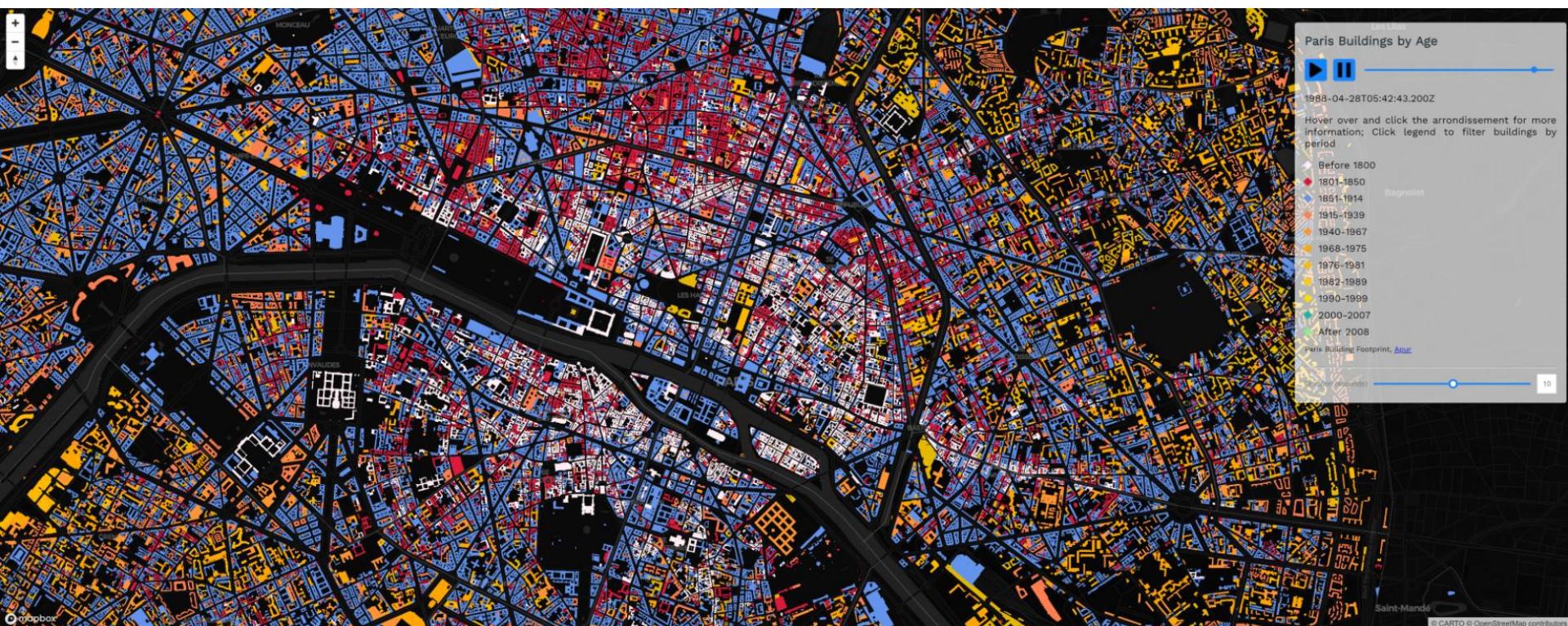


CASA0029: Urban Data Visualisation Introduction



Paris History Visualisation by Siyuan Chen, James Piggot, Chengyu Wang <https://invisiblecities-group4.github.io/>

Duncan A Smith

Centre for Advanced Spatial Analysis, UCL



Digital Viz Session Structure, Thursdays

09:00-10:00- Lecture, Royal Asiatic Society Lecture Hall, Stephenson Way.

10:00-11:00- Practicals, Royal Asiatic Society Lecture Hall, Stephenson Way.

You are expected to attend in-person. Practical videos and lecture slides will be available on Moodle.

Today

Overview and aims of the module

Timetable and Assessment Overview

Previous Group Project Examples

Group Discussion. Introductory Reading

The purpose of Data Visualisation

Making data visual; to tell stories, uncover new insights, identify patterns, demonstrate models, and communicate research with a wide audience.

Scientist, Programmer, Designer...

Visualisation multi-disciplinary by nature. Need to understand and employ different perspectives to data viz problems-



Design Aspects of Visualisation

Graphic / Cartographic Design

Matching visualisation style to topic and data. Aesthetics, and colour theory. Designing custom maps and spatial visualisation. Understanding the medium used.

Communication Design

Appropriate level of information for audience. Storytelling and visualisation; engaging the audience.

Interaction Design

Determining the level of user control. User interface design.

Visualisation Types and Medium

Lots of aspects to consider when developing a visualisation project. Approach guided by audience and output medium.

Some fundamental visualisation aspects to consider-

Interactive or Non-Interactive

Static or Animated

Scientific Research vs. General Audience

Aesthetics (e.g. Abstraction vs. Photorealism)

Immersion (e.g. 2D vs. 3D)

Live Data and Dynamics (e.g. Real time vs.
archived data)

Module Structure

Term 2 (Jan-March)

Lectures and Workshops

Individual Visualisation Hand-In (30%; 9th Feb)

Group Project Work (start in second half of Term 2)

Group Project Pitches (26th March, not assessed)

Group Project Outputs Submission (70%, 30th April)

Module Teaching Staff

Duncan Smith

Online interactive mapping techniques and tools

GIS spatial data and cartography

Valerio Signorelli

3D visualisation, advanced programming

VR and AR applications

Huixin Liu

Data visualisation, agent based modelling, transport visualisation.

Kayla McInnes

Data visualisation, transport analysis, data science.

Aims of the module

Learn to create spatial data visualisations using the latest visualisation libraries and tools.

Demonstrate understanding and ability to manipulate urban spatial data. Link GIS and data science libraries to visualisation outputs.

Demonstrate cartographic design principles; successfully apply appropriate visualisation methods for different research questions.

Understand the advantages and challenges of interactive visualisation methods; design relevant levels of user interaction for different applications and audiences.

Develop skills in communicating research outcomes using engaging and concise visualisation methods.

*Improve group-working skills through a group visualisation project.
Develop a relevant and creative intellectual toolkit for future research and professional development.*

Assessments

Individual Visualisation Assessment, 30%, 9th Feb

A relatively simple visualisation of a single dataset, typically in the form of an interactive map or chart. This assessment checks you have understood the fundamentals of data visualisation using web tools.

Group Project Assessment, 70%, 30th April

A more sophisticated series of linked visualisations on an urban spatial science theme, developed as a group project website. Groups are typically 3 students who develop a project collectively.

Group Size and Choosing Groups

This year we are going to have groups of **3 students**. You will be able to choose your group members. Discuss with course mates over the next few weeks and find out who is interested in working on similar project ideas. We will discuss group selection later in the module.

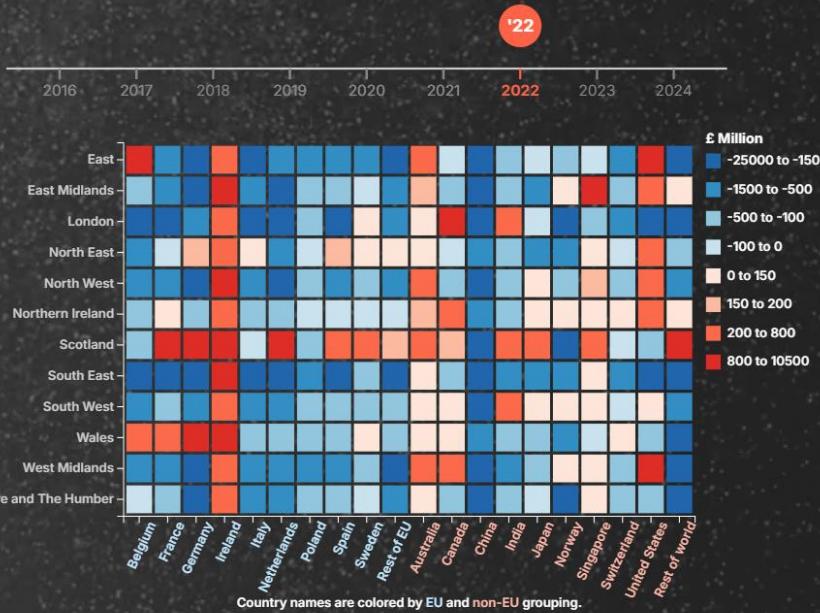
This module was previously a **30 Credit Module**, and this year is a **15 Credit Module**. The example projects from previous years are therefore larger than the projects you will complete this year. Your projects this year will be around half the size of the examples given in the following slides.

Example Group Projects From Previous Years

2024-2025: City Networks

*Each year there is a general project theme.
Themes can be interpreted in lots of different
ways: they are a starting point for your project
and not intended as a constraint.*

UK Regional Goods Trade Balance



2022

Trade deficits with EU countries widened across most UK regions, as new customs rules took full effect and long-standing supply chains with Europe came under strain.

2023 - 2024

London has been particularly affected by post-Brexit customs changes. As a key hub for re-exports and high-value goods, the city faced growing trade deficits with EU countries as new border rules disrupted its role in cross-border supply chains.



[Overview](#)[Technology](#)[Commerce](#)[Culture](#)[Future](#)

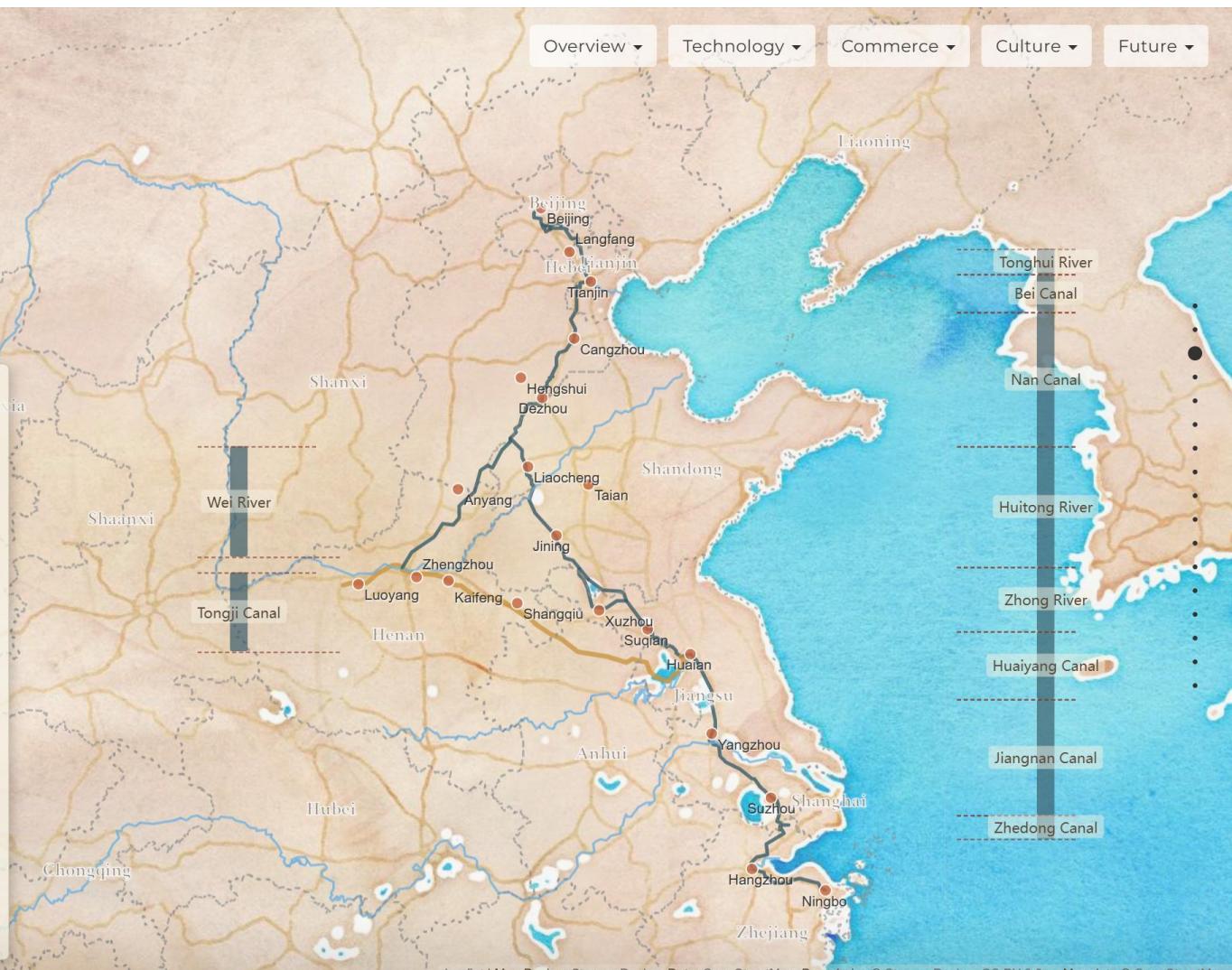
Temporal-Spatial Canal

The Grand Canal of China, stretching nearly 3,200 kilometers, is the world's longest artificial waterway system. Dating back to about 400 BCE, it has facilitated vital regional exchanges throughout China for millennia. In 2014, it was designated a UNESCO World Cultural Heritage Site.

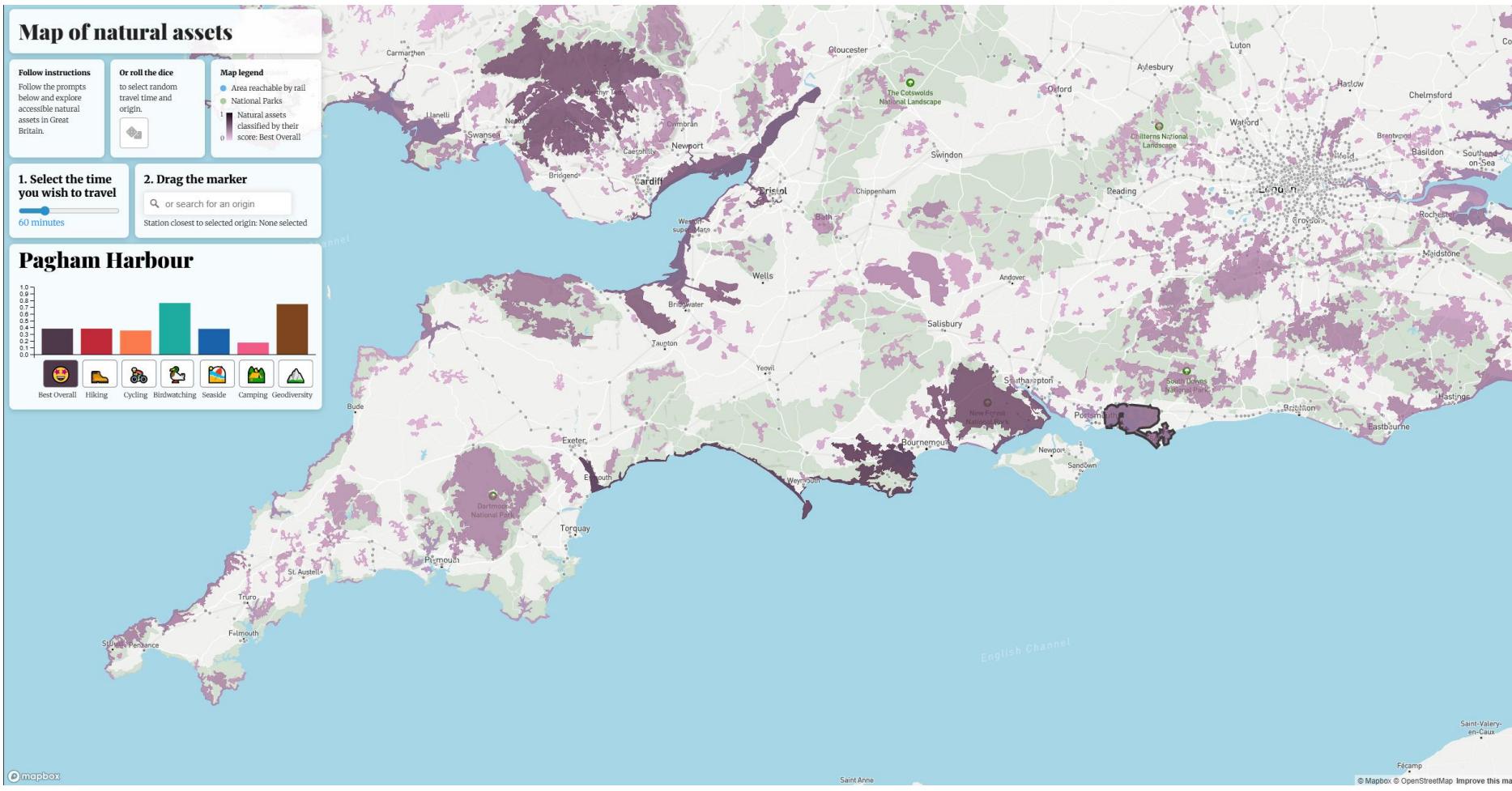
[Play](#)[Modern](#)[Stop](#)

Shang-Zhou	Spring-Autumn	Warring States
Qin-Han	Wei-Jin	Sui
Tang	Song	Yuan
Ming	Qing	Modern

Data Source: Application for World Heritage Text: The Grand Canal of China. State Administration of Cultural Heritage. 2013 | One article counts the Grand Canal | The new concept of heritage protection brought about by the application and protection plan for the Grand Canal's World Heritage status



Networking China: The Grand Canal's Legacy by Keyi Heng, Yiduo Yun, Jialei Guo
<https://jialeiguo1108.github.io/The-Grand-Canal/1Main-web.html#LandingPage>

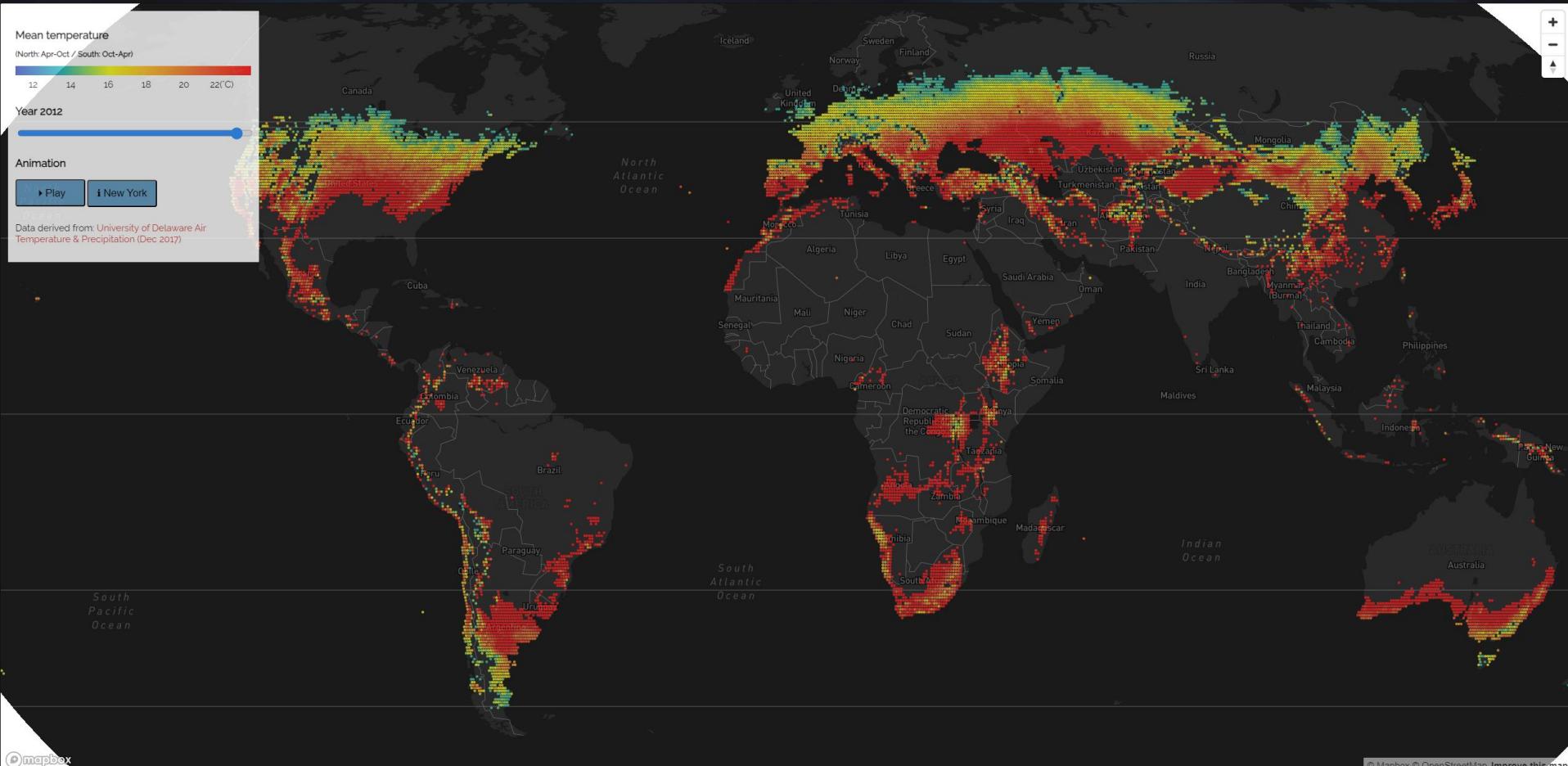


A web tool to inspire sustainable journeys into British nature by rail networks by
 Anna Saveleva, Yale Lu, Yaqi Cui-
https://a-saveleva.github.io/casa_0003_group_project/#section7

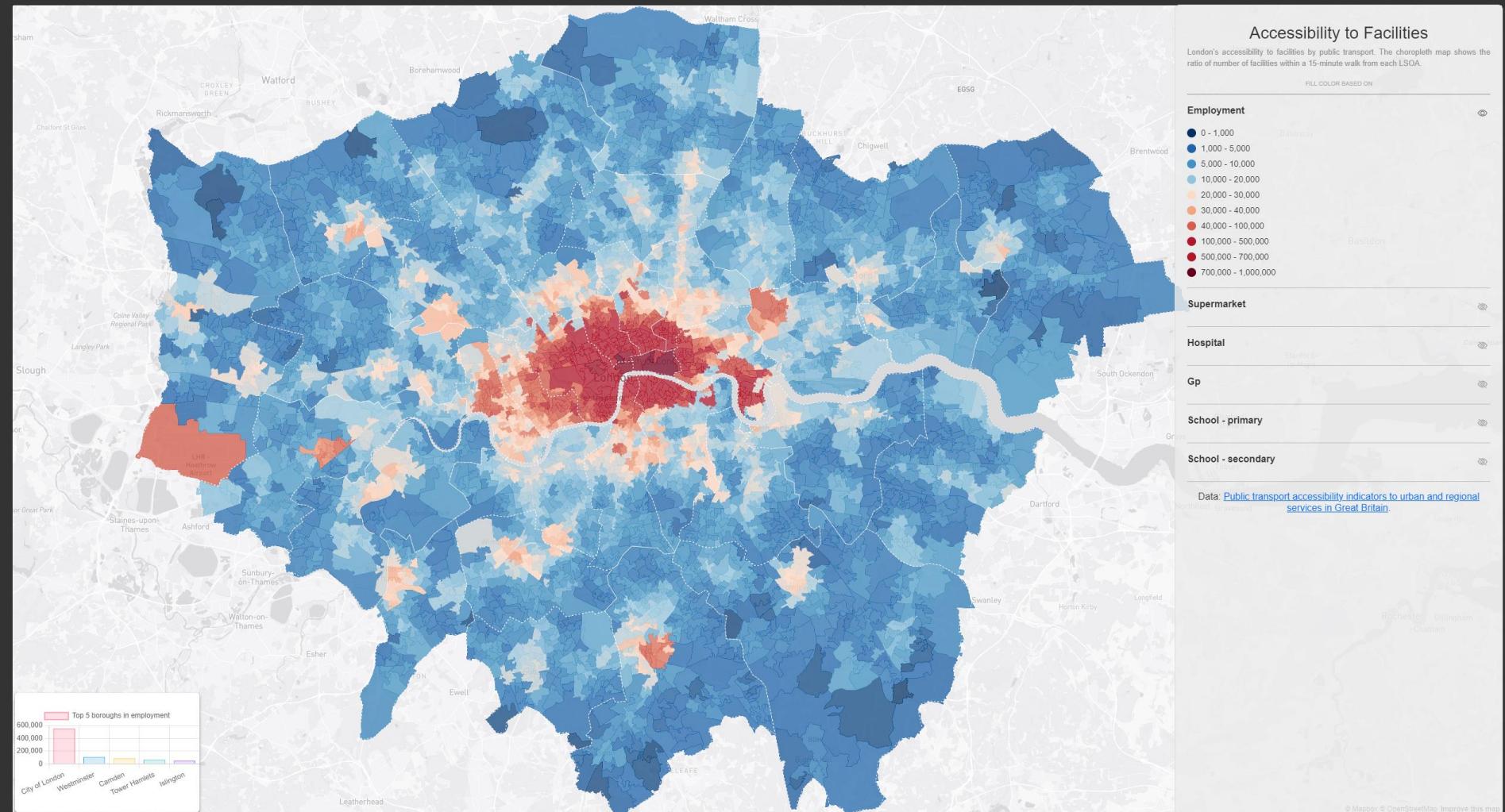
Example Group Projects From Previous Years

2023-2024: Urban Futures

*(Each year has a general project theme.
Themes can be interpreted in lots of different
ways. Starting point for your project).*



Sea Level Rise & the Future of NYC, by Wenhao Xu, Jie Zhou, & Yunlong Li. https://gordenleee.github.io/Casa0003_Group_Work/



Is London a 15 Minute City? By Xinyu Wu, Shijie Wang & Chenxi Yan. https://sheenwu-student.github.io/Viz-15min/visual_website/html/base.html

Factors of the UHI: Urbanization

Select the Year You Want:

Year: 2000

Select the Layer You Want:

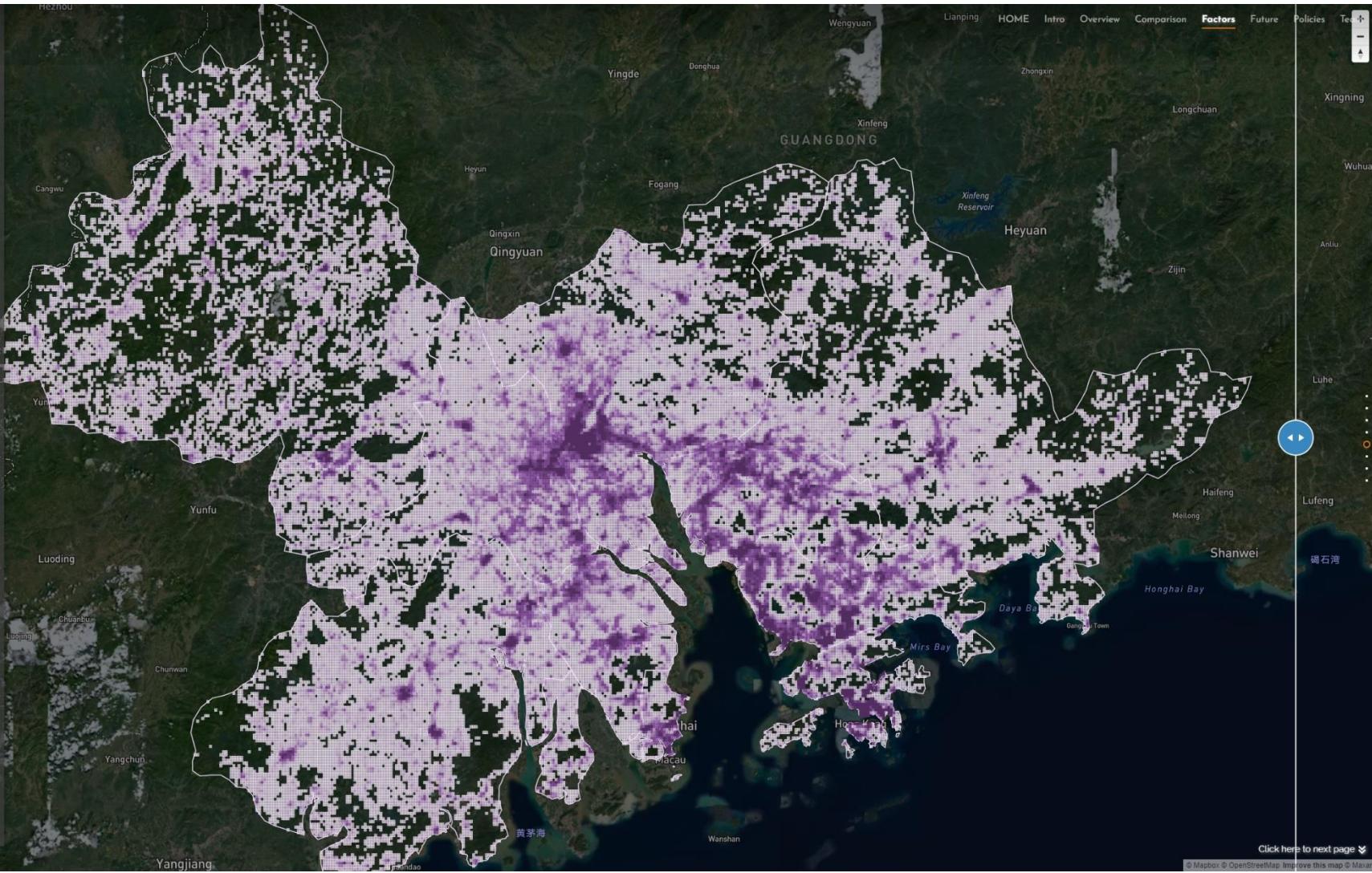
- Population Density
- Built-up Surface
- High Temperature Heatmap
- Temperature Distribution

Temperature

Population Density

Built-up Surface

Source
Land Surface Temperature | Population Density | Built-up Surface | GBA Boundaries



Urban Heat Island in Greater Bay Area, by Heyang Zeng & Yuqing Han. <https://mazzylion.github.io/>

Click here to next page

© Mapbox © OpenStreetMap. Improve this map © Maxar

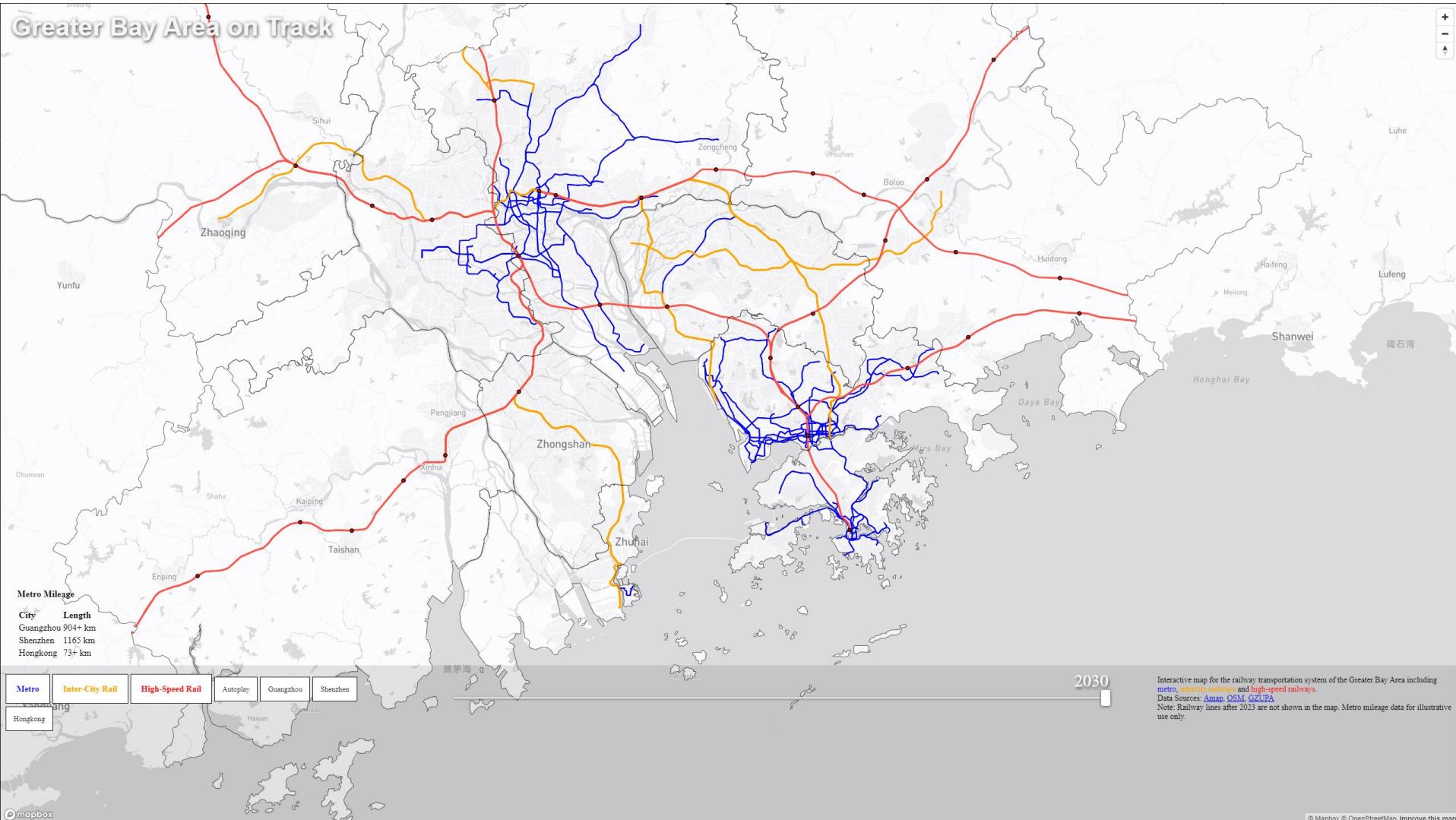
Example Group Projects From Previous Years

2022-2023: Urban Regeneration

*(Each year has a general project theme.
Themes can be interpreted in lots of different
ways. Starting point for your project).*



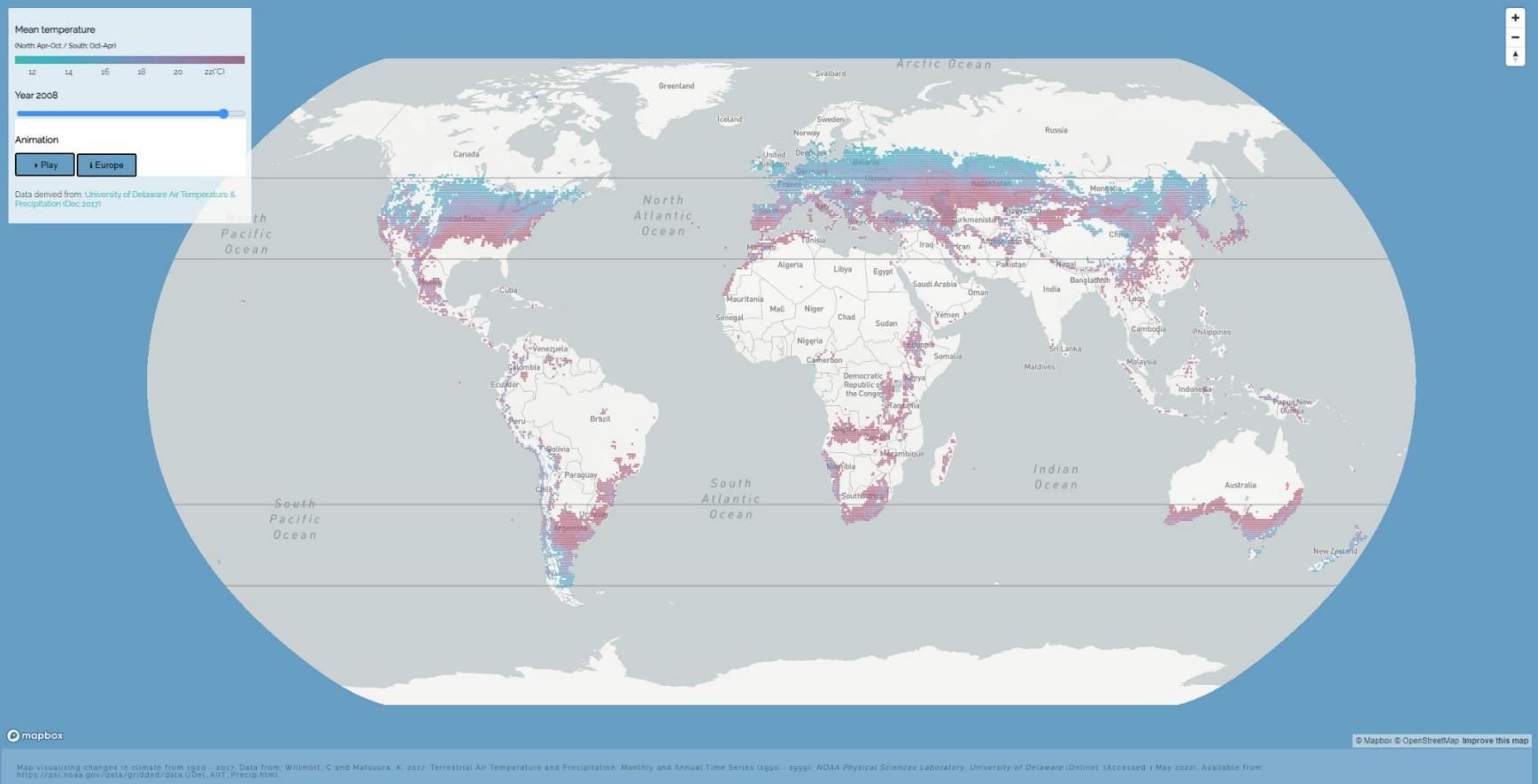
[Chrono-Urban Workspaces](#). Group members- Gerardo Ezequiel, Jiabao Zhu, Hilman Prakosa, Jianhong Liu .



[Greater Bay Area Regeneration Project](#). Group members- Jin Jiang, Shumeng Zhang, Zhiang Chen.

Example Group Projects From Previous Years

2021-2022: Global to Local



The Silk Road (130 BCE-1453 CE)

Source: UNESCO About the Silk Roads

The Silk Road was an ancient trade route originating at Chang'an (Xian). The 6,400 km road followed the Great Wall of China to the northwest, bypassed the Takla Makan Desert, climbed the Pamirs, crossed the Middle East, and went on to the Levant; from there the merchandise was shipped across the Mediterranean Sea. Few people travelled the entire route, and goods were handled in a staggered progression by middlemen.

The vast trade networks of the Silk Roads carried more than just merchandise and precious commodities. The constant movement and mixing of peoples brought about the widespread transmission of knowledge, ideas, cultures, and beliefs, which had a profound impact on the history and civilizations of the Eurasian peoples. Many of cities developed into hubs of culture and learning. Science, arts, and literature, as well as crafts and technologies, were thus shared and disseminated into societies along the lengths of these routes and in this way, languages and cultures developed and influenced one another.

The Silk Road reached its golden age in the Tang dynasty (600 CE). With the gradual loss of Roman territory in Asia and the rise of Arabian power in the Levant, the Silk Road became increasingly unsafe and untravelled. In the 13th and 14th centuries, the route was revived under the Mongols, and at that time, the Venetian Marco Polo used it to travel to China. After the fall of the Mongol Empire, the great powers along the Silk Road became separated. The discovery of a sea route from Europe to Asia in the late 15th century dealt a damaging blow to the Silk Road trade again. Since then, the prosperous Silk Road has been on the decline.

Show the full routes

Setup the Viewport:

Global view Overlook Eyelevel Starting point

Please drag the arrow on the right to compare the time changes of important cities on the Silk Road.



[The Silk Road and Chinese global cultural diffusion by Group 4 \(Rongrong Xue, Yuning Jiang, Zhonghao Li, Ce Hou\)](#)

Global Overview

Use the *time slider* to select a year or *hover over the legends* to filter.

Zoom in and *hover* over a point to get more info.

Hold *shift* and *drag* the map to see all floods affecting selected region.

Year: 1985 - 2021



Show all years

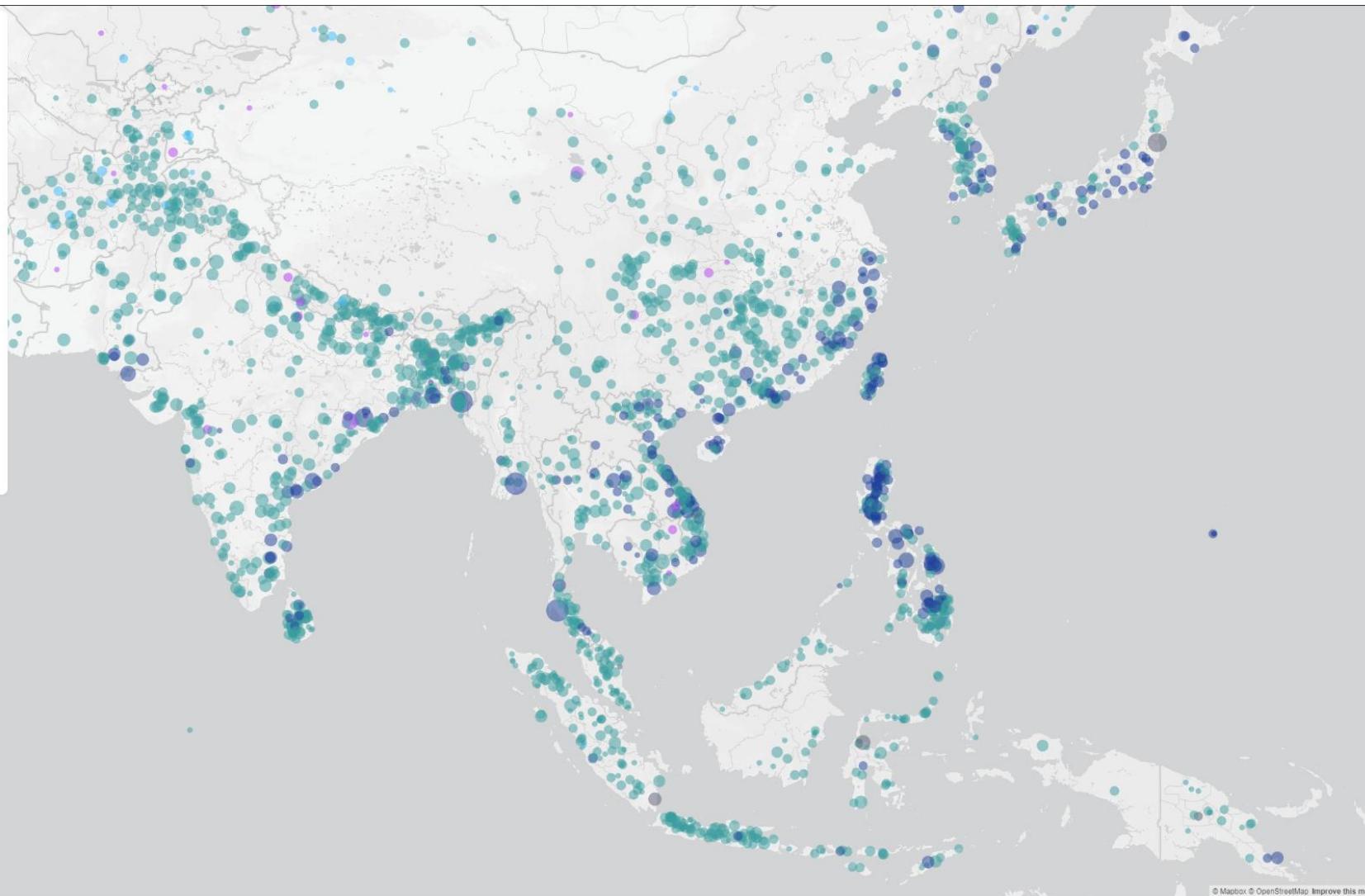
Main Cause

- Heavy rain
- Tropical storm/surge
- Snowmelt, ice
- Dam

Number of Deaths

- 0
- 1 - 1,000
- 1,000 - 100,000
- > 100,000

Source: Dartmouth Flood Observatory



mapbox

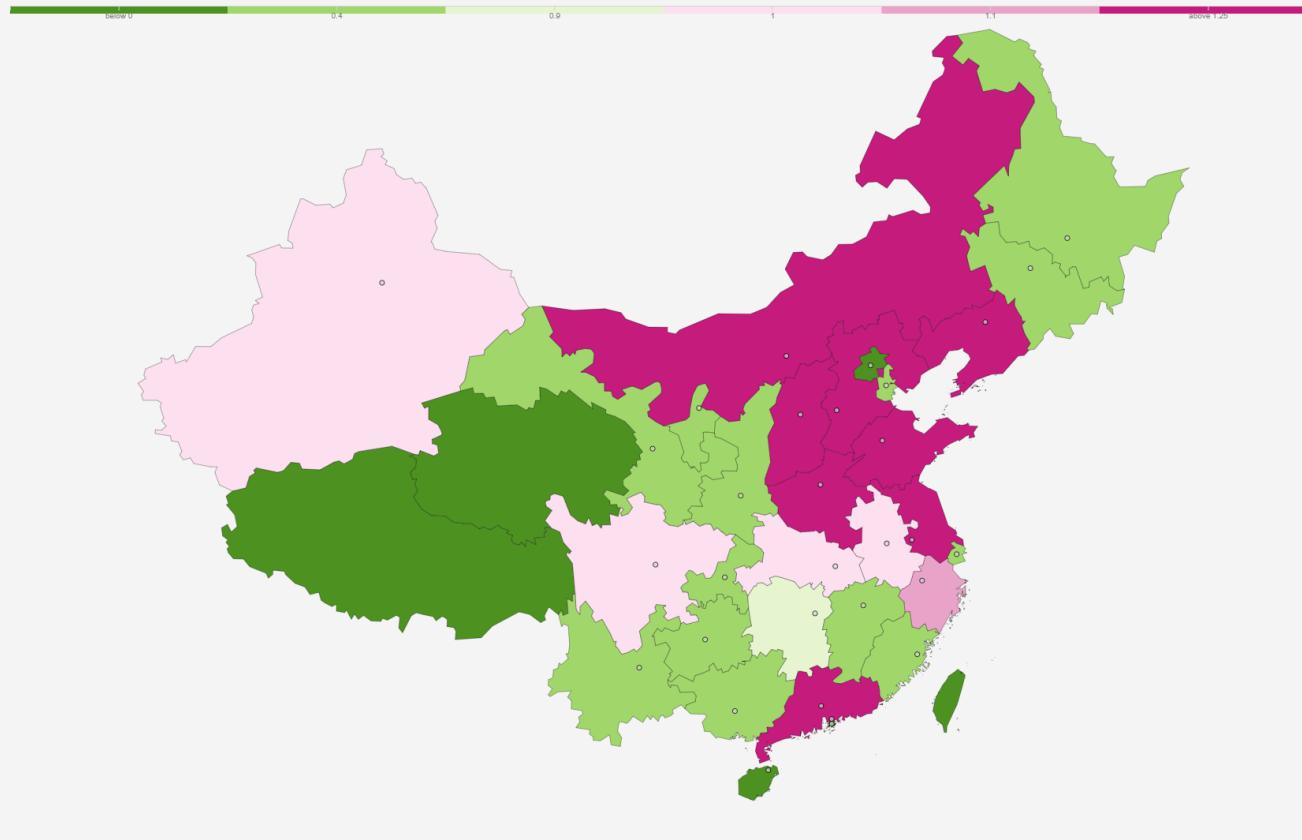
© Mapbox © OpenStreetMap Improve this map

[Global Flooding Events Map by Group 1](#) (Nina Fabsikova, Sangbin Lee, Murray Chapman, Xinyi Huang, Henry Song)

Example Group Projects From Previous Years

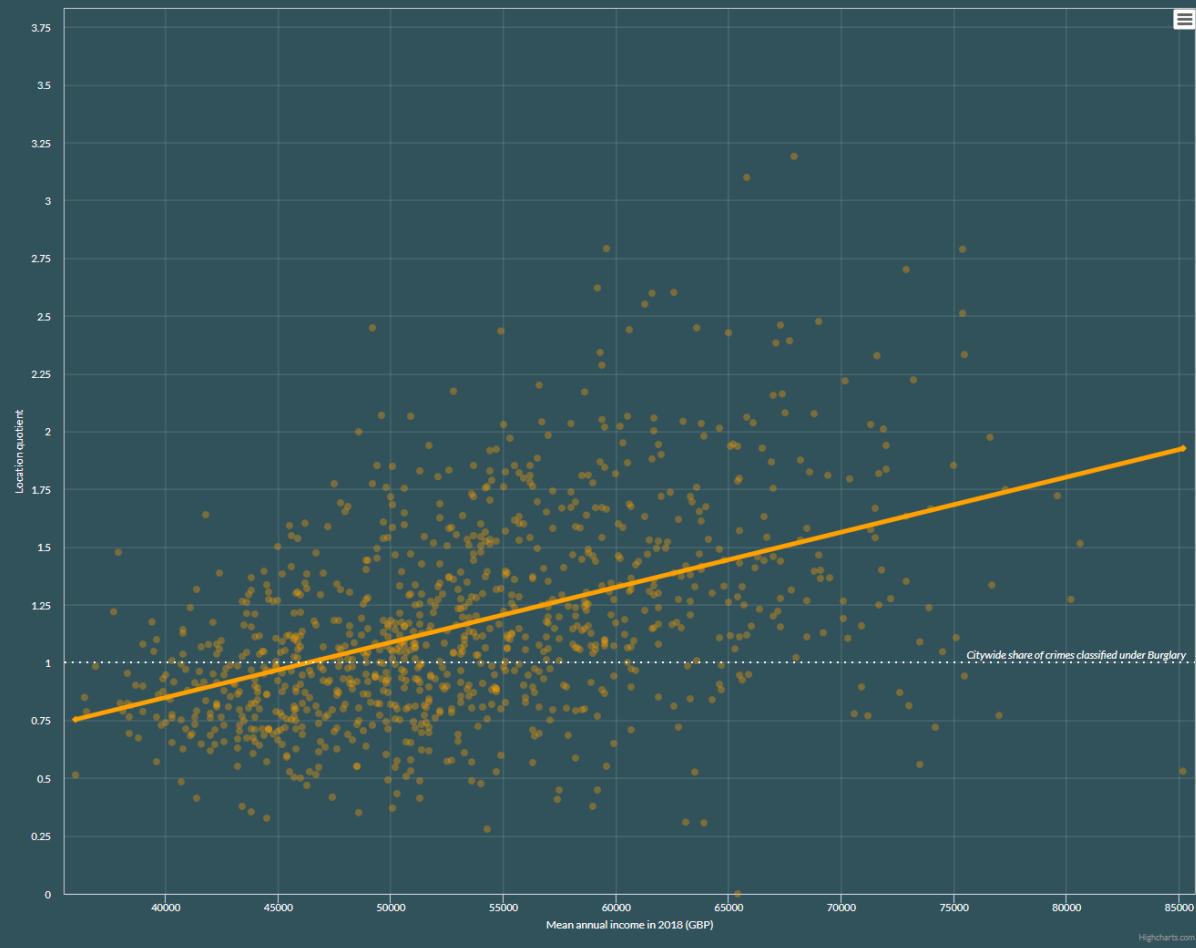
2020-2021: City Transformations

The Carbon Dioxide Emission Map of China, 2017



Provincial Map: Spatial Agglomeration Emerged

In China, the most developed regions and cities are located in the southern and eastern parts of the country. The most developed provinces, like Guangdong and Shanghai, produce relatively more carbon dioxide annually, as can be seen in this province boundary map. But some provinces like Inner Mongolia, Shanxi and Hebei, located in the North of China, still contain much higher emission levels compared to the average level.



Each crime type has a different relationship with area-level income.

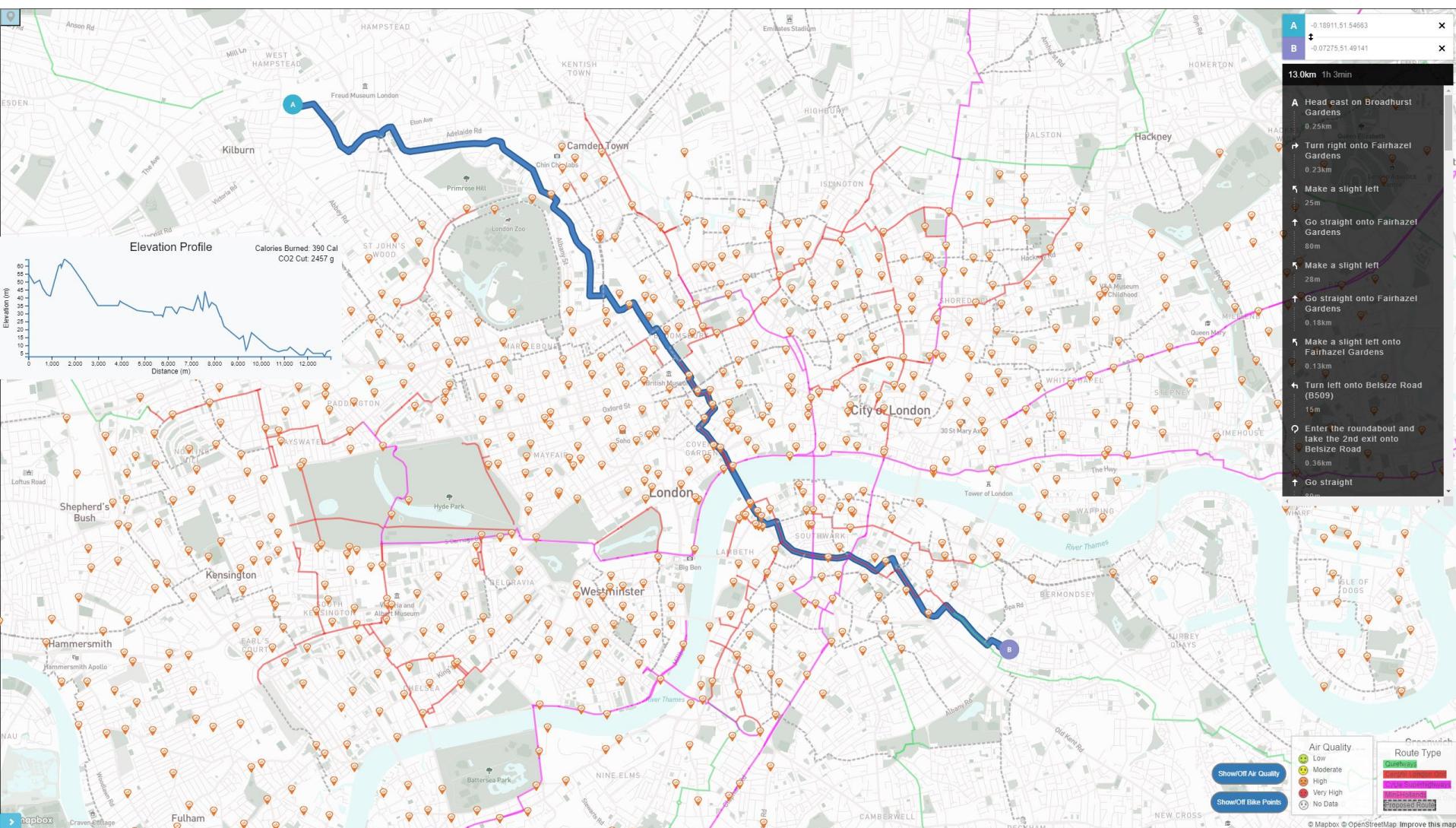
Relative to the overall share of property crimes in London, burglary and theft are overrepresented in areas with higher average incomes. The opposite can be seen for violent crime, which is linked to socio-economic conditions in deprived areas; and drug-related offences, for which ethnic minorities – who are more likely to live in deprived areas – are over-prosecuted.

Explore how the local concentration of each major crime category correlates with income. ⓘ



Example Group Projects From Previous Years

2019-2020: The Living City



Cycling City: Yang, Zhaoqin; Cun, Yipei; Huang, Kexiang; Lin, Yu-Mei <https://dv-group8.github.io/index.html>

Project 4 | A directional analysis

Description:

This project explores the direction of travel at a monthly level between cities in China. You can choose to view migration towards or away from a city as well as a colourscheme which will help you uncover different patterns in the data. Click on a city to see its connections, click on a blank space on the map to deselect your city. If no connections appear try changing directions of travel. Alternatively, it may be possible that no data is available.

Data exploratory controls:

Least arriving to the city Colour peak

Colour scale (min-max): applied to individual cities

Peak measure that shows the progress of each city's migration between its lowest and highest value

Min Max

Temporal exploratory controls:

Play Reset + Step - Step

Month: January 2019

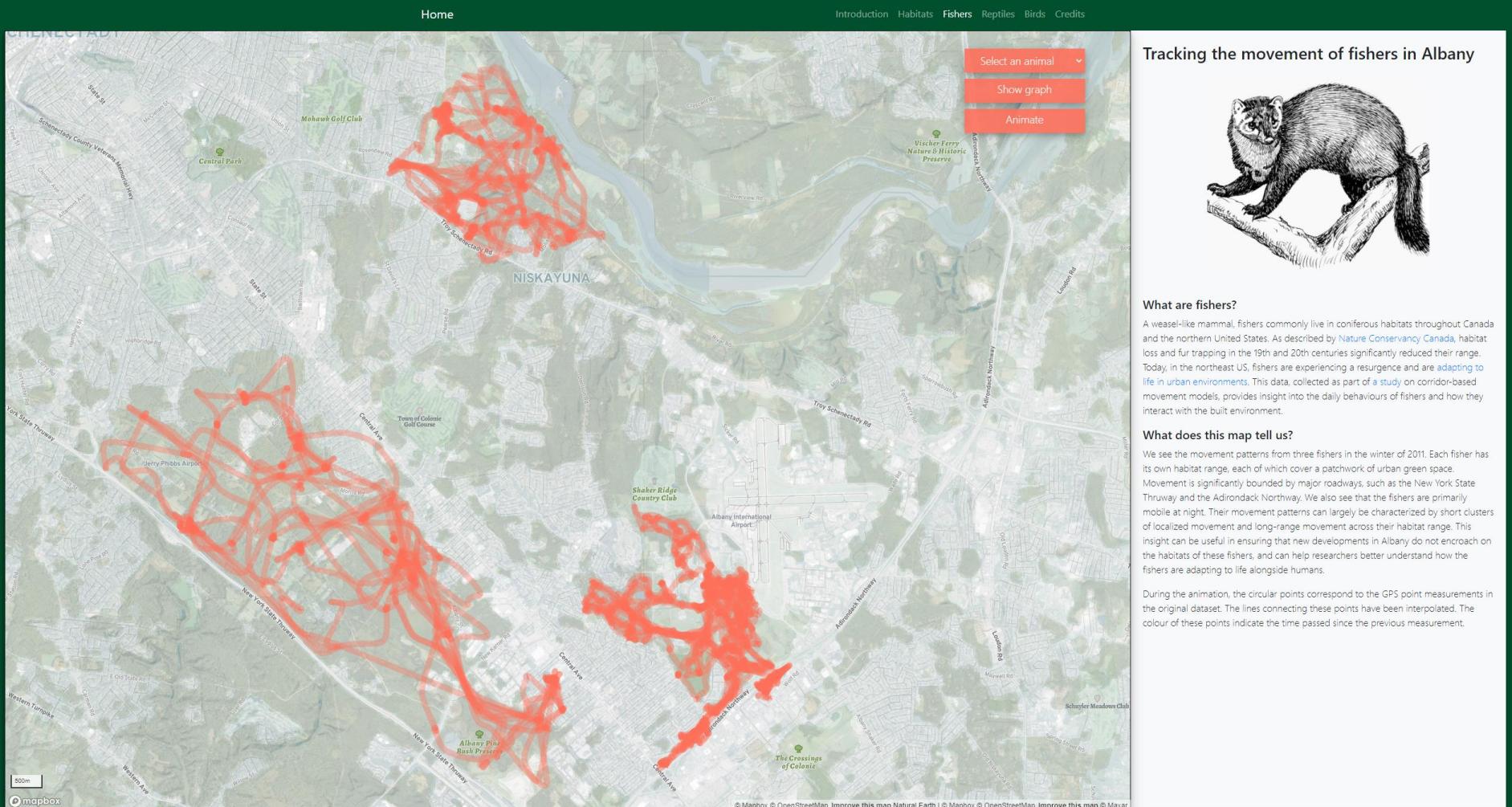
Source:

Data purchased from [Raw Data Store](#) for Jan 2018 – June 2019



Urban Migration: Antonios; Xiang Zhou; Diqu Yang; Xin Zhang

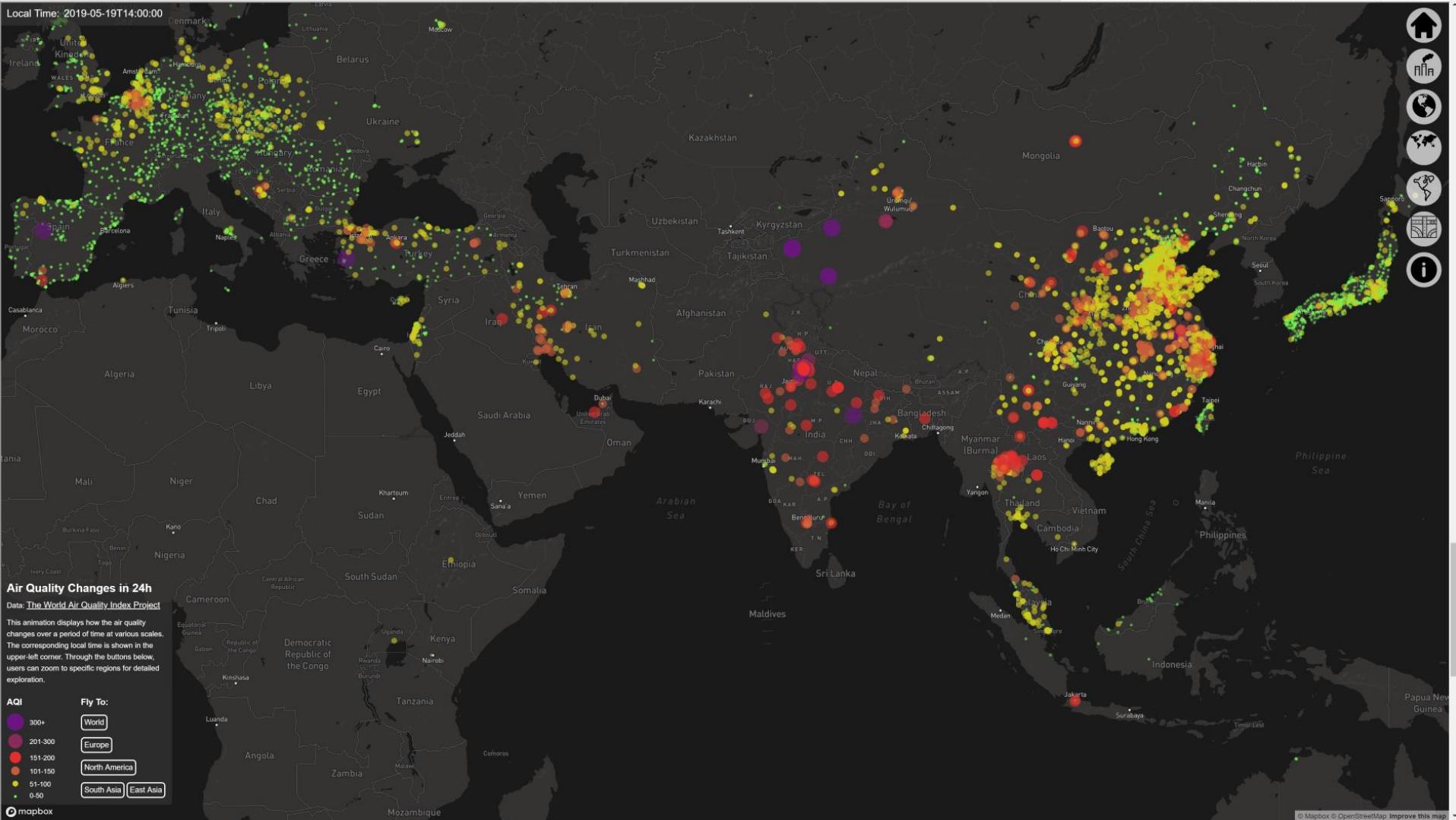
https://antoniosfiala.github.io/UCL_Visualisation_Population_Flow/Website/

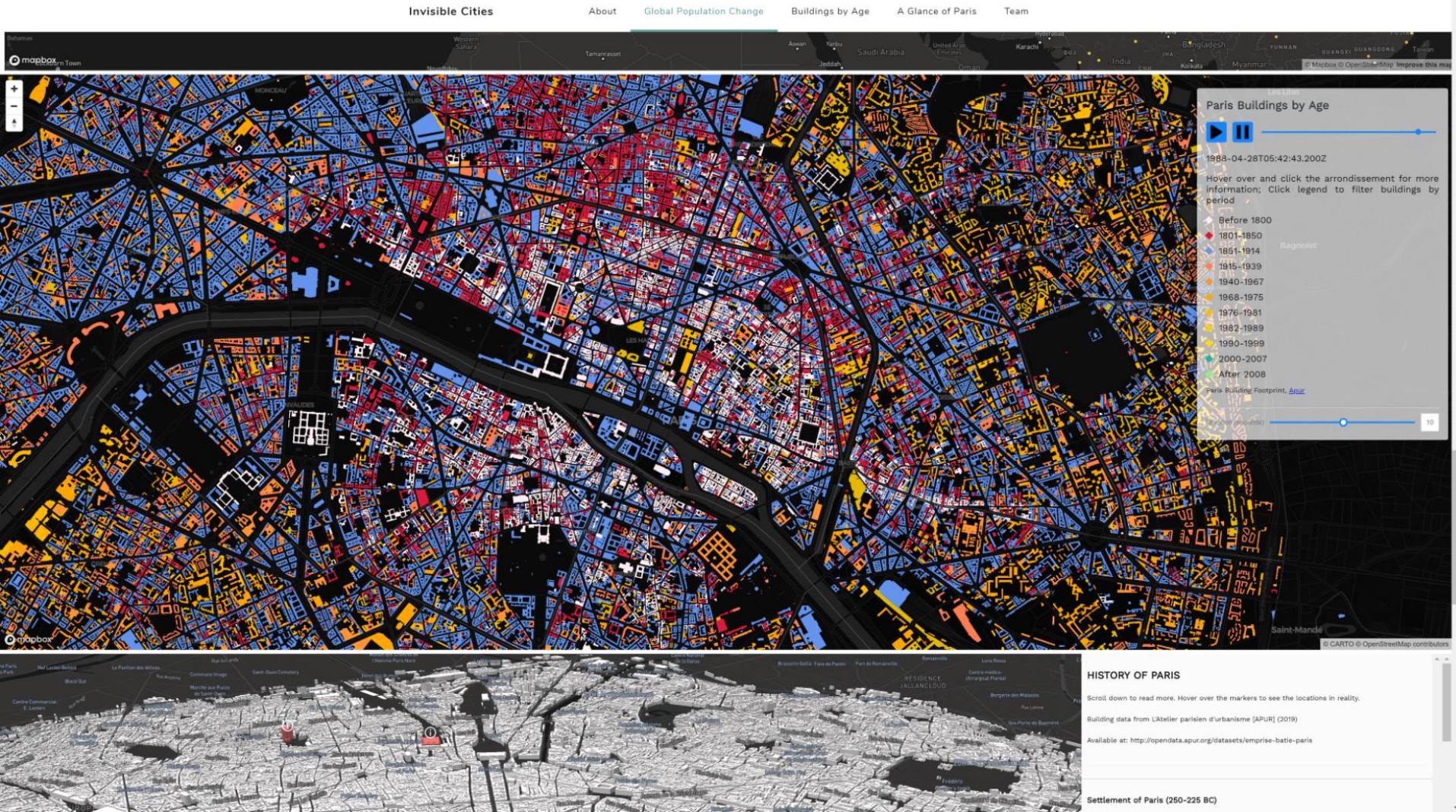


Wildlife in the City: Hannah Ker, Yu Fu, Jingwen Huang, and Wanzhi Xie-
<https://hannahker.github.io/living-city-visualization/site-build/index.html>

Example Group Projects From Previous Years

2018-2019: Invisible Cities

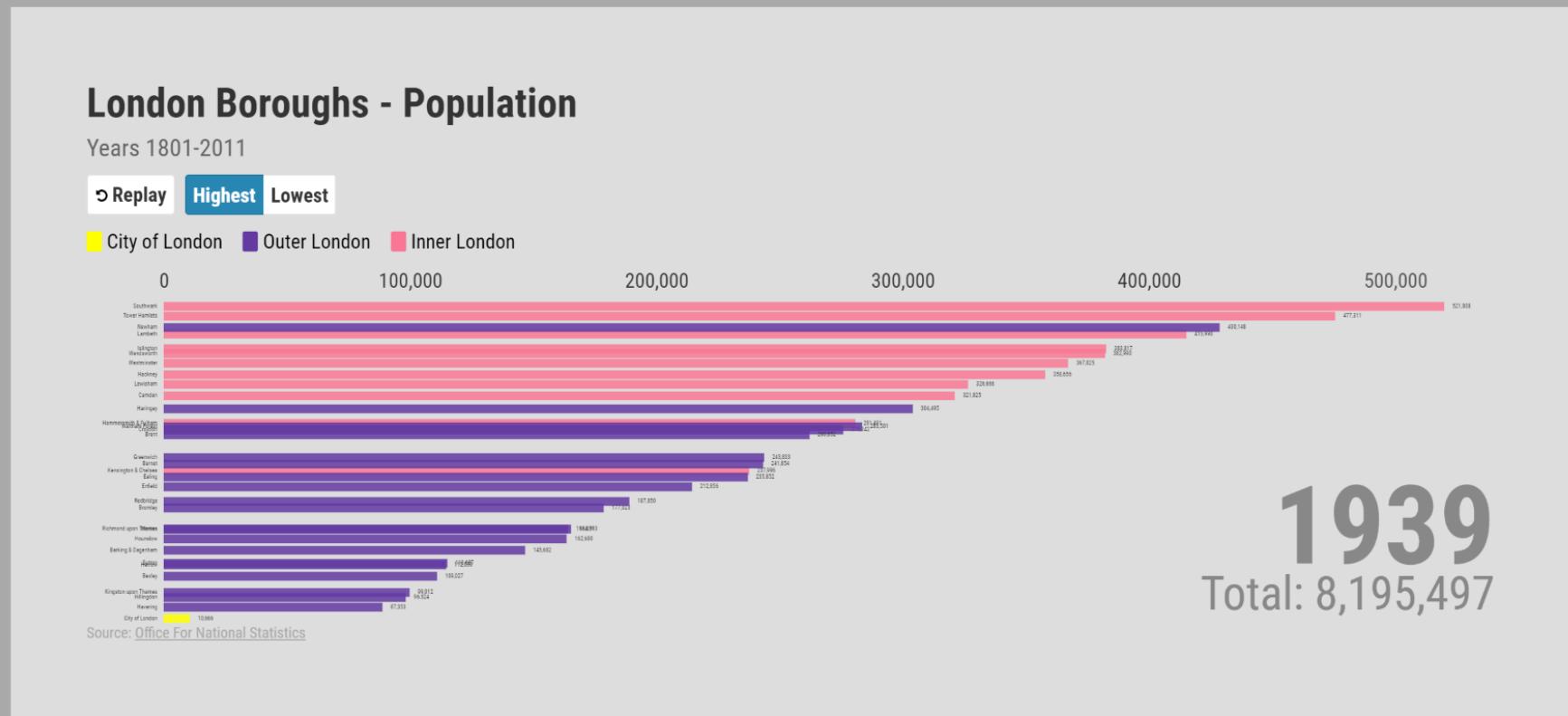




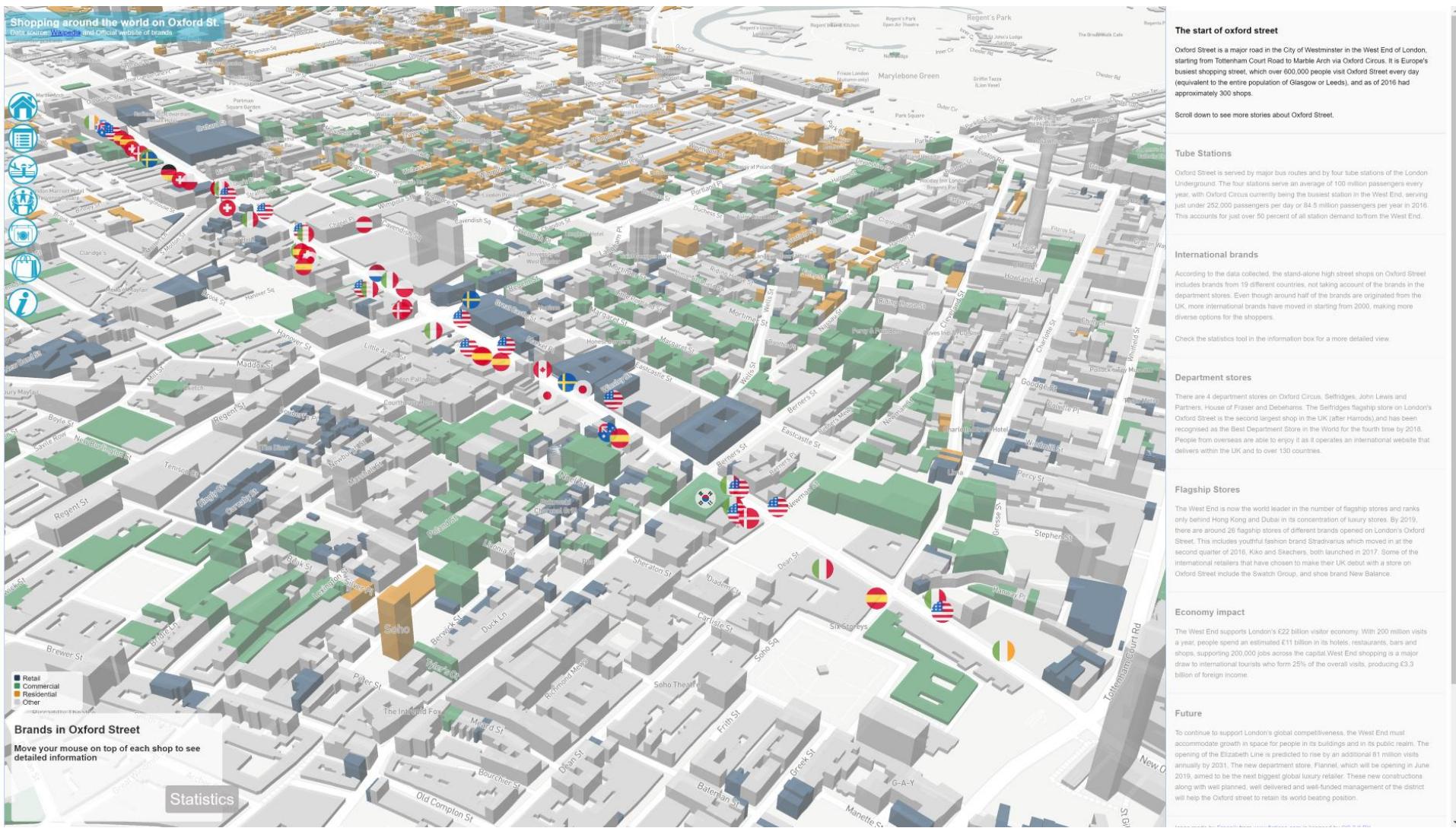
Siyuan Chen, James Piggot, Chengyu Wang <https://invisiblecities-group4.github.io/>

London, 100 Years Apart | How did the population of London change over time?

Between 1801 and 2011, London's population grew from around 1 million to over 8 million people. But which of London boroughs hold most of the population? Did this change over time? Click 'Replay' to find out.



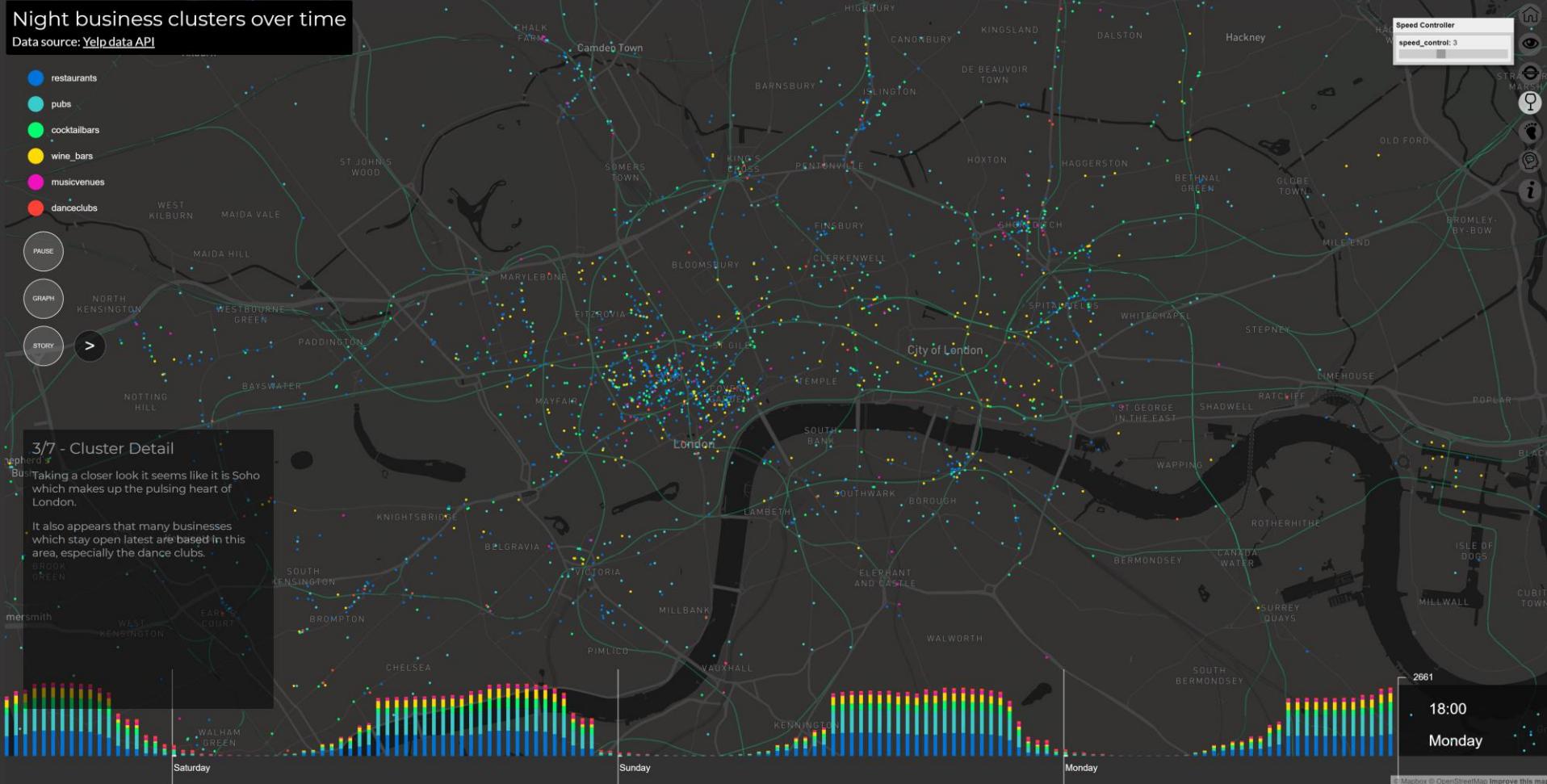
A Flourish data visualisation



Bowen Zhang, Chia-Yin Lu, Fei Xu, Yunjing Hu <https://helloworld-fromlondoners.github.io>

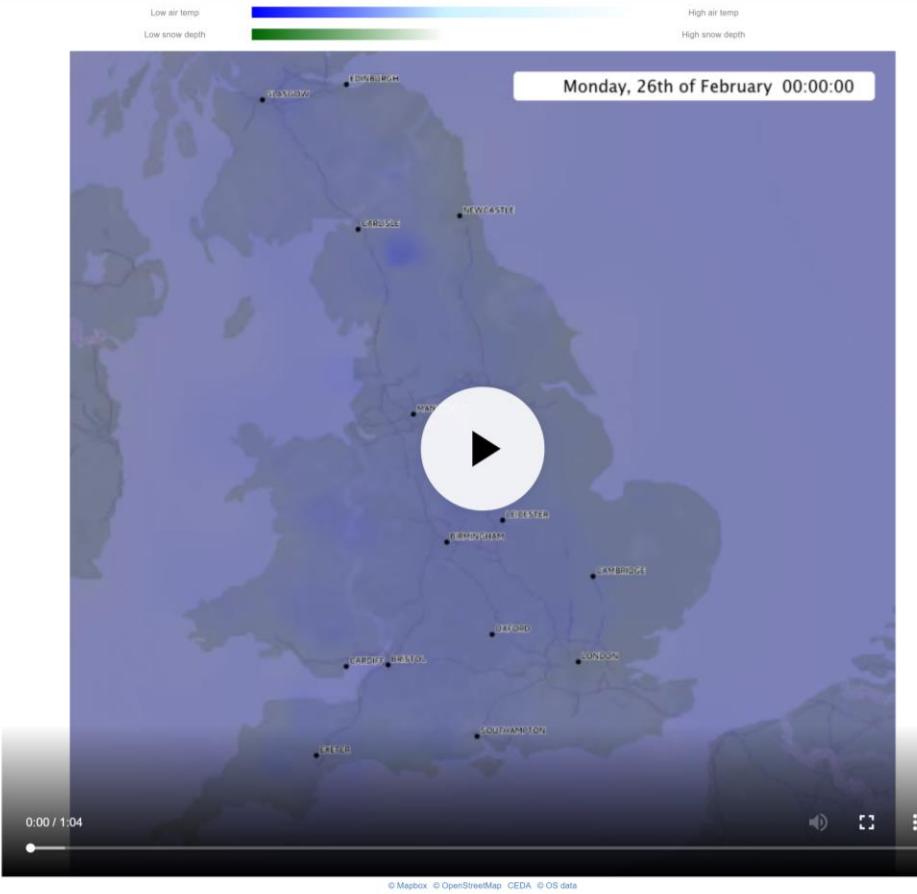
Example Group Projects From Previous Years

2017-2018: The Pulse of the City



Air Temperature

Temperature Change in UK Cities (°C)



Tuesday 10h 20m

Dynamic TimeScale: 25

II

Journey by Disabled Freedom Pass holders
on the London Underground network



 @emergentcity

Gareth Simons, Katerina Alexiou, Stelios Tsaparas

<https://vimeo.com/96998519>

Project Theme 2026- Urban Analytics

This year's group project theme is “Urban Analytics”, and it's your task find an interpretation of that theme, and create a coherent visualisation project which communicates your group's vision. Use data and/or models to explore and visualise spatial patterns and processes that relate to Urban Analytics.

For example, your project could focus on visualising activities and interactions that provide Urban Analytics at different spatial scales e.g. communications, data, energy, environment, economy, culture... Your group could demonstrate Urban Analytics in a particular city or region. Or your group could consider how new technologies (e.g. AI, remote sensing) are influencing Urban Analytics, or how Urban Analytics is responding to policy requirements (e.g. sustainability/resilience).

Module Timetable

Week 1 - *Module Overview and Introduction to HTML*

Week 2 – *Interactive Mapping and Spatial Data: Mapbox and Leaflet*

Week 3 – *Interactive Charts and Statistical Visualisations*

Week 4 – *Advanced Interactive Mapping: 2.5D and Animation*

Week 5 - *Working with Online Data and APIs*

[Reading Week]

Week 6 – *Composite Indicators and Open Source Visualisation*

Week 7 – *3D Visualisation Introduction*

Week 8 – *Group Projects Overview and Discussion*

Week 9 – *Visualising Spatio-Temporal Data Introduction*

Week 10 – *Group Project Pitches*

Taught Sessions Typical Structure

9:00am: Live Lecture and Small Group Discussion (45mins)

10:00am: Practicals (around 60 minutes)

Software – Familiar and New Tools

Use existing skills with new tools. Learn how to integrate tools successfully, understand the capabilities, strengths and weaknesses of different approaches. New tools are for visualisation capabilities; add this to your data science (R/Python/GIS) workflows.

Web Technologies

Web tech is the glue that links the module together. JavaScript the main coding language used. Web tech free, open, allow sharing visualisations with large audiences online.

3D Software Tools

3D visualisation can be achieved with web technology or more specialized tools. Valerio will teach using JavaScript/AFrame. Unity is optional in this module.

You are Not Expected to Learn Everything!

Not expected to master every single tool. Rather understand capabilities, and how they can be integrated together. Develop your own areas of expertise; find complementary skills and share knowledge with your course mates.

Linking Spatial Visualisation Tools

Data Prep. & Analysis

Data Science Programming
Python, R

GIS, Spatial Databases
[QGIS](#), ArcGIS, PostGIS

Web Data Feeds
[GeoJSON](#),
XML

Visualisation

Online Mapping
JavaScript, Mapbox,
Leaflet, PMTiles.

Graphics Programming
JavaScript, D3,
[AFrame](#), Flourish.

3D Geometry
CityEngine, SketchUp,
Rhino3D, Blender,
3DSMax...

3D Game Platforms
Unity, Unreal,
Cinema4D.

Dissemination

Web Sites

Videos & Animations

**Apps- Mobile,
Desktop,
VR/AR.**

Linking Software Tools

The course provides workflows to transform spatial data into analyses and visualisations. Often this involves combining different types of software, e.g. GIS and web mapping; online data feeds & JavaScript; Mapbox & QGIS.

Shared Techniques & Skills

Some of the links across the module sessions are direct, such as the application of JavaScript and use of spatial data formats. Some links are conceptual, e.g. Object Oriented Programming, stylesheets.

Design and visualisation skills are relevant to all aspects of the course.

Introductory Digital Visualisation Discussion: Static and Interactive Visualisations

Visualisation Types and Medium

Lots of aspects to consider when developing a visualisation project. Approach guided by audience and output medium.

Some fundamental visualisation aspects to consider-

Interactive or Non-Interactive

Static or Dynamic

Scientific Content vs. General Audience

Aesthetics (e.g. Abstraction vs. Photorealism)

Immersion

**Live Data and Dynamics (e.g. Real time vs.
archived data)**

Interactivity and Dynamics

Fundamental decisions when creating a visualisation. Often driven by the output medium (e.g. book vs. website). Need to consider the audience; the nature of the research topic; and benefits/costs of developing interactivity.

'Static' here refers to whether visualisation is of a single moment in time, or dynamic change over time.

	Non-Interactive	Interactive
Static	Static Graphic	Comparative Static Interactive Graphic / Map
Dynamic	Movie / Presentation	Animated Interactive Graphic / Map / Model

Static Graphics

This module focusses on interactive visualisation, but static graphics are very important, and far more common than interactive visualisations.

Static graphics are quicker to create, huge range of tools can be used (GIS, Python/R, Illustrator/Photoshop). Can also create static graphics from interactive web tools (D3, Carto). Book graphics & posters can be very high quality, with higher resolution than screen graphics.

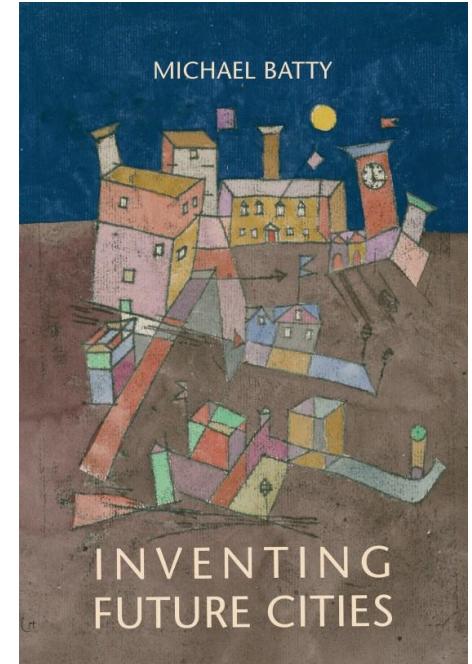
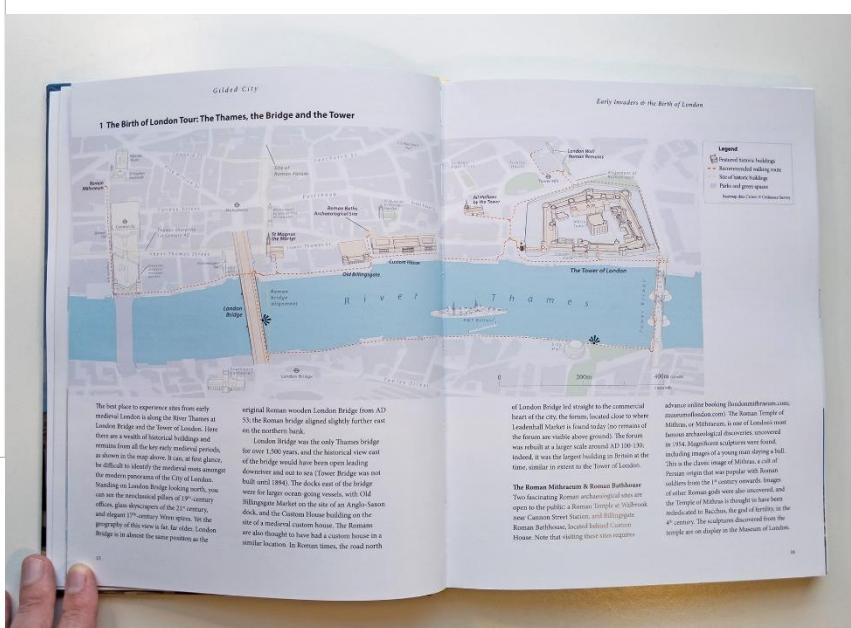
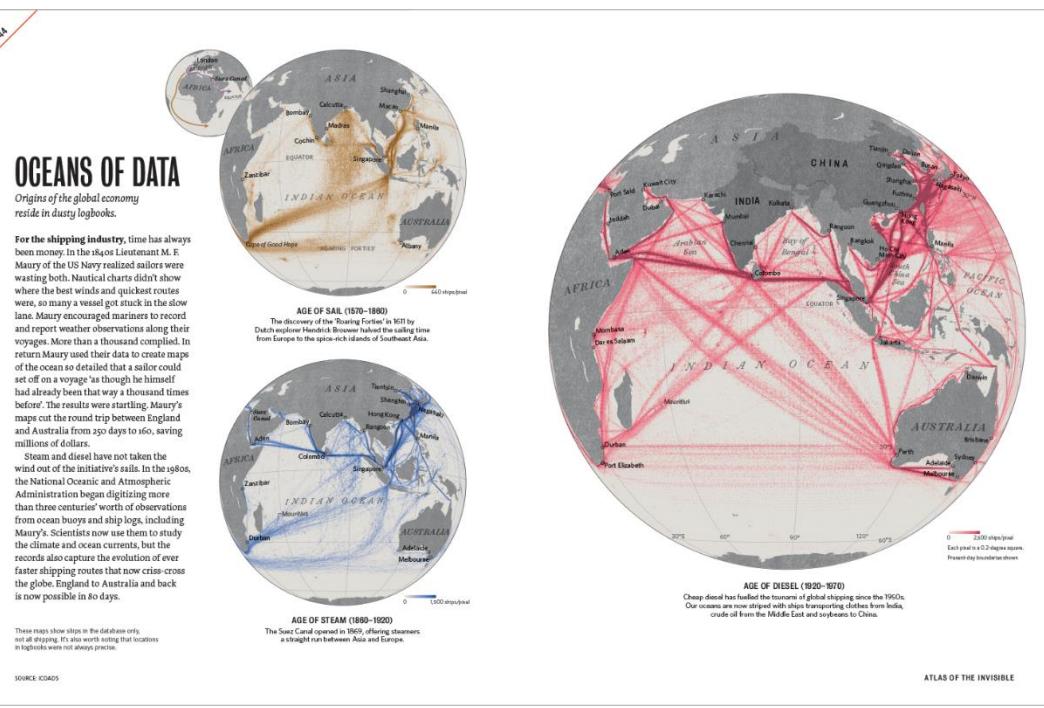
Static graphics very common for academic publications, including recent ‘featured graphics’ in academic journals.

Static Graphics- Books

Books opportunity for high quality static graphics-
Prof James Cheshire & Oli Uberti produced high quality spatial data vis books- London Information Capital, Atlas of the Invisible.

Prof Batty several books on Urban modelling- Inventing Future Cities, Science of Cities.

Mapping of historic London- Gilded City.

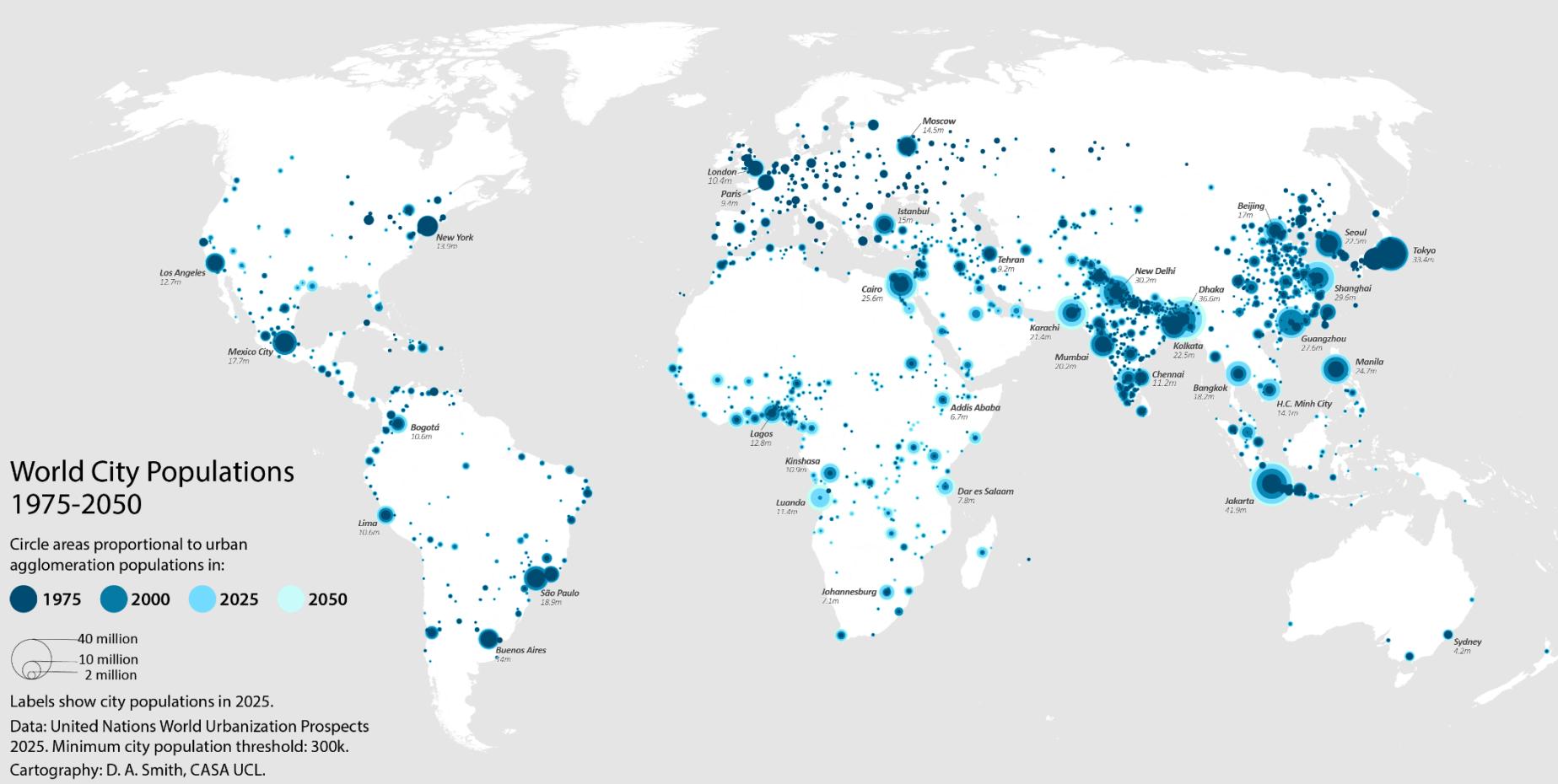


Static Graphics- Journal Features

Journals traditionally B&W graphics only, but increasingly colour, online and offering ‘Featured Graphics’ publications-

<https://citygeographics.org/2025/11/19/world-city-population-map-update-with-the-new-world-urbanization-prospects-2025/>

<https://citygeographics.org/2016/04/04/environment-planning-featured-graphic-world-city-populations-time-series-map/>



Movies and Animation

Add a timeline to static visualisations. Clear relevance for spatio-temporal animation.

Also great strengths for storytelling, guiding the viewer through a topic. Easy to understand and can have mass-media appeal (TV, documentaries etc.).

Movie format allows more advanced animation effects, such as transitions, particle effects, advanced 3D graphics.

Spatio-Temporal Animation: Transit

Old CASA project, but still good- Joan Serras, <https://vimeo.com/21351764>



Spatio-Temporal Animation in a Museum! Transport Museum Real Time Data Projection

Ed Manley, Richard Milton,
Kin Design



Ed Manley @edthink - 10 Nov 2015

Very proud to have built the new live data visualisation at [@ltmuseum](#) with the brilliant [@kindesign](#)



Animated Storytelling: London History

Polly Hudson, Flora Roumpani, Kiril Stanilov, English Heritage

<https://www.youtube.com/watch?v=NB5Oz9b84jM>



Interactive Mapping

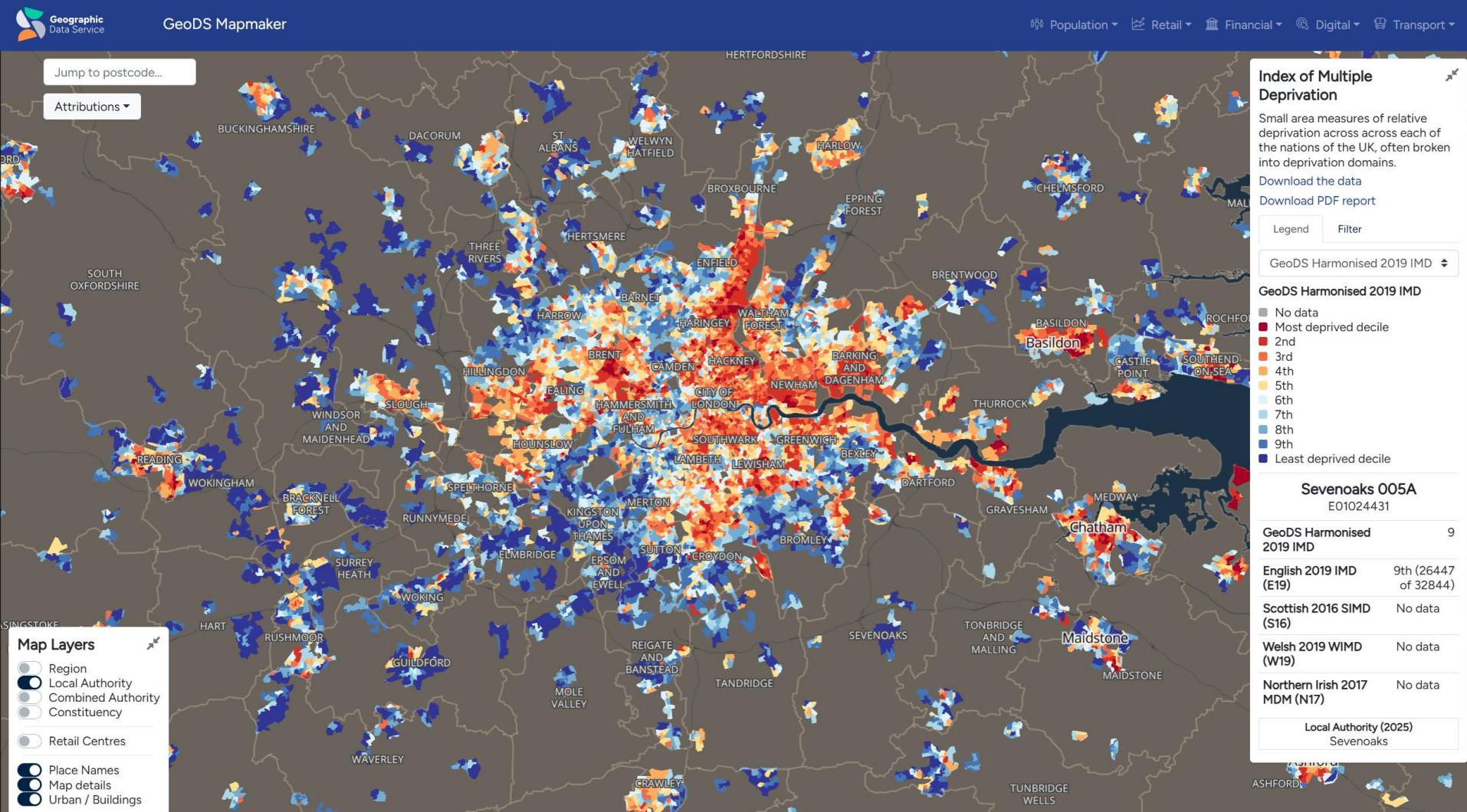
Previous examples do not allow the user to substantially change the visualization. Interactive maps allow users to change the cartography.

Most basic function: changing location and scale- user can zoom to points of interest. Can also add complementary descriptive statistics and spatial queries for each location (analytics).

More advanced interactive maps allow users to substantially change data being mapped and cartographic style. These tend to be exploratory data discovery applications.

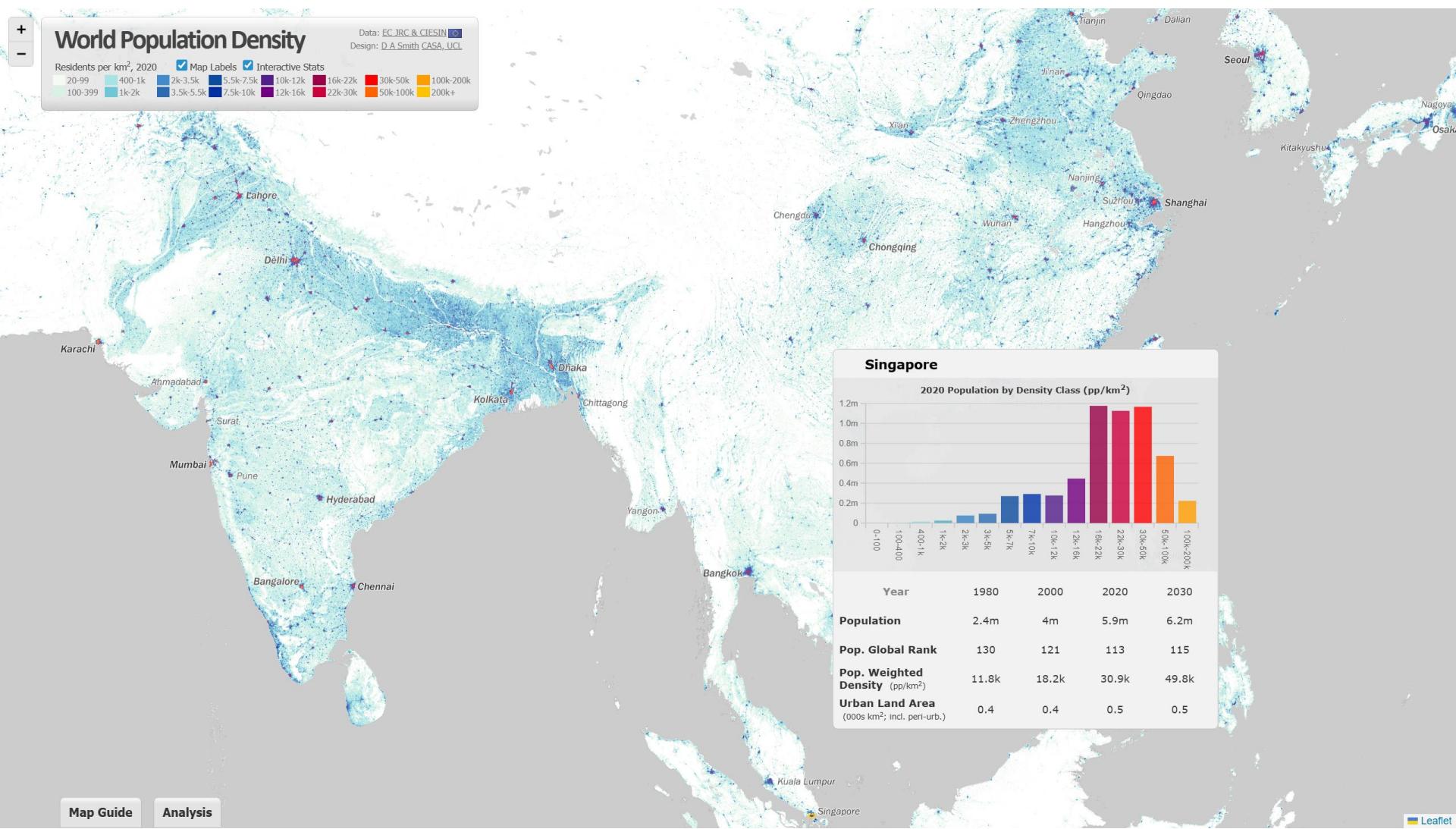
Exploratory Maps & Data Discovery: GeoDS

Based on design by Ollie O'Brien at UCL - <https://mapmaker.geods.ac.uk/>



Navigation and Stats: World Pop Density

Duncan Smith, <http://www.luminocity3d.org>



Animated Interactive Visualisation

Standard interactive maps largely ‘comparative static’: user switching between static visualisations. More advanced visualisations include animated effects and transitions whilst providing the user with sophisticated interactivity.

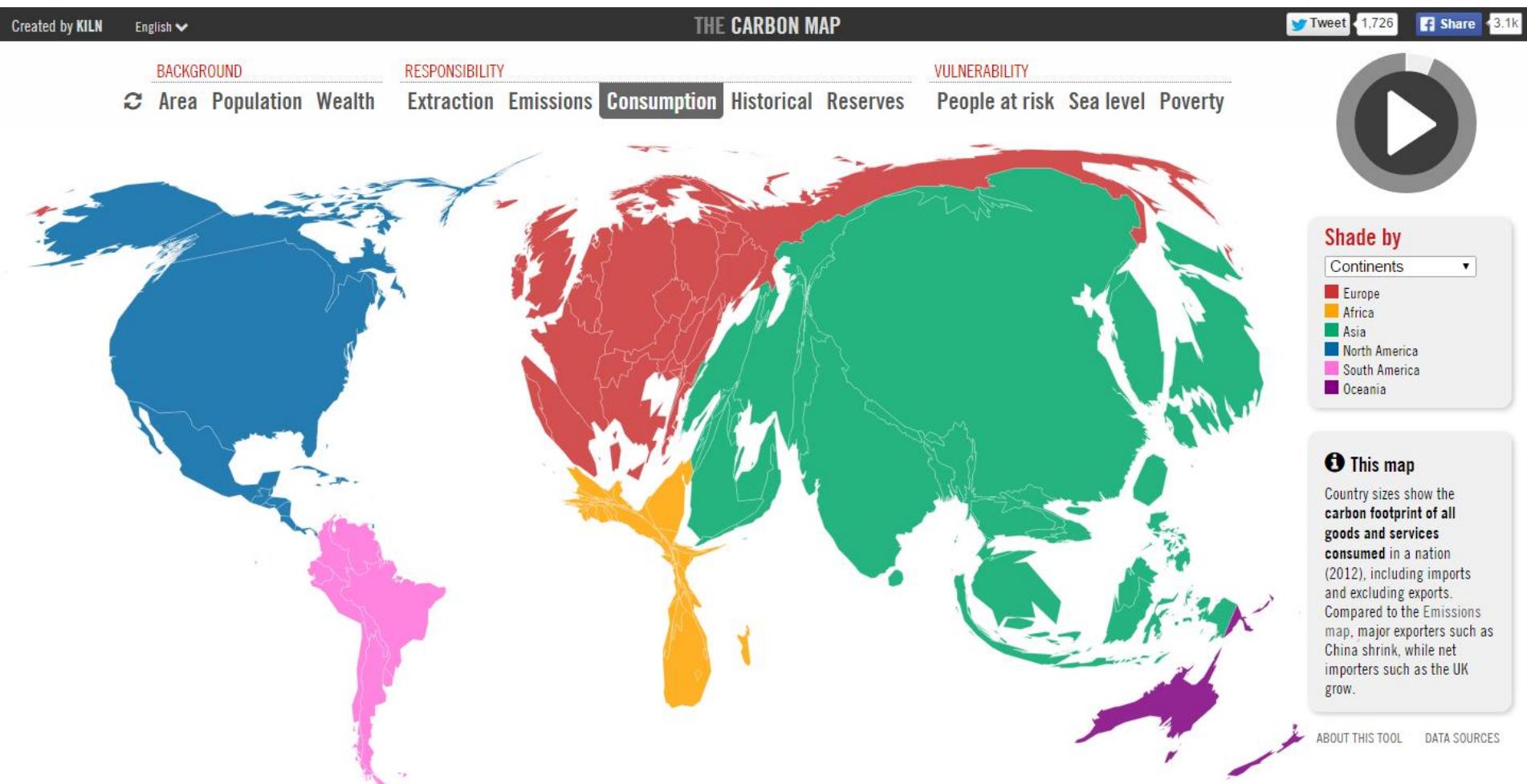
This type of graphic is still evolving, not many examples. WebGL is a good foundation for this approach, as it allows more advanced graphic effects within browsers.

Could argue this represents a largely superficial advance on standard interactive mapping. But particularly useful for spatio-temporal data and modelling.

Animated Transitions: The Carbon Map

Created by Data Design Company Kiln, Animated Cartogram- www.carbonmap.org

More recently Kiln working on Flourish data viz platform- <https://flourish.studio/>



Summary

Urban Data Viz module will develop your design, scientific and programming visualisation skills, both the practical and conceptual aspects.

Teaching and Workshops in Term 2, with Group Project Work.
Small individual assessment early in Term 2 (30%), then main group assessment submitted in April.

Using a range of software tools, linked through web technologies and programming languages, and shared design concepts.

Want to develop critical understanding of key visualisation characteristics: cartographic design, interactivity, animation, immersion...

Group Discussion

Going to think about static and interactive visualisations today.

Two different visualisations of the same dataset, UK journey to work flows. One static, one interactive.

Discuss-

- What kind of map is the visualisation? What is the map designed to show?
- What cartographic decisions have been made by the map designer?
- What are the advantages and disadvantages of the static print map?
- What are the advantages and disadvantages of the interactive online maps?

Static Print Map- London the Information Capital pp.42-43

James Cheshire & Oliver Ulberti, https://jcheshire.com/wp-content/uploads/2014/09/home_work_print.jpg

From Home to Work

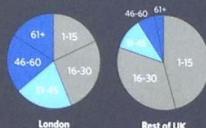
High-paying jobs draw workers from far, far away

In this depiction of daily commutes, London shines like the Sun in the constellation of Southern England. Like all stars, it has an immense gravitational pull. Whether by car, train or tube, thousands travel into the capital each day from all directions. Including this 'commuter belt' beyond the Greater London Authority boundary makes the capital one of the largest metropolitan areas in the EU with a population of more than 13 million.

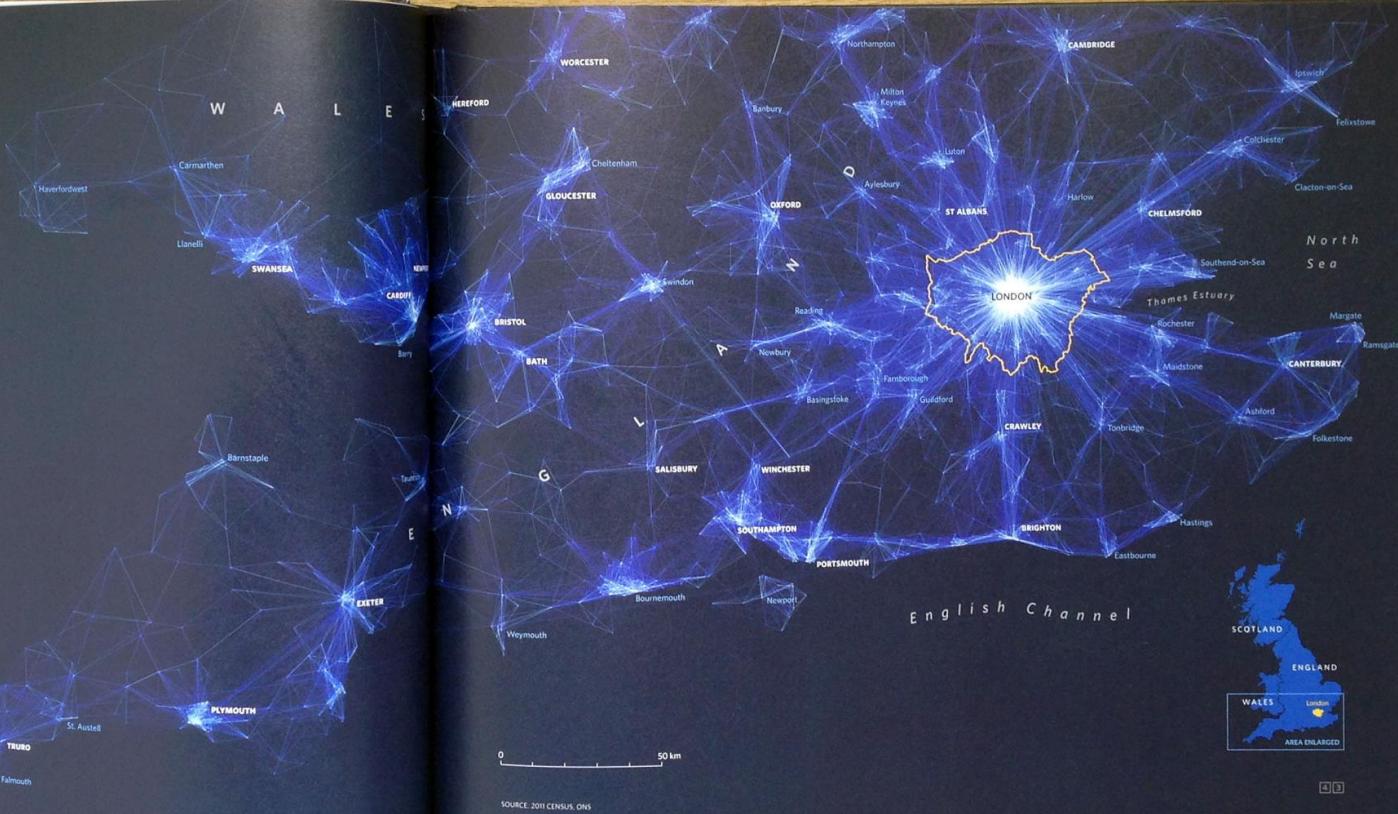
Half of London's workforce make their journey by public transport, compared with only 9% in the rest of the country. Still, most need thirty minutes or more to get to work. Elsewhere in the UK, only 20% have commutes that long. Why do so many live so far away?

For one, London salaries go further in satellite towns like Banbury. As of May 2014, a five-bedroom converted barn there was going for the price of two-bedroom flats along the Underground's Central Line (see pp. 66-7). It's only a matter of time before faster trains propel commuters into even wider orbits.

Commuting times in minutes by region of workplace
October-December 2009

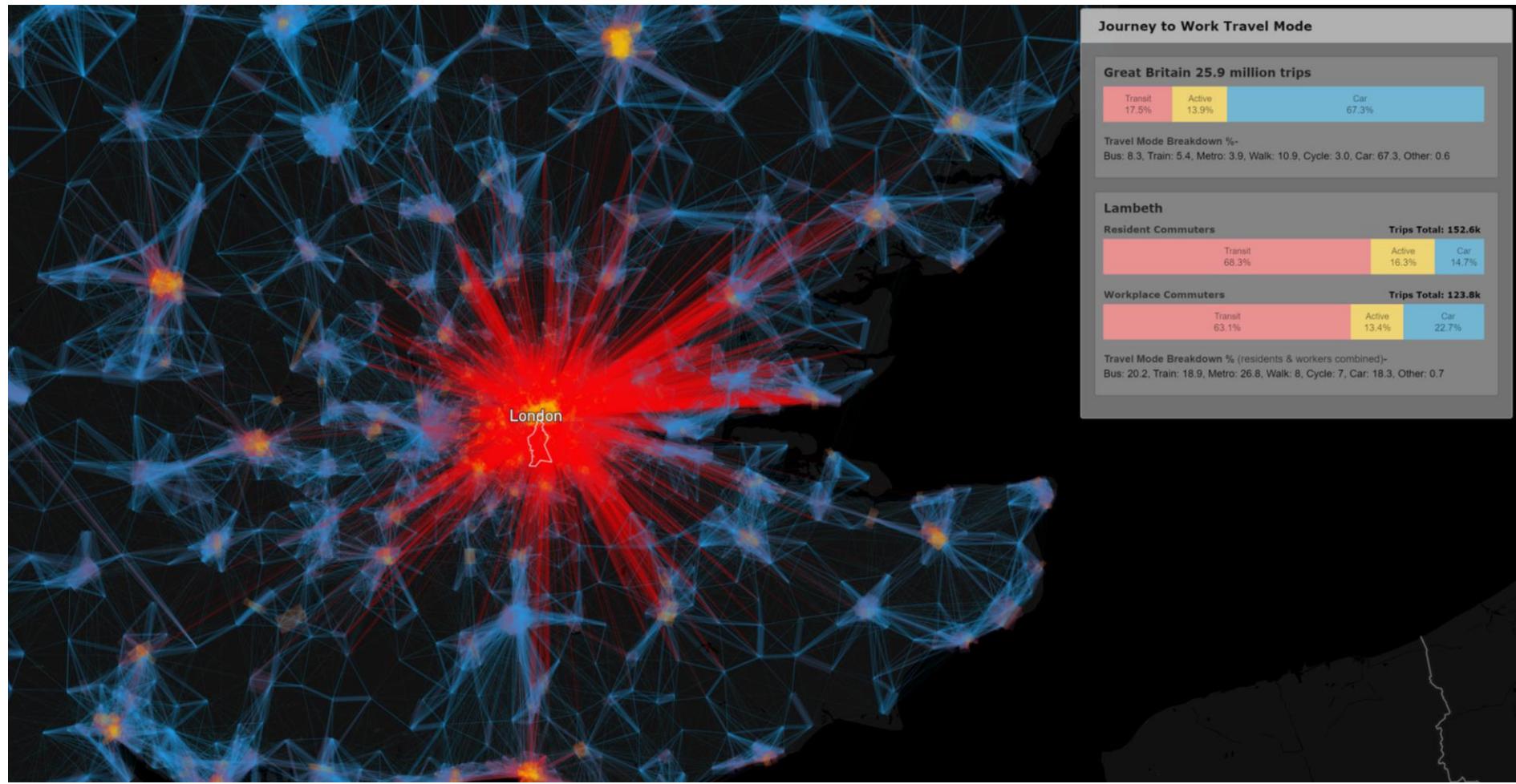


WHERE WE ARE



SOURCE: 2011 CENSUS, ONS

Interactive Map- <http://luminocity3d.org/flows/>



ONS Flow Data Exploratory Tool-

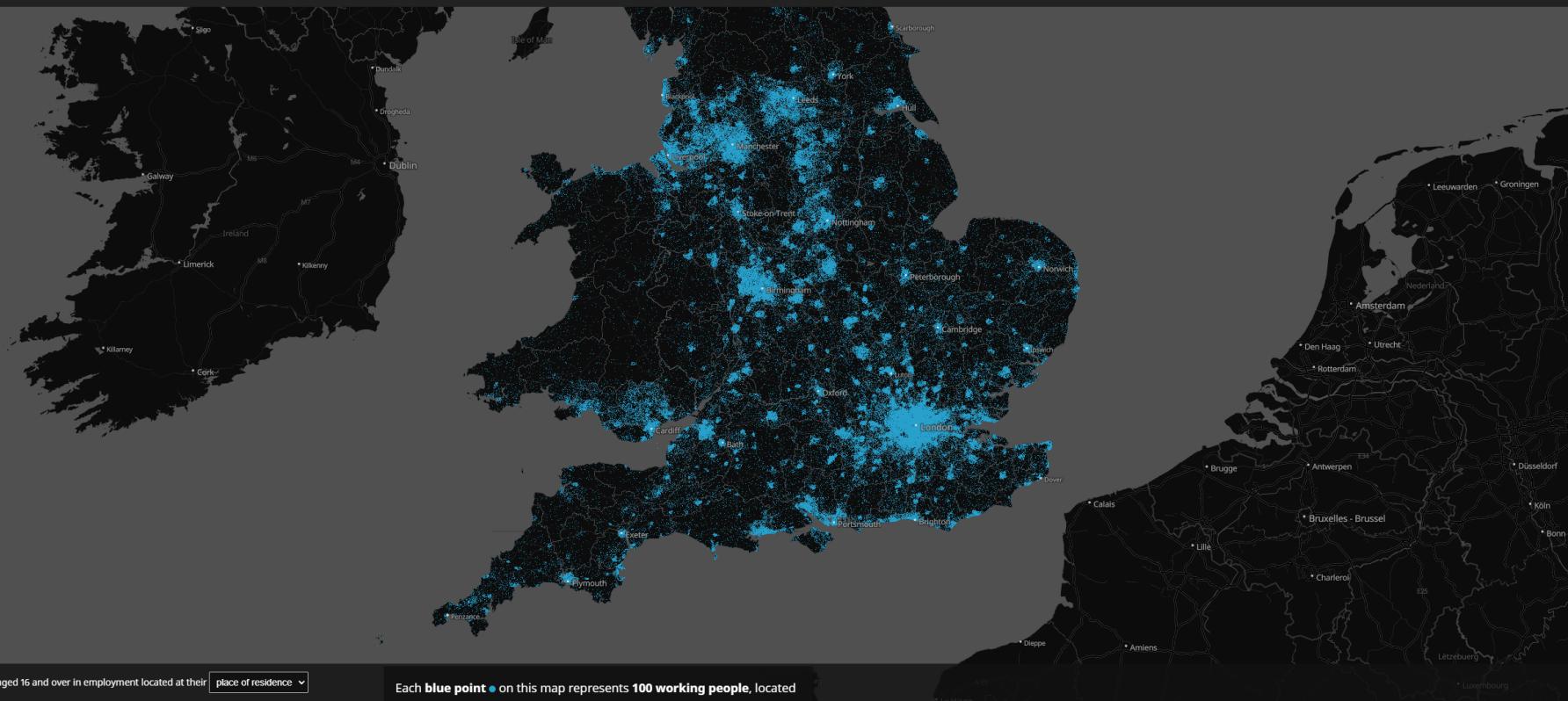
<https://www.ons.gov.uk/visualisations/censusorigindestination/>

Workplace flow data

There were 27.8 million usual residents aged 16 and over in England and Wales who were working in the week before the census. This map gives a representation of where they lived and where they worked.

Lockdown restrictions and the furlough scheme that was in place in March 2021 had a significant impact on travel to work data. As such, **the data are not reflective of current commuting patterns.**

Read our [travel to work quality information for Census 2021](#).



10 Minute Discussion...

Reading Materials on Interactivity

Overview of Interactive Mapping-

Online interactive thematic mapping: Applications and techniques for socio-economic research

<https://www.sciencedirect.com/science/article/pii/S0198971516300023>

Blogpost on challenges of interactive visualisations-

The Death of Interactive Graphics?

<https://medium.com/@dominikus/the-end-of-interactive-visualizations-52c585dcafcb>

Course Reading List

Many materials we will use are online in the form of tutorials and resources. These are provided in the specific sessions.

Also useful to read some more general references on data visualisation, design and cartography-

<http://readinglists.ucl.ac.uk/modules/casa0003.html>

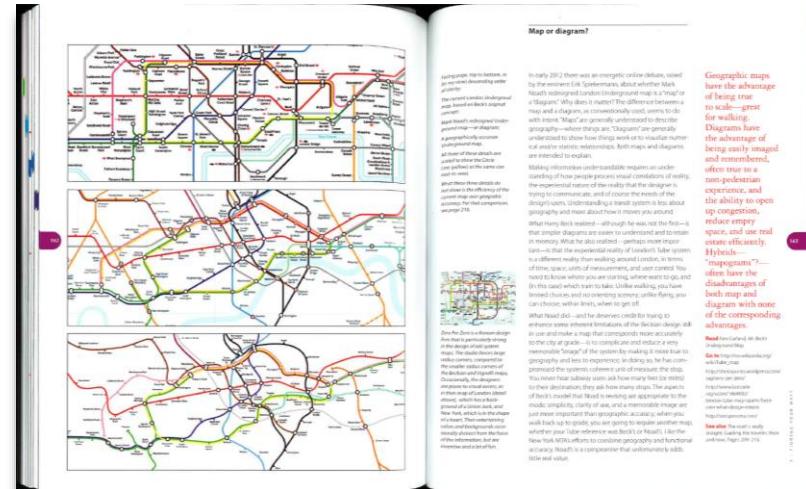
Introductory Reading on Cartography

Katz, J., 2012. Designing Information:
Human Factors and Common Sense in
Information Design

Krygier and Wood, Making maps: a visual
guide to map design for GIS

Alberto Cairo, The Truthful Art

(these books are all online via-
<http://readinglists.ucl.ac.uk/modules/casa0003.html>)



Practical on HTML & JavaScript

We will work through the practical in class. You can also use the PDF file and/or video resources on Moodle.

Practical is Introduction to HTML and JavaScript, core tools of web design and web visualisation

You will need an HTML editor to complete the practical.

Visual Studio Code recommended-

<https://code.visualstudio.com/>

Please ask questions here or on Slack Forum