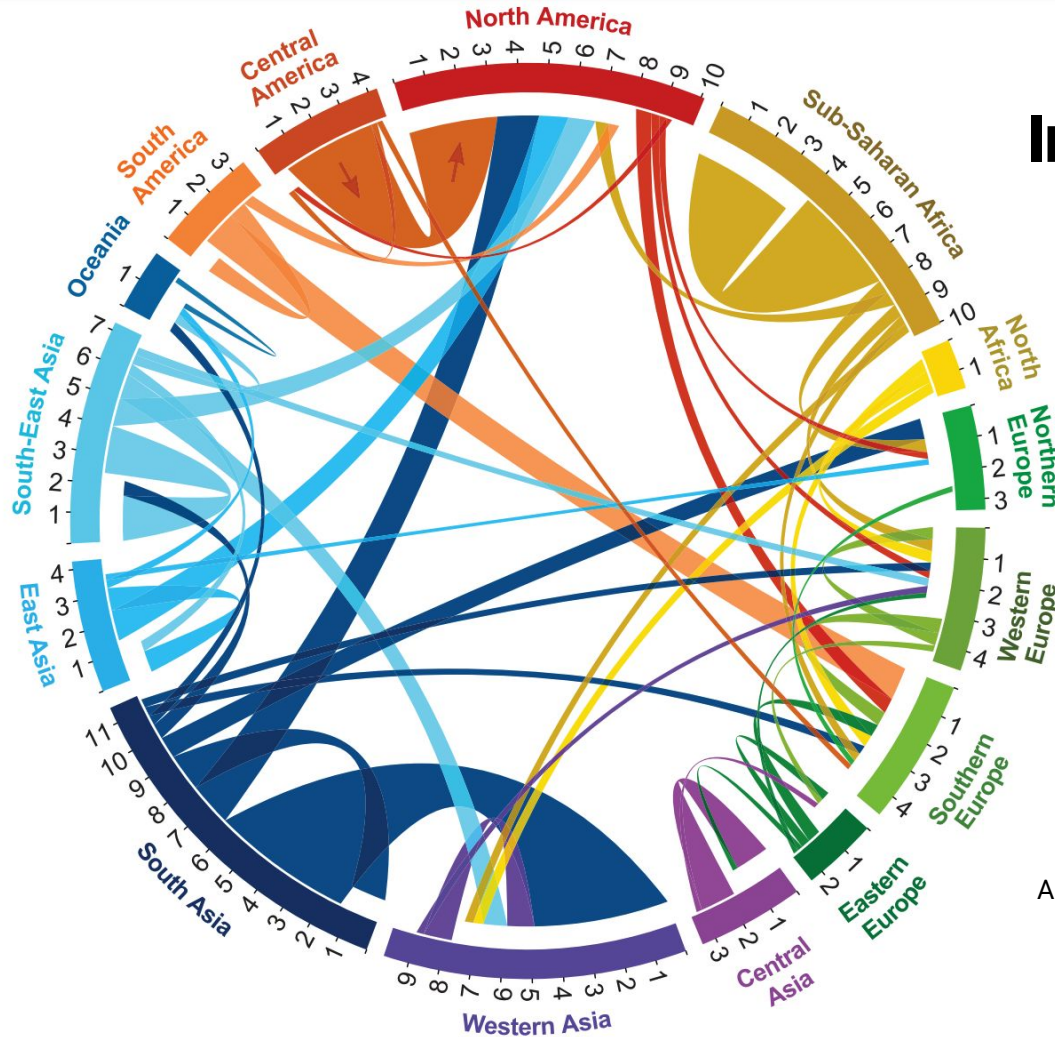




Ships trajectories: <https://www.shipmap.org/>

International migration flows

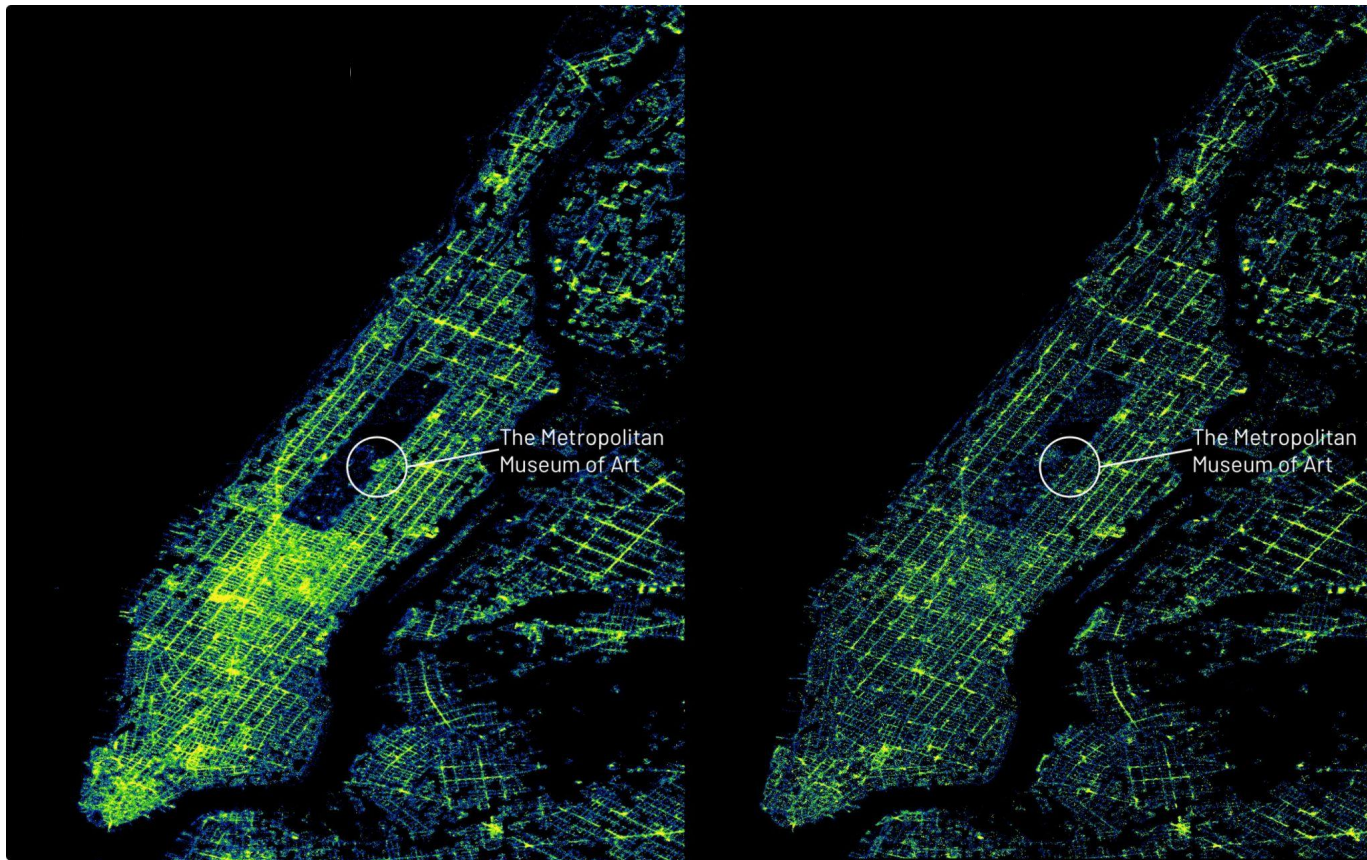
2005-2010

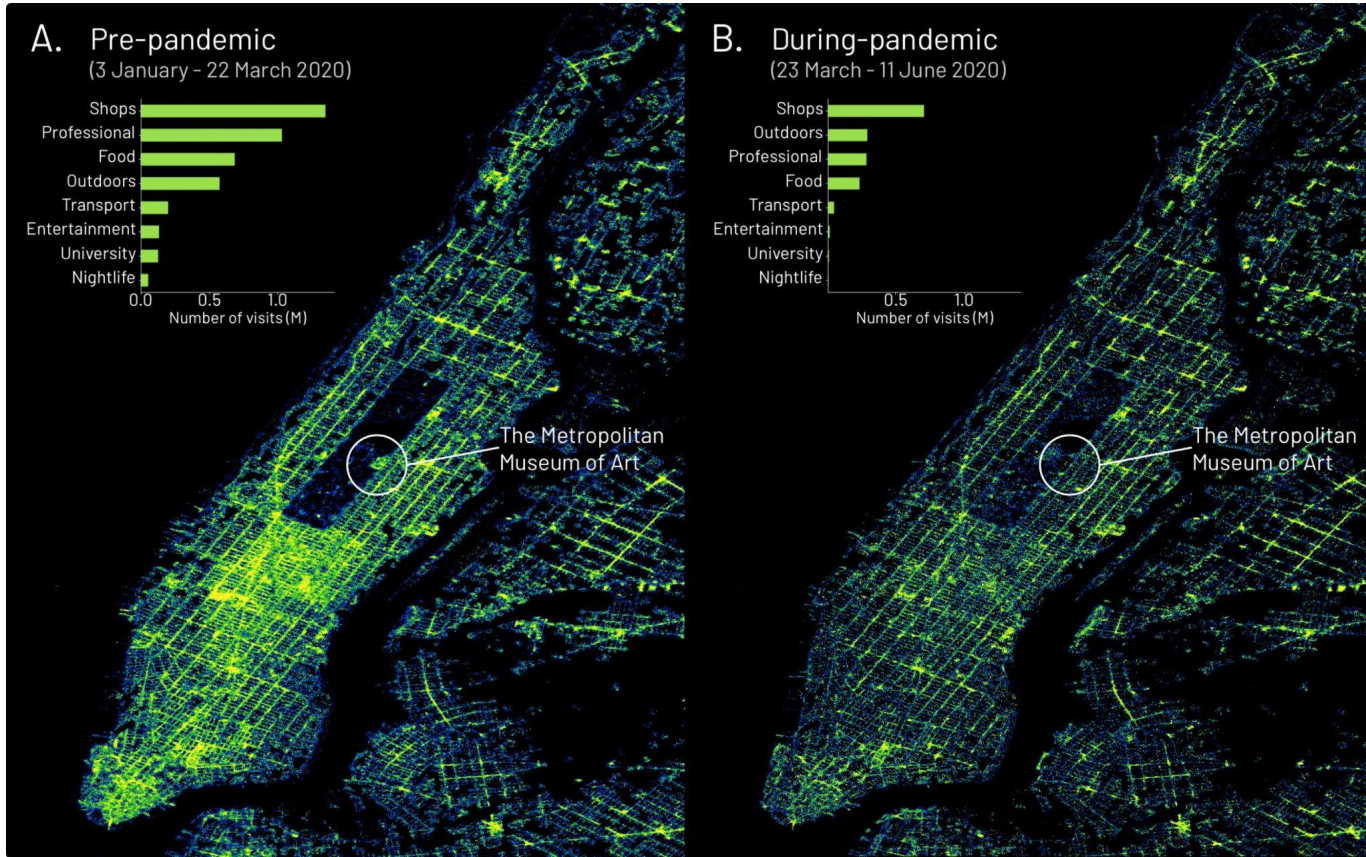


- number of migrants (inflows and outflows) in millions between and within world regions
- (only flows containing at least 170,000 migrants)

Abel and Sander, Quantifying global international migration flows, Science 343.6178 (2014): 1520-1522.

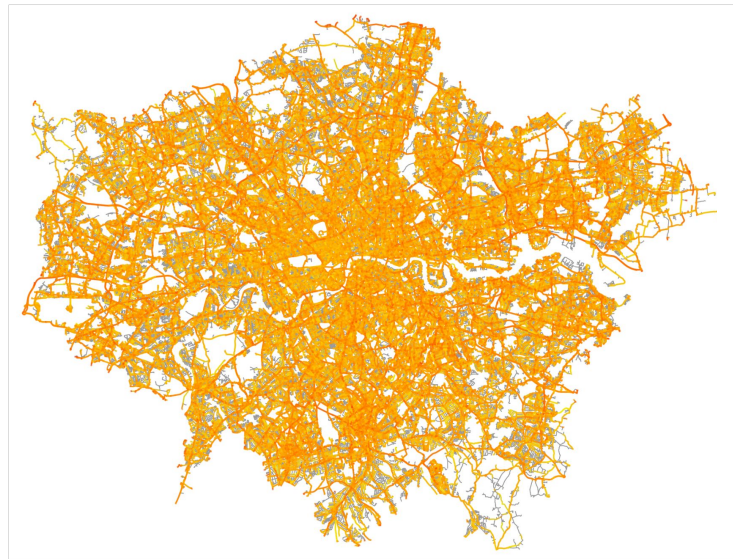




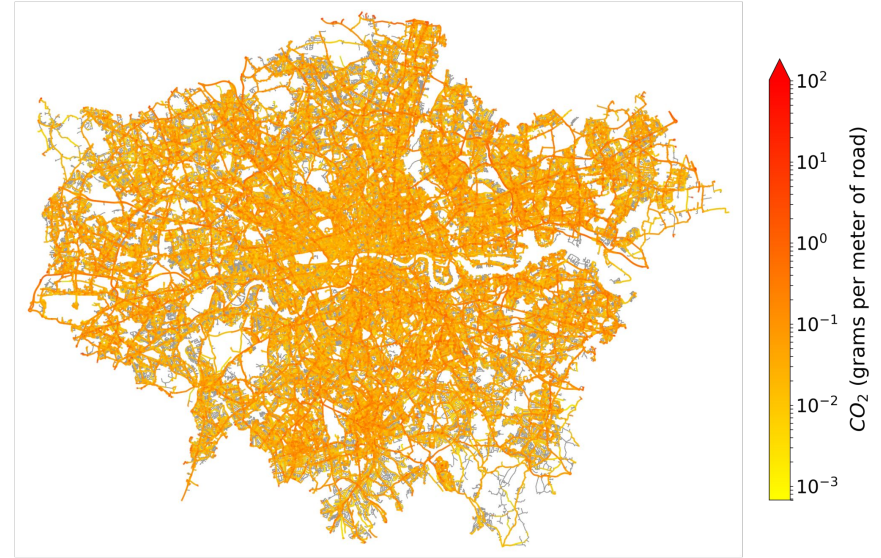
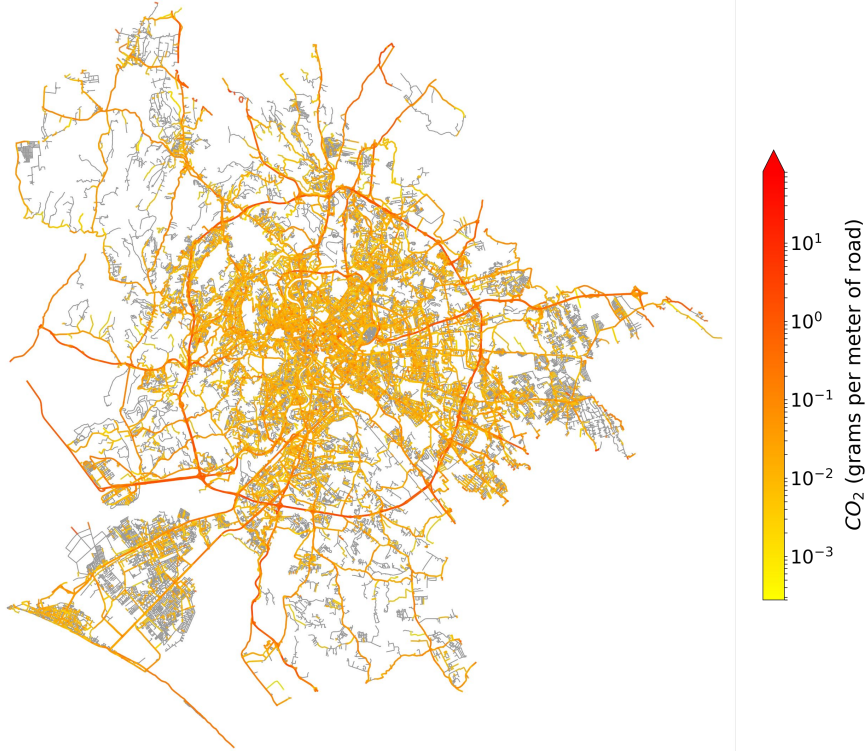


Lucchini et al., Living in a pandemic: changes in mobility routines, social activity and adherence to COVID-19 protective measures. Scientific Reports 11, 24452 (2021). <https://doi.org/10.1038/s41598-021-04139-1>





CO₂ emissions on roads



Böhm et al. Gross polluters and vehicle emissions reduction. Nature Sustainability 5, 699–707 (2022).

<https://doi.org/10.1038/s41893-022-00903-x>



Material

- [book] [Human Mobility: an Introduction](#), Nanni and Pappalardo (draft)
 - Chapter 1
- [book] [Introduction to geographic information systems](#), Kang-Tsung Chang, McGraw-Hill
 - Chapter 1
- [paper] [Human Mobility: Models and Applications](#), Barbosa et al., Physics Reports
 - Section 1 (Introduction)

Quiz

Which of the following best describes geospatial analytics?

- a) The study of daily commuting patterns in cities
-  b) The analysis of any data with a geographic component
- c) The design of transportation policies for urban areas
- d) The simulation of human decision-making in mobility

Quiz

Which of the following best describes human mobility?

- a) The collection of spatial datasets
- b) The visualization of satellite imagery
-  c) The movement of individuals and populations through space and time
- d) The optimization of supply chains across regions

Quiz: GSA or HM?

GSA

Mapping air pollution hotspots in a city.

HM

Analyzing why commuters prefer one route over another.

GSA

Measuring accessibility of hospitals across neighborhoods.

HM

Modeling how people evacuate during a natural disaster.

HM

Studying the distribution of trip lengths in a population.

both

Optimizing the placement of public bike-sharing stations.

GSA

Identifying spatial correlation between income and housing prices.

HM

Examining how highways shape route choices.