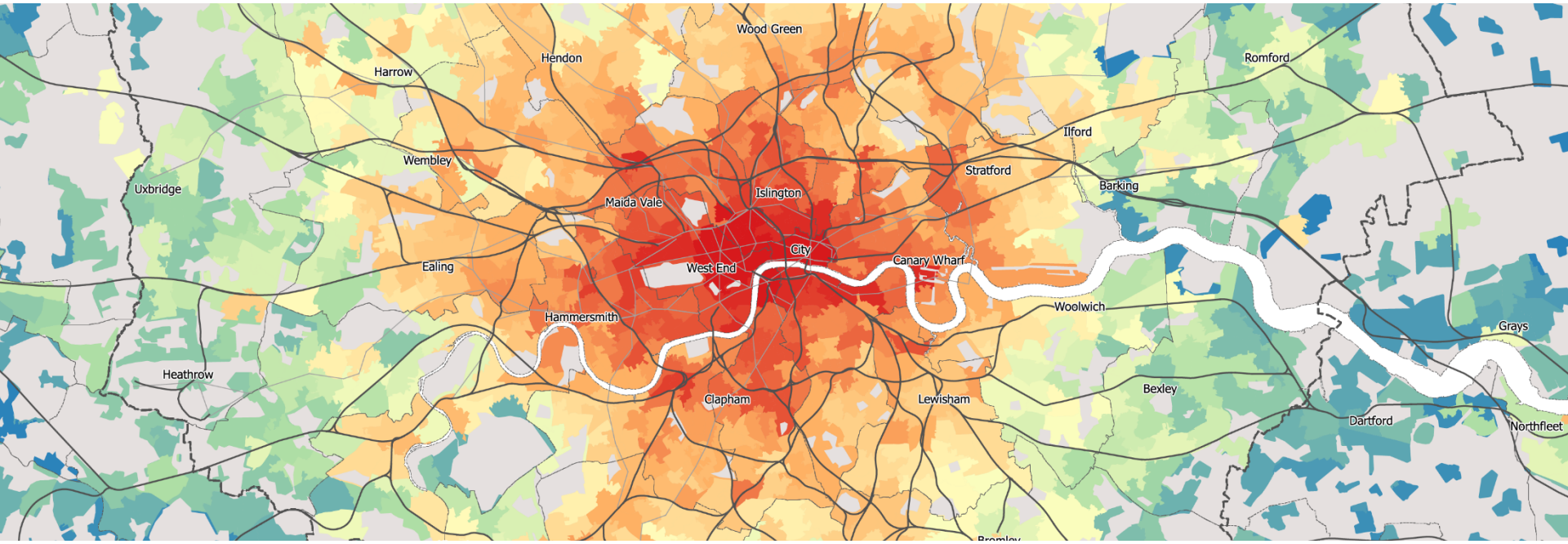
RGS-IBG 2016

Open Source Global Urban Modelling: an Example of Public Transport Accessibility



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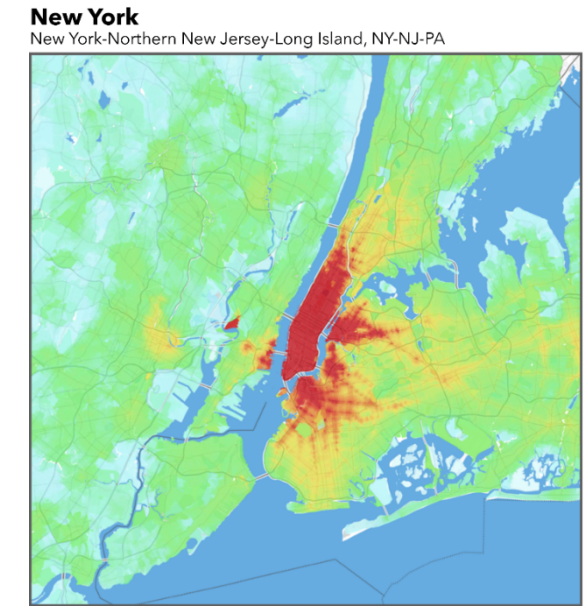
Overview

Argue for Open Data, Open Source Approach to Geocomputation
Increasingly powerful and flexible methods. Many technical challenges now overcome. Tensions with corporate big data.

Example of Urban Transport Accessibility
Investigates efficiency, sustainability and equity of city transport systems. Now possible to model many cities around the world for comparative analysis.

Future Challenges and Opportunities
Great potential for understanding urban processes at global scale, but data challenges. Open approach facilitates sharing best practice.



Open Source, Open Data

Wide Range of Powerful and Flexible Tools Available
Languages, libraries, databases, GIS, collaborative code repositories…

Transparent, reproducible?
Cleary Open Science agenda much more comprehensive than open source, but can help.

Sharing Code, Models, Results
Can change how software built. Facilitate connections between academia, government, businesses, publics.

Global Urban Open Data
Increasingly global comparative studies possible. Opportunity for testing models in international contexts.

Challenges- data ownership, attribution, Global North bias, code as research outputs, privacy…

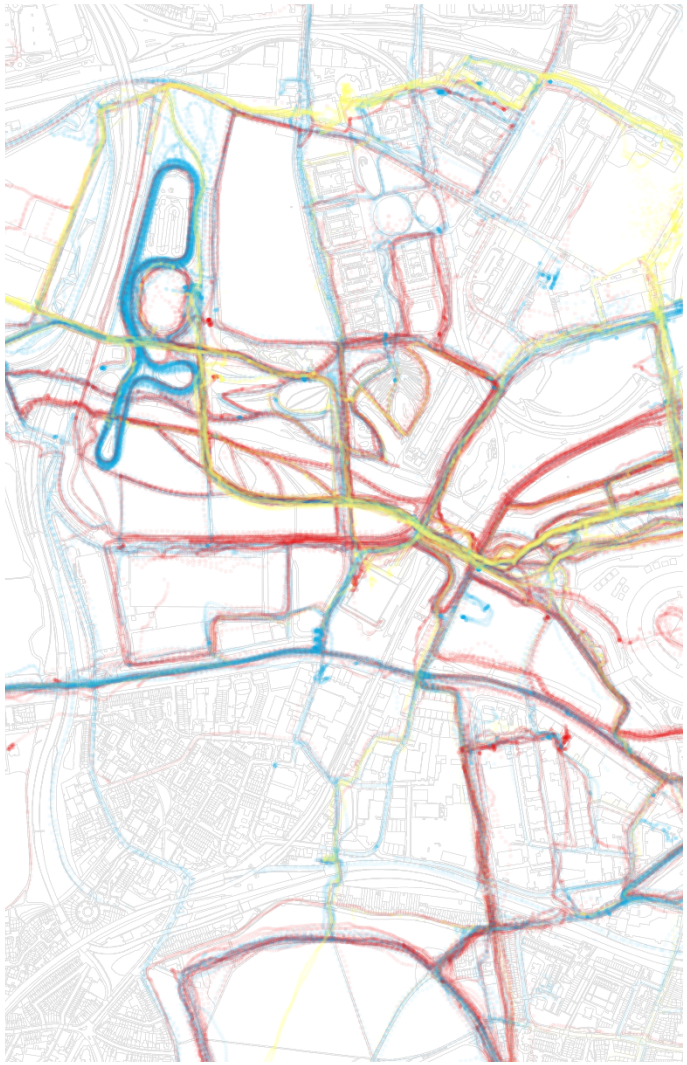
Opportunities & Tensions with Big Data

Explosion of Spatio-Temporal Data & Computational Research
Tech companies driving amazing innovation in trajectory data and computation, new fields emerging. Creating new global data standards as companies expand into new markets.

Data Restrictions Part of Tech Business Model
New frontier in public/private ownership. Partnerships with academia/gov possible, but often conflicts with open data approach.

Transport Data Examples
Public transport Service and flow data provided by public agencies (TfL, DfT). New tech companies like Uber and Strava protecting data (ditto mobile operators). Ongoing challenge given rapid expansion.

Some companies also creating open standards. GTFS created by Google interesting example.



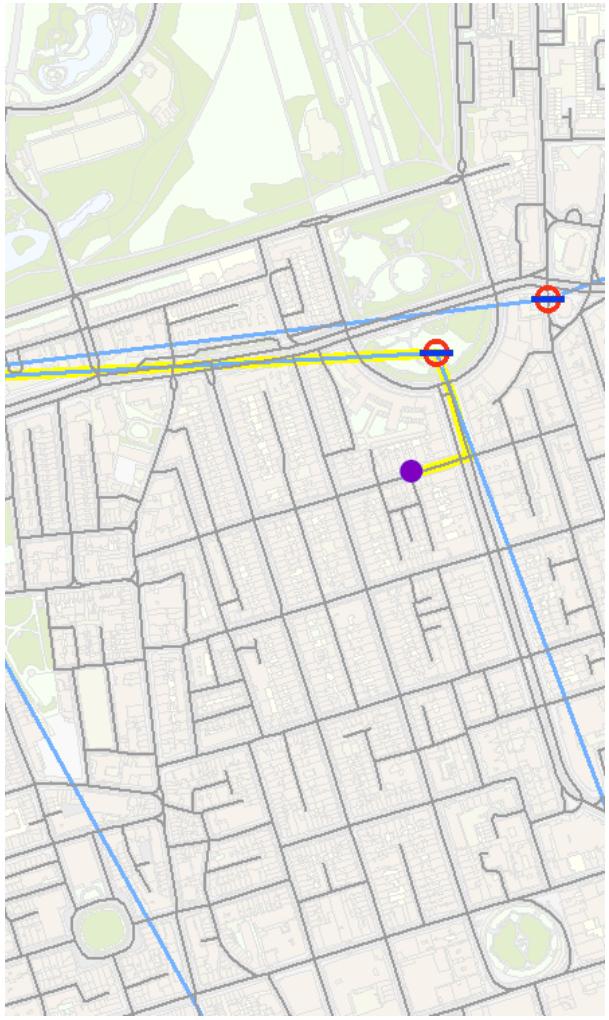
Example of Urban Accessibility Modelling

Transport Efficiency, Equity and Sustainability
Accessibility modelling measures ease of access to opportunities of populations by particular modes of transport, taking into account geography of origins, destinations and transport services.

Can be disaggregated by transport mode, time and by socio-economic groups. Much simpler than comprehensive transport model, but faster, less data hungry and easier to communicate.

Applications
Input to any spatial model that needs accurate travel times: housing, migration, retail….

Or applied directly to study equity of (public) transport systems, changes from new infrastructure, comparison of public and private accessibility.

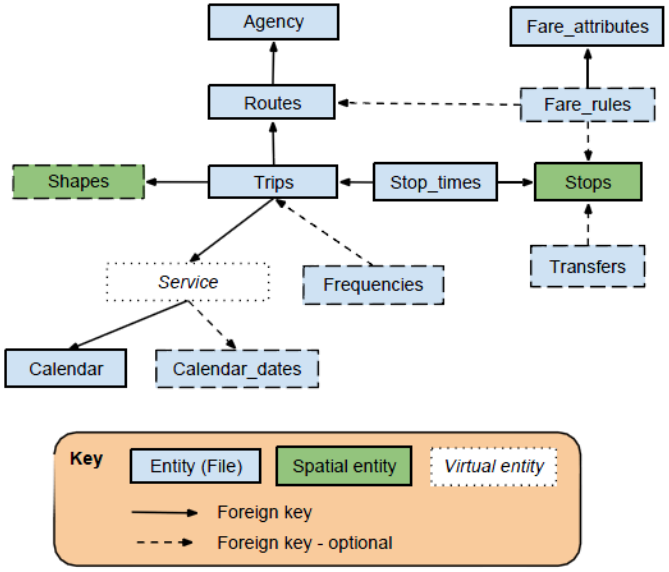


Open Source Public Transport Data

Challenges with Calculating PT Accessibility
Road network travel times easier to calculate (more accurate with GPS speeds). Public transport more difficult- service variation, multimodal, interchanges, fares. Often greatly simplified in urban models.

Public Transport Data Improvements
Online journey planners in EU & US stimulus for standardised PT data. General Transit Feed Specification (GTFS) from Google adapted from Portland transit authority timetable data in 2006. De facto US standard, now increasingly global.

Pedestrian street network topography also essential. For open data global modelling, OpenStreetMap very useful.



Open Source PT Accessibility: Open Trip Planner
Combination of GTFS and OSM clear opportunity for open source approach to PT modelling. Several projects, OpenTripPlanner largest, led by developers from Portland TriMet authority. Can be used as journey planner but also crucially for analytical modelling.

OpenTripPlanner

Network Analysis and Scalability

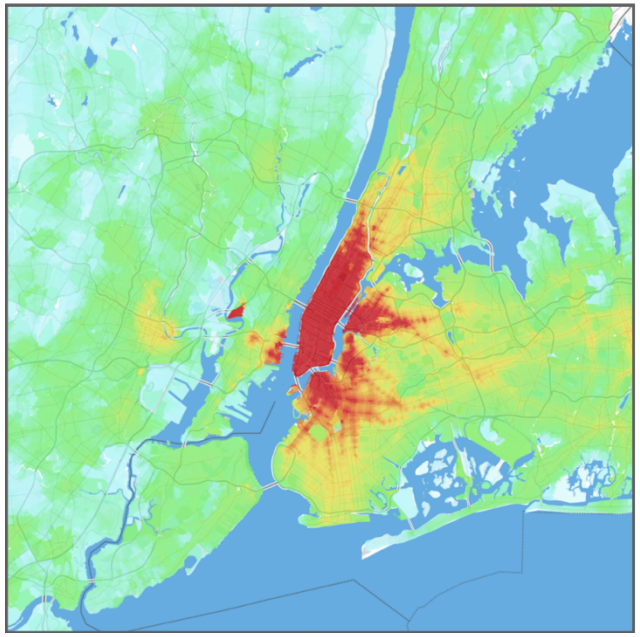
Calculating Millions of Trips
Accessibility modelling calculating the full matrix of journeys. For example London region at MSOA level, 2000 zones, 4 million trips. Model speed crucial.

Need to Use Efficient Algorithms
OTP utilising recent research in transport algorithms: multi-objective Pareto shortest paths (Müller-Hannemann and Schnee, 2007; Perny and Spanjaard, 2009)- see
http://docs.opentripplanner.org/en/latest/Bibliography/

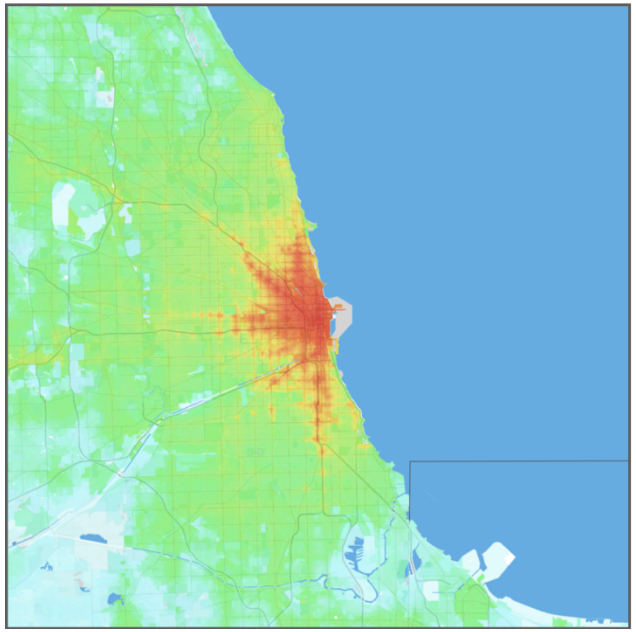
Good performance. Typical city calculate PT matrix in a couple of hours. London more like 10 hours due to size and complexity of PT network. Parallel computing methods very relevant here.

Comparative Urban Analysis Possible
Run model for many cities and modes, comparative urban analysis. Most advanced current example from Accessibility Observatory at University of Minnesota. Access Across America included 46 US cities, transit, car and walking-
http://ao.umn.edu/research/america/index.html

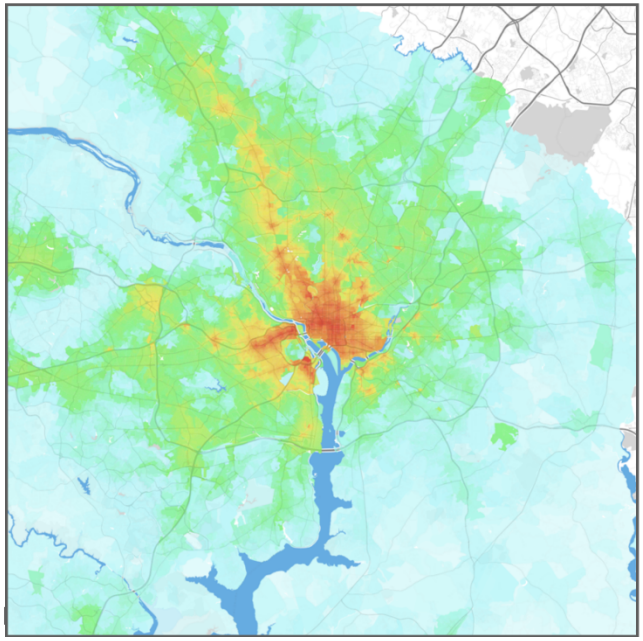
New York
New York-Northern New Jersey-Long Island, NY-NJ-PA



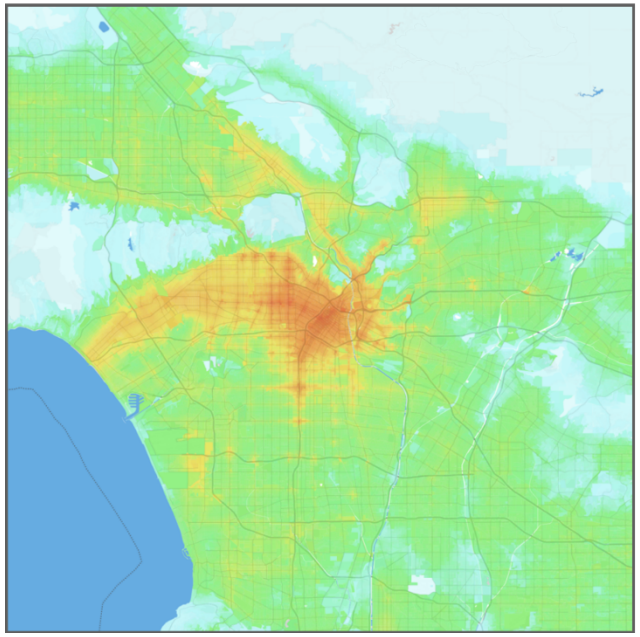
Chicago
Chicago-Joliet-Naperville, IL-IN-WI



Washington
Washington-Arlington-Alexandria, DC-VA-MD-WV



Los Angeles
Los Angeles-Long Beach-Santa Ana, CA



Jobs within 30 minutes
by transit, averaged 7 – 9 AM

- 0 – 1,000
- 1,000 – 2,500
- 2,500 – 5,000
- 5,000 – 7,500
- 7,500 – 10,000
- 10,000 – 25,000
- 25,000 – 50,000
- 50,000 – 75,000
- 75,000 – 100,000
- 100,000 – 250,000
- 250,000 – 500,000
- 500,000 – 750,000
- 750,000 – 1,000,000
- 1,000,000 +

Access Across America,
University of Minnesota-
http://ao.umn.edu/research/america/index.html

Modelling Temporal Variation

Key Issue in Accessibility Research

Hourly variations between peak, off-peak, night; and weekly between weekday and weekend. Timetable data contains this temporal variation. Also real-time data possibilities: special events / disruptions. Lots of work in this area using smart card data; scalability challenges.

Incorporation into Accessibility Models

Most advanced accessibility models including techniques for capturing temporal variation (profile routing, continuous accessibility).

OpenTripPlanner currently requires multiple model runs for each time period. Improved functionality being developed for future versions.

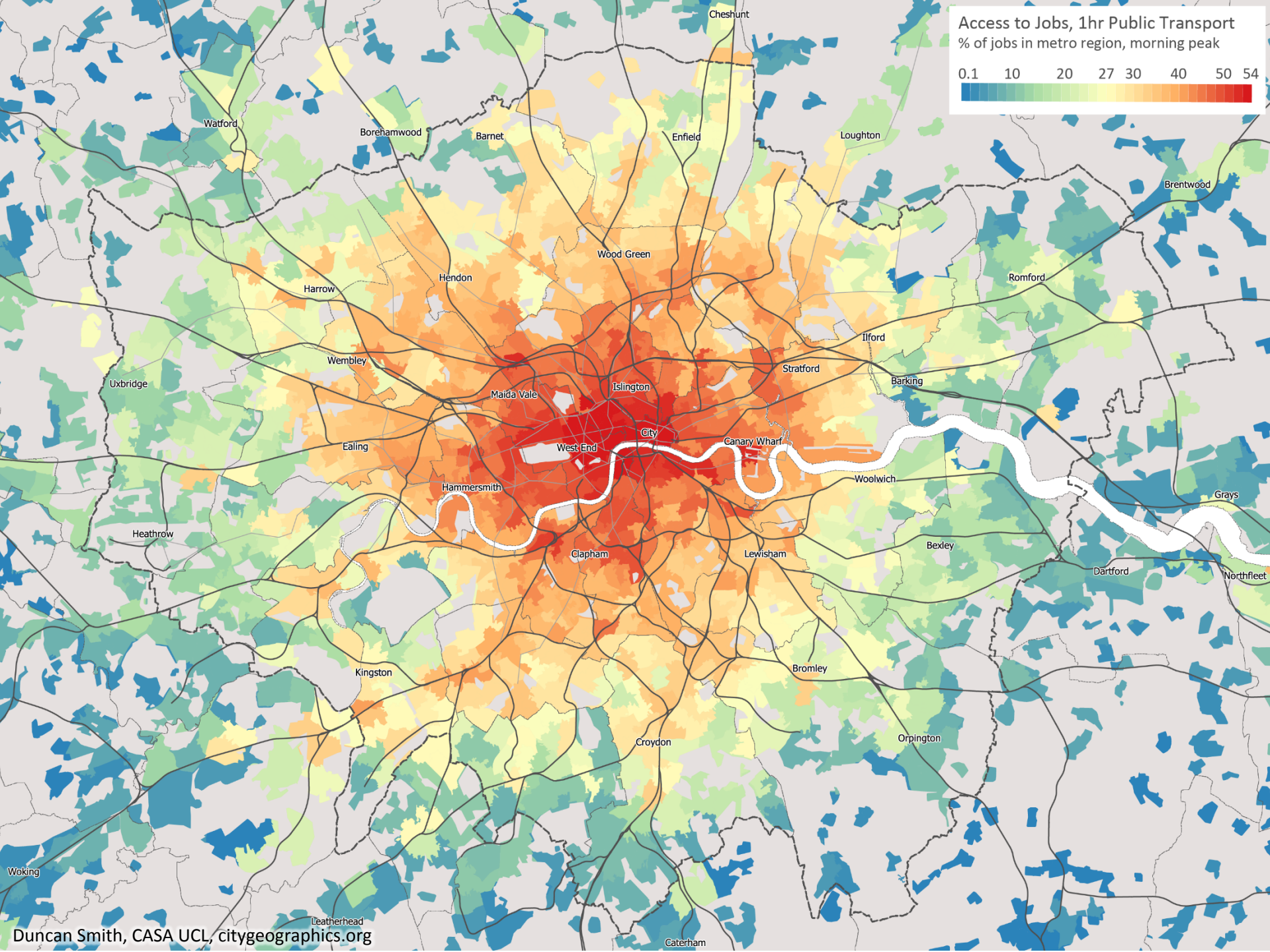
Testing Approach for London: RESOLUTION Project

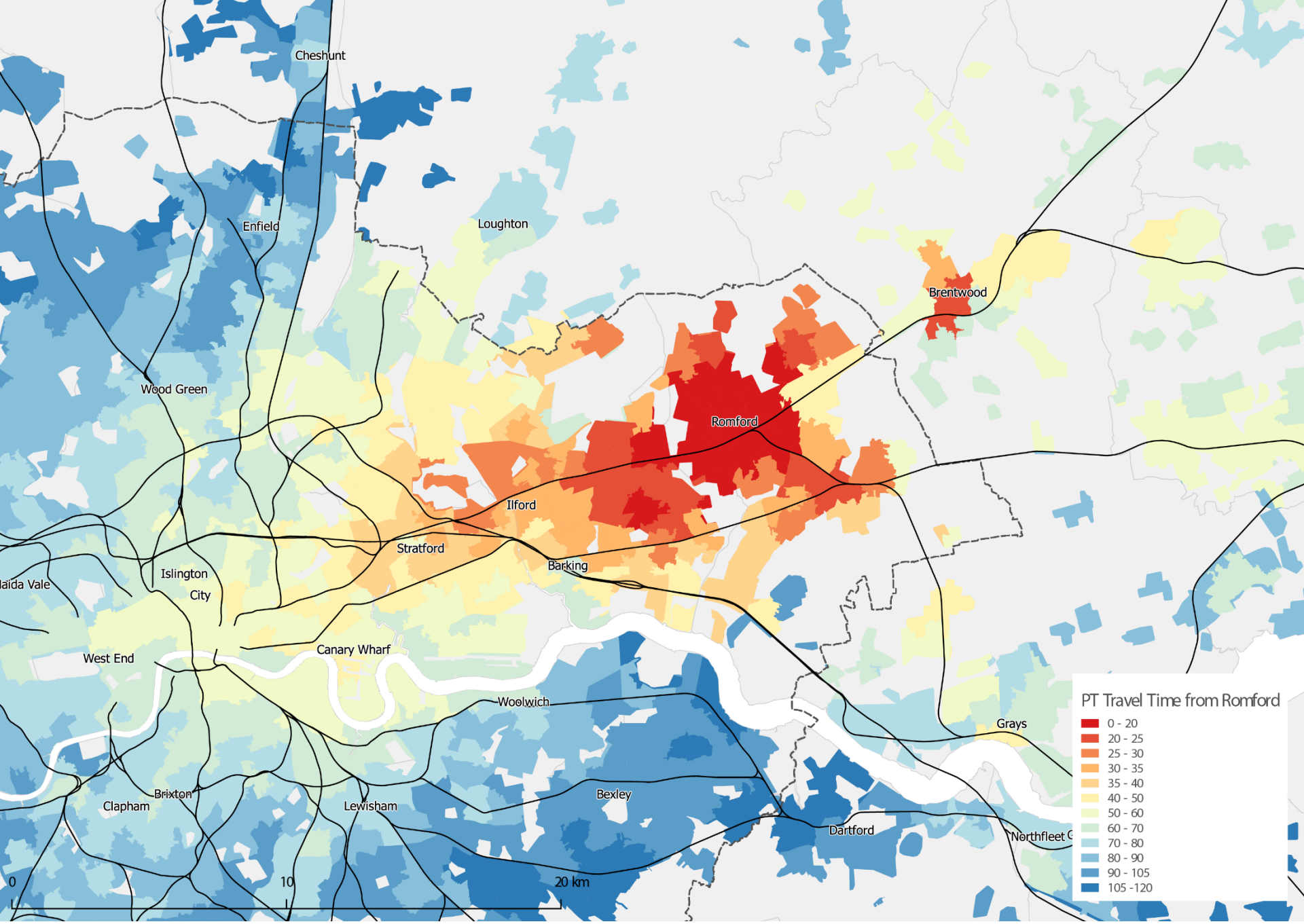
RESOLUTION: REsilient Systems for Land Use TransportatION

ESRC grant looking at accessibility in relation to housing, segregation and equity. International comparison of London and Sao Paulo-
http://www.urbantransformations.ox.ac.uk/project/resolution-resilient-systems-for-land-use-transportation/

Flexible and Reproducible Modelling Approach

Want regional model, flexible for different scenarios. Include further cities in the future. Test OpenTripPlanner for London…


Access to Jobs, 1hr Public Transport
% of jobs in metro region, morning peak
0.1 10 20 27 30 40 50 54
Cheshunt
Watford
Borehamwood
Barnet
Enfield
Loughton
Brentwood
Wood Green
Hendon
Harrow
Romford
Ilford
Wembley
Stratford
Uxbridge
Barking
Islington
Maida Vale
City
Canary Wharf
Ealing
West End
Woolwich
Hammersmith
Grays
Heathrow
Clapham
Lewisham
Bexley
Dartford
Northfleet
Kingston
Bromley
Croydon
Orpington
Woking
Leatherhead
Caterham
Duncan Smith, CASA UCL, citygeographics.org



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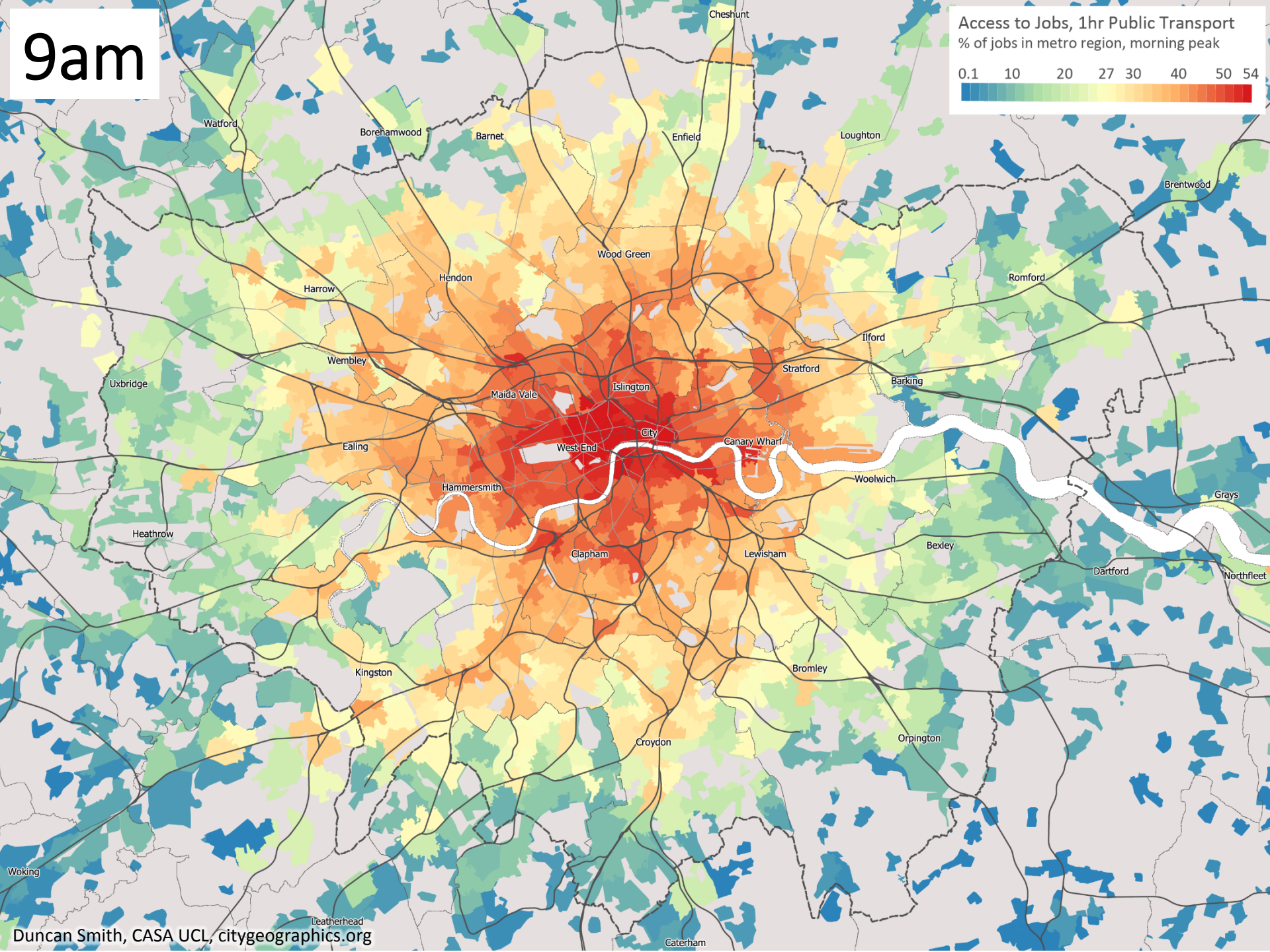
9am
Access to Jobs, 1hr Public Transport
% of jobs in metro region, morning peak
0.1 10 20 27 30 40 50 54
Cheshunt
Watford
Borehamwood
Barnet
Enfield
Loughton
Brentwood
Wood Green
Hendon
Harrow
Romford
Ilford
Wembley
Stratford
Uxbridge
Barking
Islington
Maida Vale
City
Canary Wharf
Ealing
West End
Woolwich
Hammersmith
Grays
Heathrow
Clapham
Lewisham
Bexley
Dartford
Northfleet
Kingston
Bromley
Croydon
Orpington
Woking
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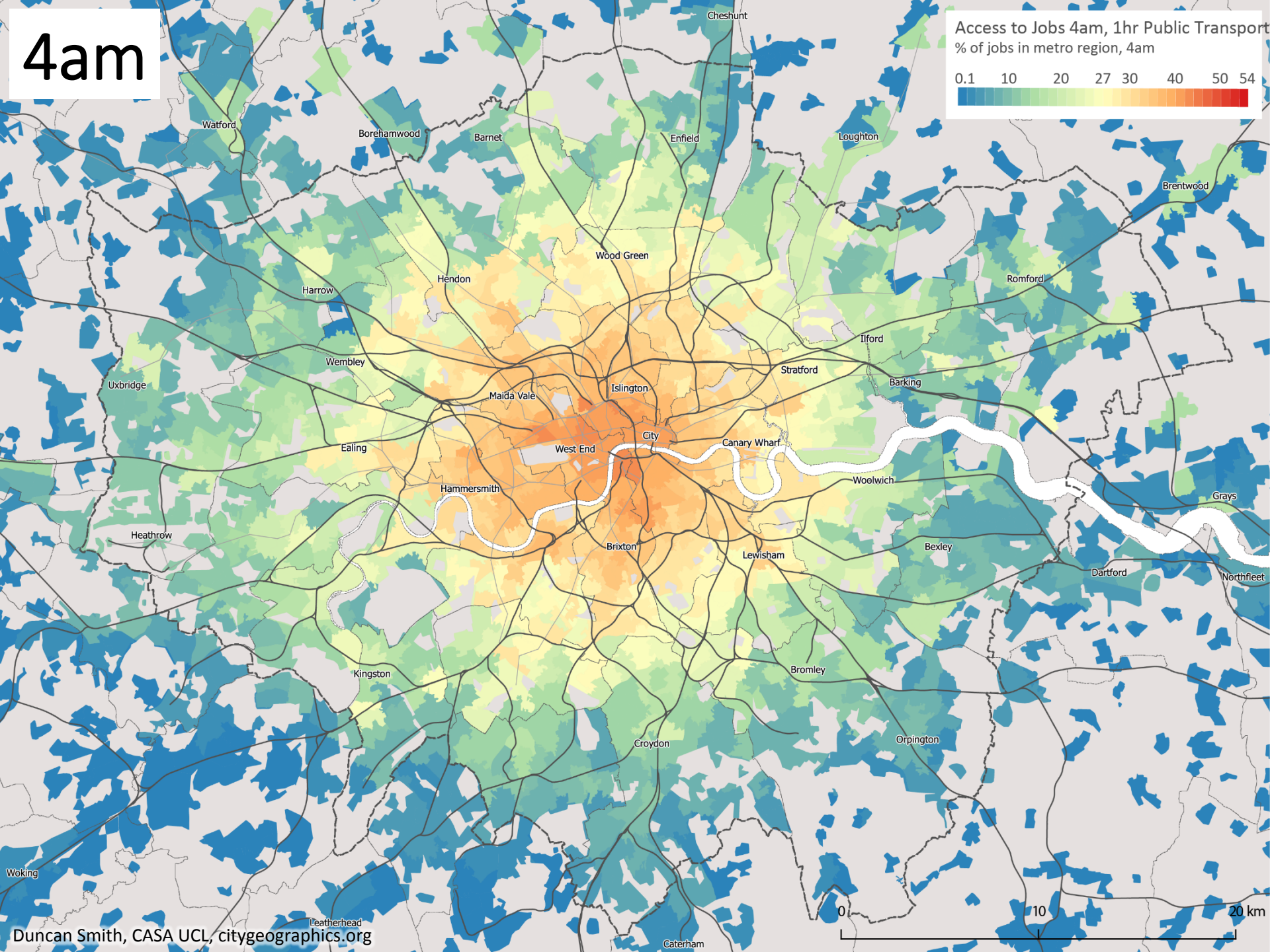
4am
Access to Jobs 4am, 1hr Public Transport
% of jobs in metro region, 4am
0.1 10 20 27 30 40 50 54
Cheshunt
Watford
Borehamwood
Barnet
Enfield
Loughton
Brentwood
Wood Green
Hendon
Harrow
Romford
Ilford
Wembley
Stratford
Uxbridge
Barking
Islington
Maida Vale
City
Canary Wharf
Ealing
West End
Woolwich
Hammersmith
Grays
Heathrow
Brixton
Bexley
Lewisham
Dartford
Northfleet
Kingston
Bromley
Croydon
Orpington
Woking
Caterham
0
10
20 km
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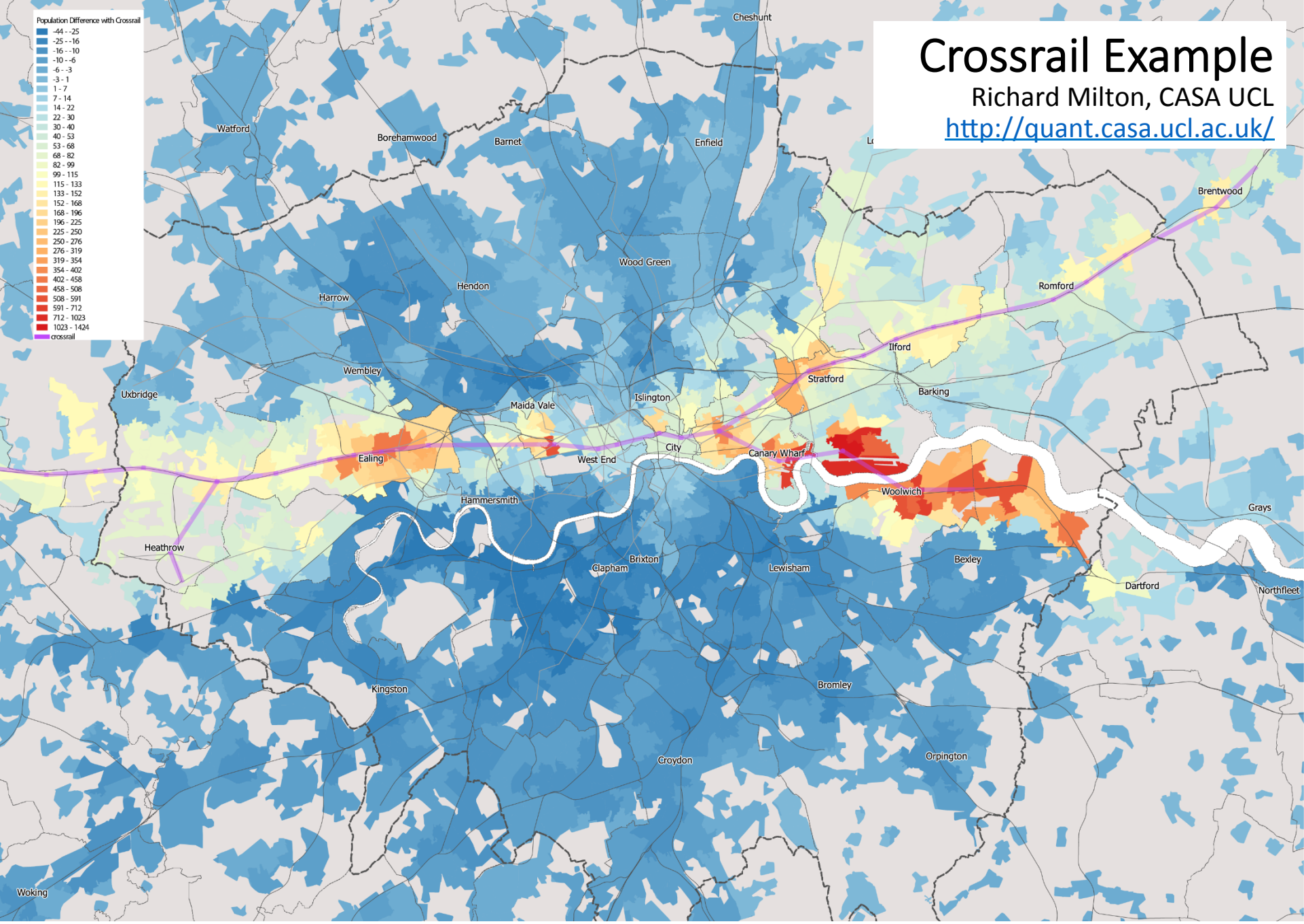


Crossrail Example

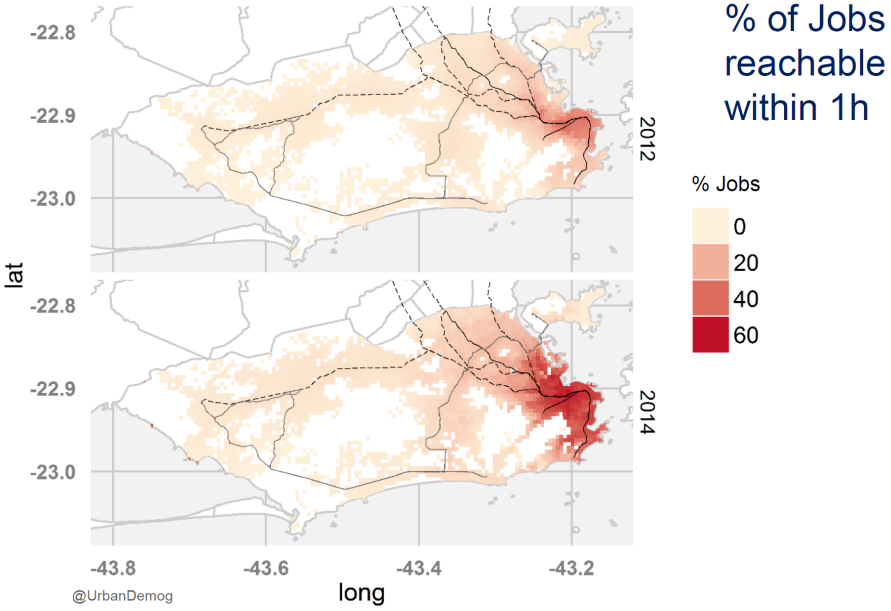
Richard Milton, CASA UCL
http://quant.casa.ucl.ac.uk/

Brazilian Example

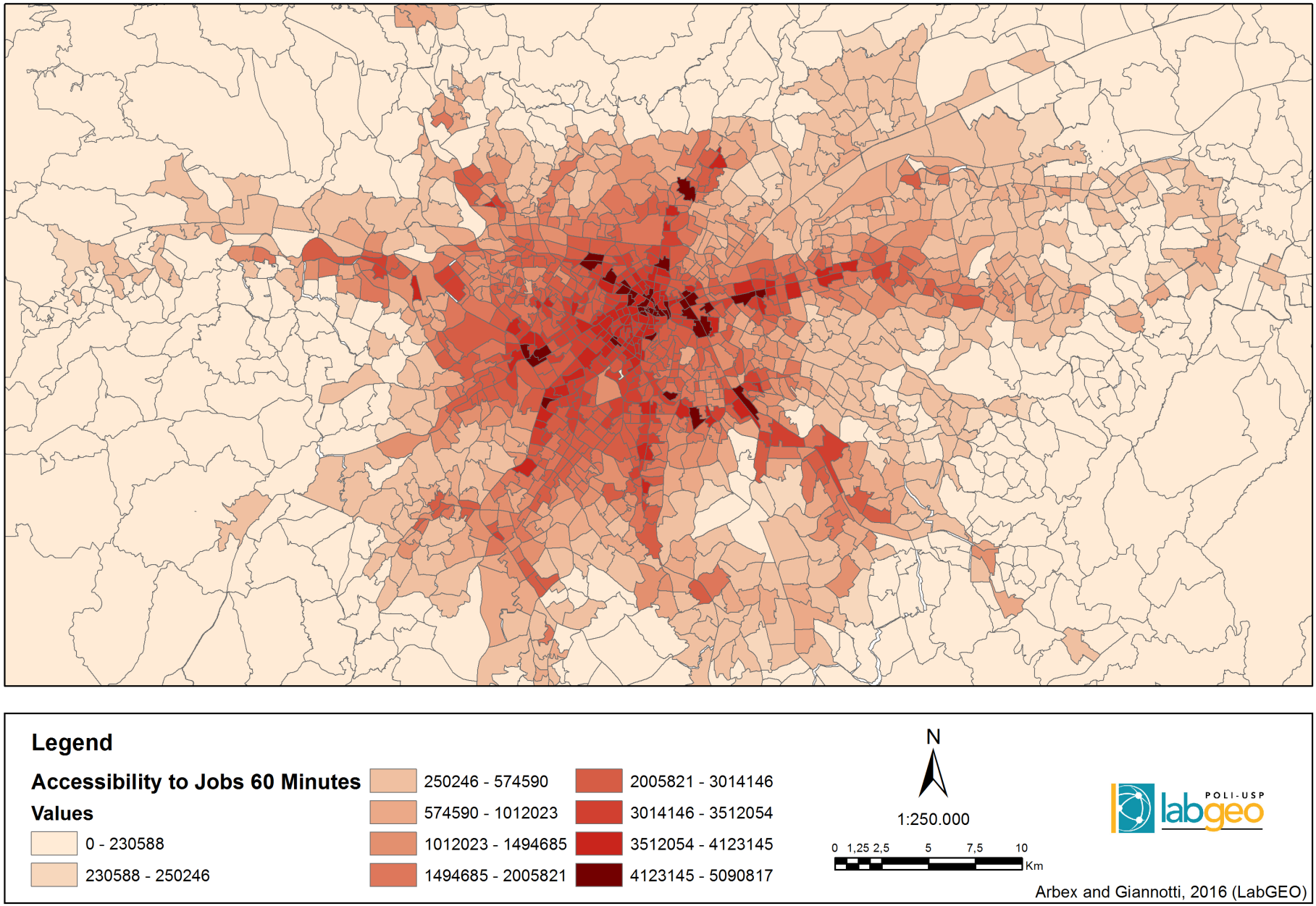
Method Replicated in Different International Context

RESOLUTION project working with Sao Paulo. Still early in research so only initial results.

Same methods- GTFS, OpenStreetMap, OpenTripPlanner- have been used successfully by Rafael Pereira at Rafael Pereira at University of Oxford looking at Rio de Janeiro- http://urbandemographics.blogspot.co.uk



Analysis by Rafael Pereira- http://urbandemographics.blogspot.co.uk



Duncan Smith, CASA UCL, citygeographics.org

Challenges with Applying Methods in Brazil

Data not always available for wider metropolitan region.

Informal public transport services can be important service (applies to many other countries). Also need to look at data on reliability of services in relation to the timetable data.

Do not have a journey-to-work trip matrix to validate accessibility results.

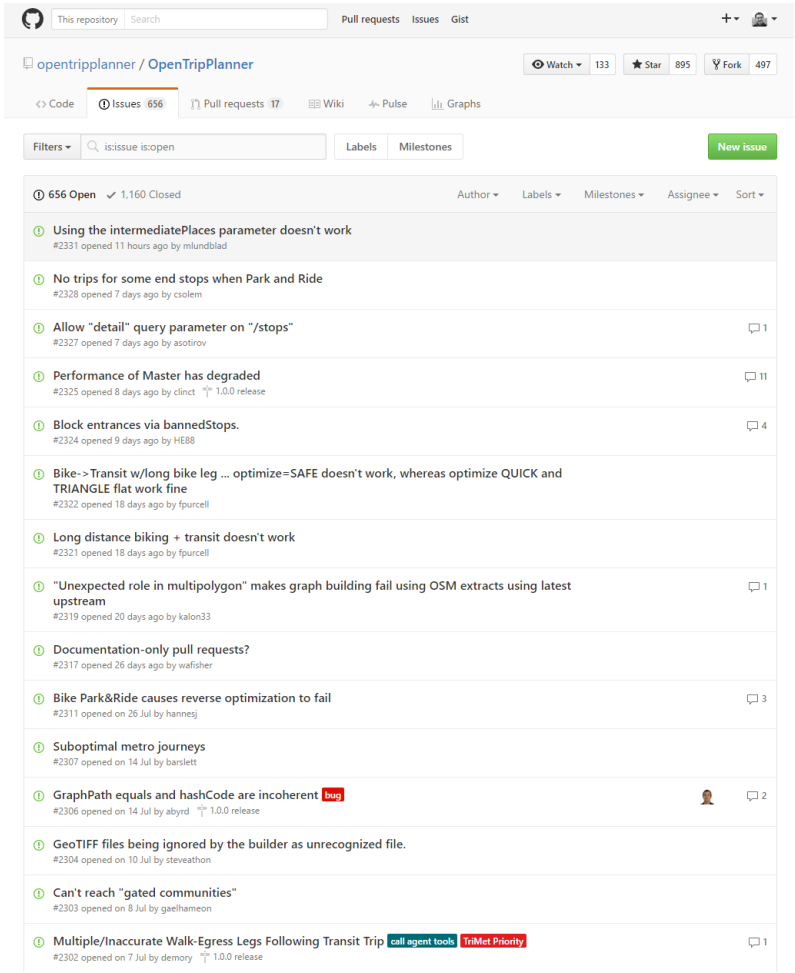
Reflections on Using OpenTripPlanner

Open Development Process
Not just the model that is open, but the process of its development is also open. Useful as a user- bug reports, future updates, forks etc. See where model already being used, share progress.

Limited Documentation
Fully customisable, but not user-friendly for non-coders.

Open Source Best for 'Foundational' Datasets
Accessibility results useful for lots of modelling applications, suits open source approach, developers willing to contribute. More specialised areas, could be less feasible.

Data Requirements Remain Challenging Outside of Global North
Want comprehensive GTFS for entire urban region, and complete OpenStreetMap. Informal transport, limited data creates problems.



Future- Global Comparative Analytics

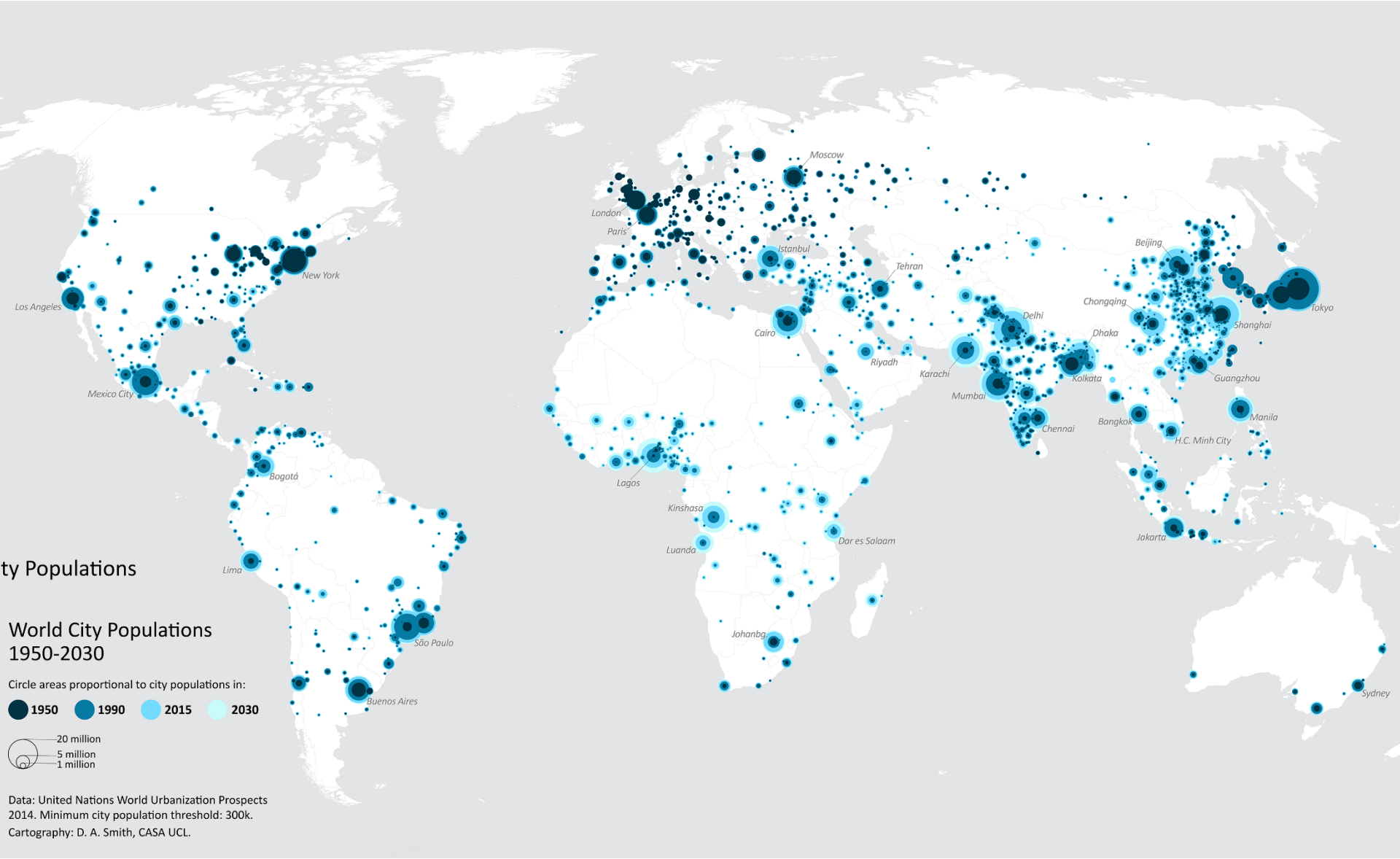
Aim for Global Urban Datasets

Consistent international comparisons between cities across range of socio-economic indicators/ models. Global connections & changes in topics like accessibility explored.

Limited Current Examples

Progress using remotely sensed approaches, but fewer examples of detailed socio-economic analysis. Transport accessibility one of many applicable areas- demographic data, economic, environmental…

UN- World Urbanization Prospects



Results are open data, but methods and inputs not fully open.

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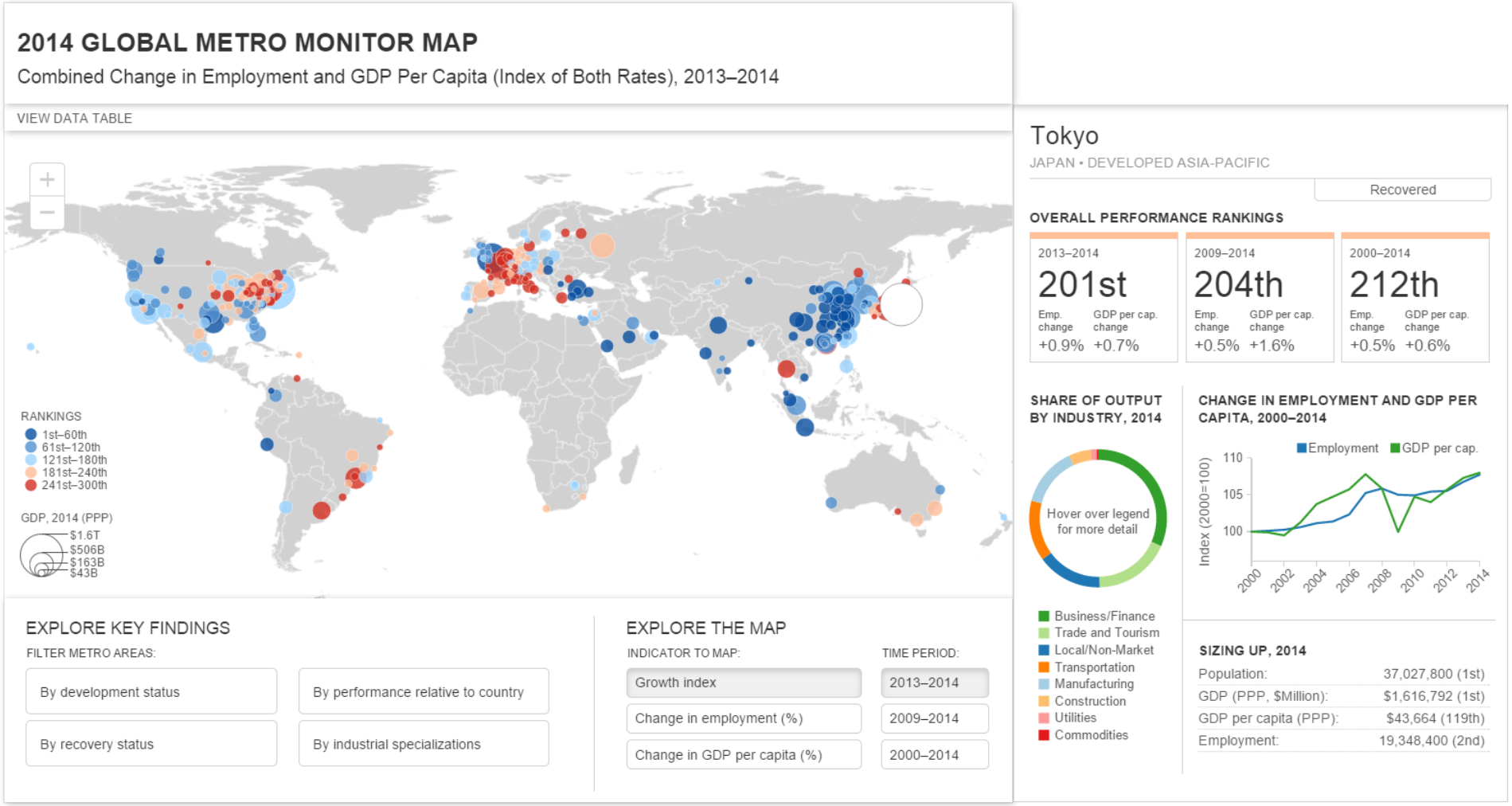
Economic Performance- Brookings



Not open data.

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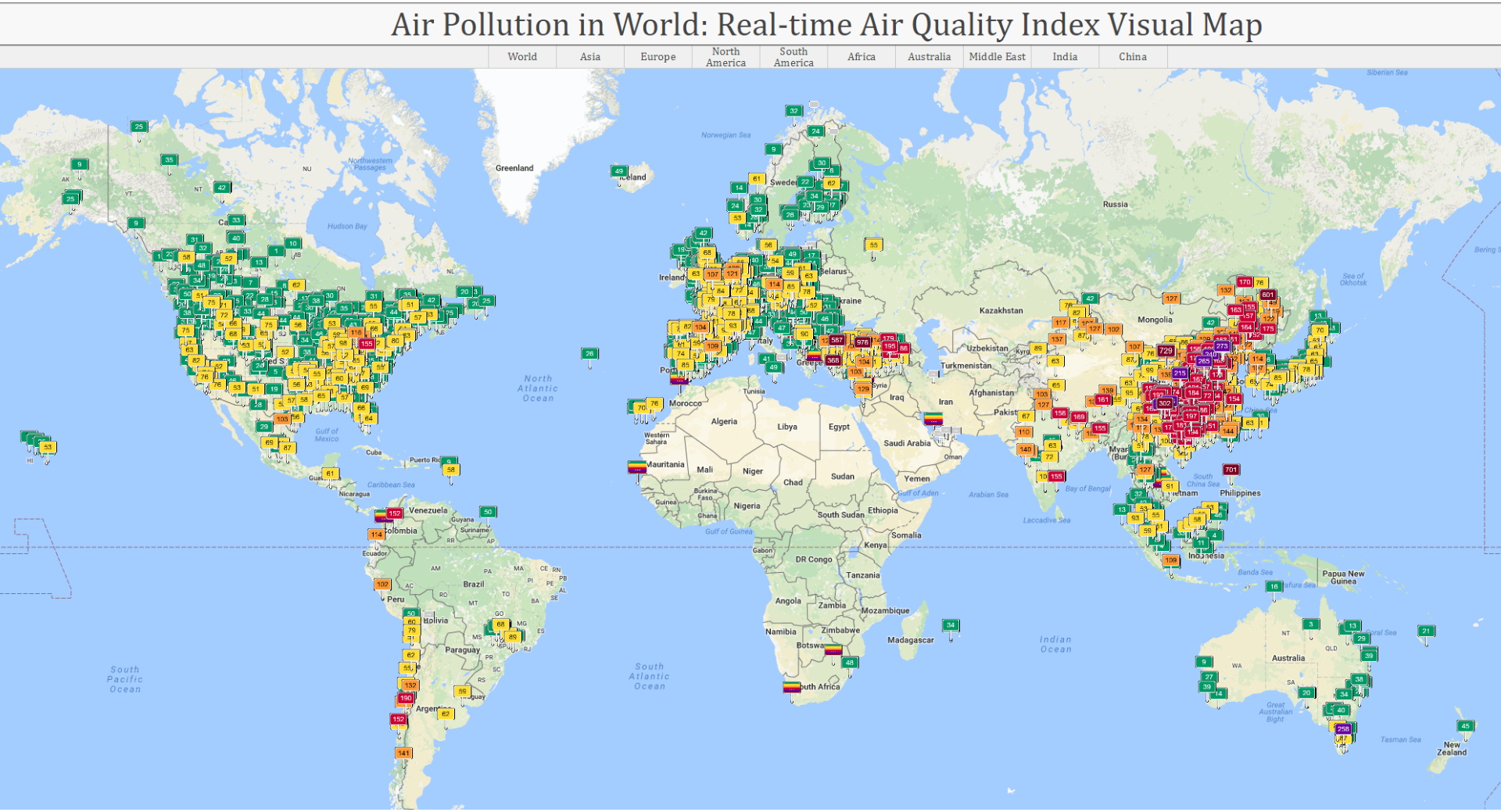
Air Quality- World Air Quality Index



http://aqicn.org/map/world/

Conclusions

Open Source & Open Data Modelling Approach
Flexible and robust. Argued approach facilitates modelling in different international contexts, allowing global comparisons. Example of accessibility modelling using OpenTripPlanner. Approach could be applied for many modelling tasks, where there is a critical mass.

Shared Development
Computational power continually expanding; nature of collaborative development could be biggest future challenge, between companies, government and academia, and between countries. Data increasingly essential infrastructure.

Links with Interactive Online Platforms, Tools
Many potential users of model outputs not going to be data analysts. Interactive mapping and data viz perfect match for global model outputs.

Future Improvements
Early days, many improvements. Better temporal modelling. Integration with accurate road travel times. Fares. Formal validation. Testing of comparative indicators…

Welcome questions & feedback

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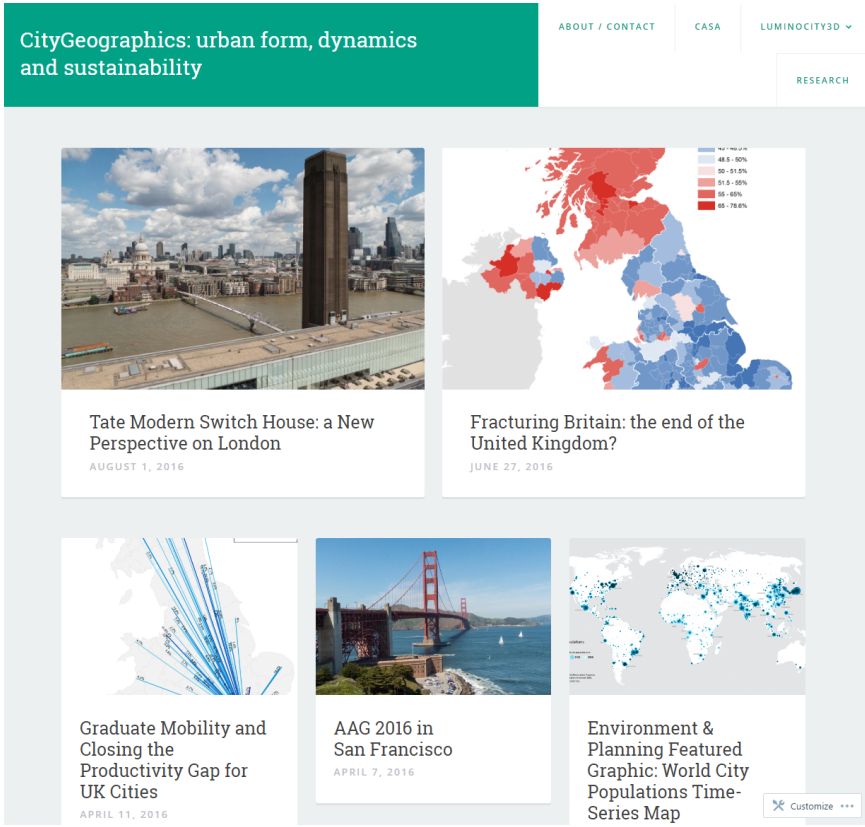
RESOLUTION Project-
http://www.urbantransformations.ox.ac.uk/project/resolution-resilient-systems-for-land-use-transportation/