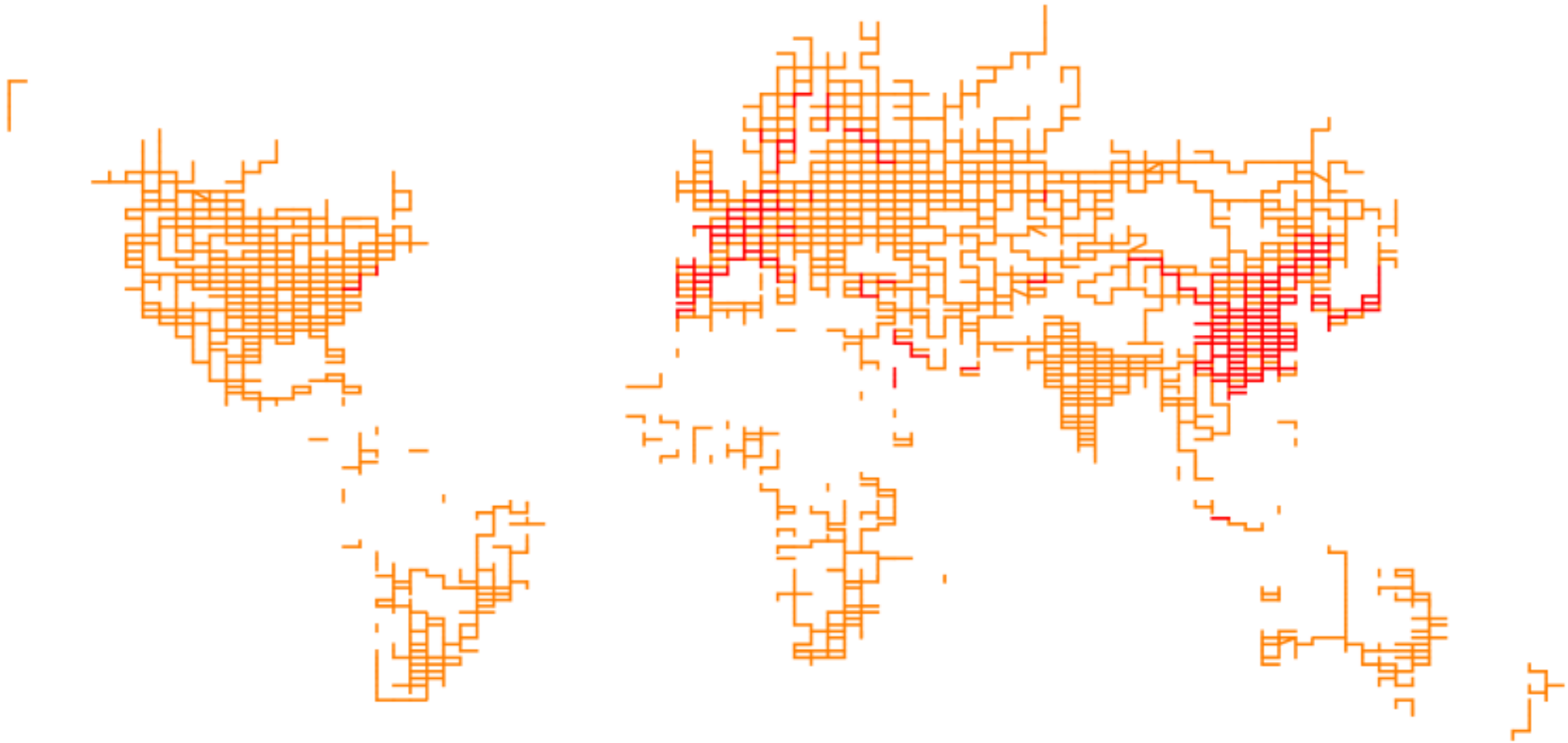
A Fully Automated Global Public Transport Network



A talk by Will Deakin using open data and open source tools to work out what this might look like

A Fully Automated Luxury Global Public Transport Network

Leeds is a friendly, diverse, international city.

But getting here can be awkward.

If you were going to build a global high-speed transport network to serve the needs of the students and workers of the People's Republic of West Yorkshire, what would it look like?



Will Deakin

With 25-years of being paid to work with technology, by day I am the Network Rail Trains Portfolio Architect and European Infrastructure Manager speaker at the European Agency for Railways data standards board

At night I use data science™ to think about things like where people go on trains

@wnd@fosstodon.org



You may also know me from...

LEEDS DIGITAL FESTIVAL | 2022

Sheffield DIGITAL FESTIVAL 22

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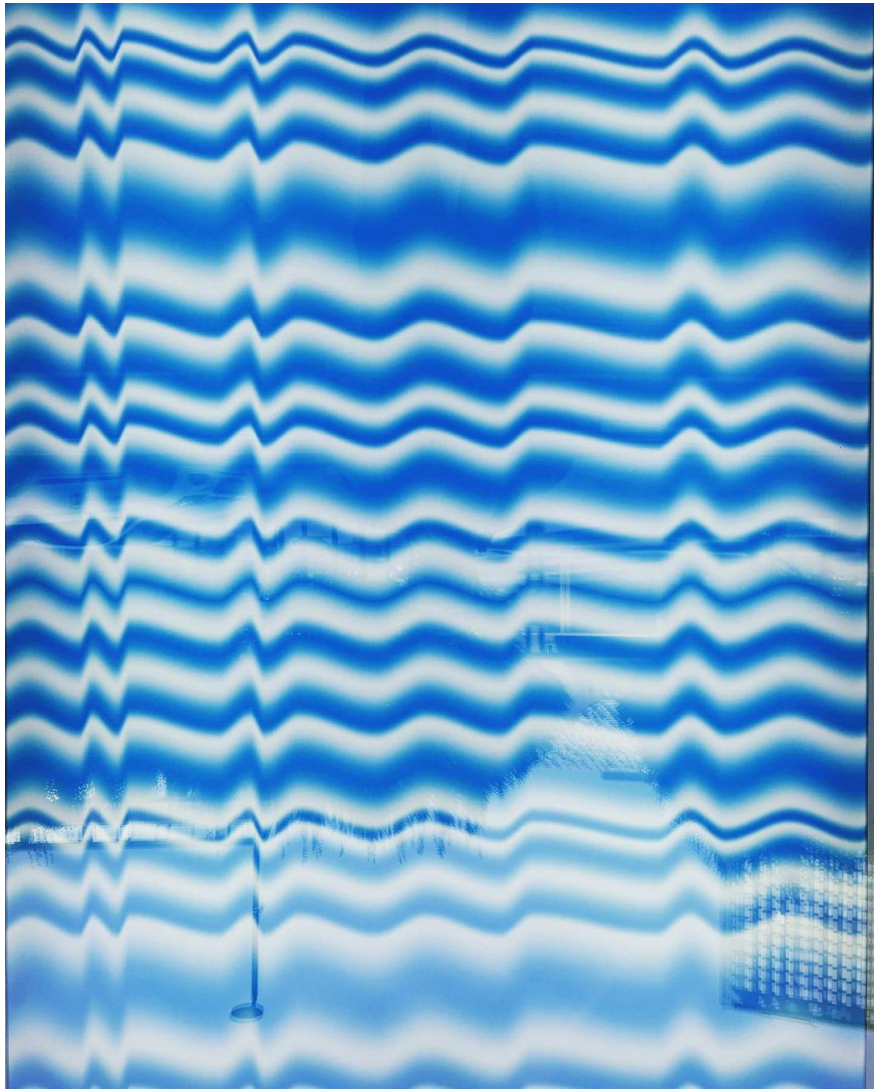
Leeds Digital Festival 2026

COM3523
Software Re-engineering

TRAN5340M
Transport Data Science

INF4000 Data Visualisation

INF4001 Information Visualisation for Decision Making



Introduction

Will Deakin

will.deakin@networkrail.co.uk

Trains Portfolio Architect

IT Delivery



Will Deakin

Other Stuff

@wnd@fosstodon.org
~~**X/Twitter: @WillDeakin1**~~
GitHub: @anisotropi4



Will Deakin

Other Stuff

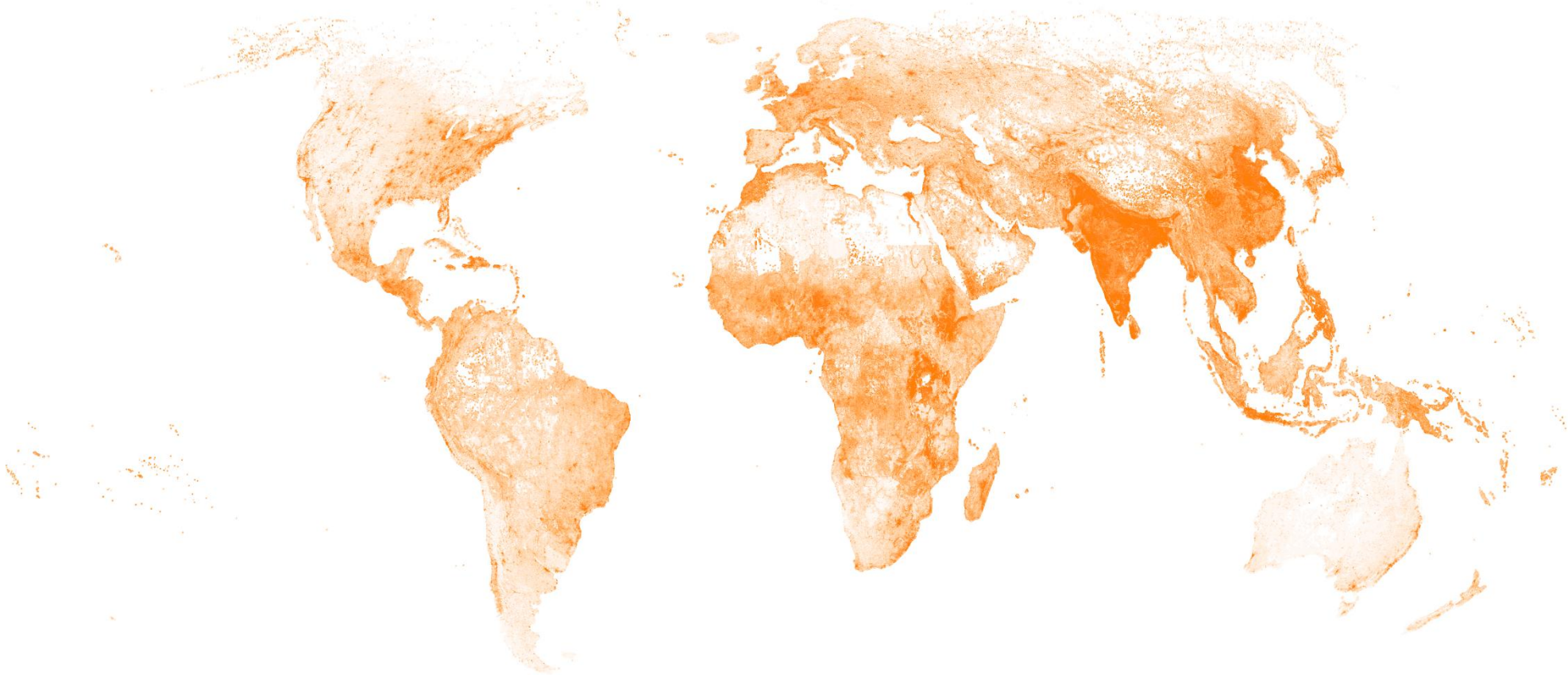
@wnd@fosstodon.org
GitHub: @anisotropi4



The People

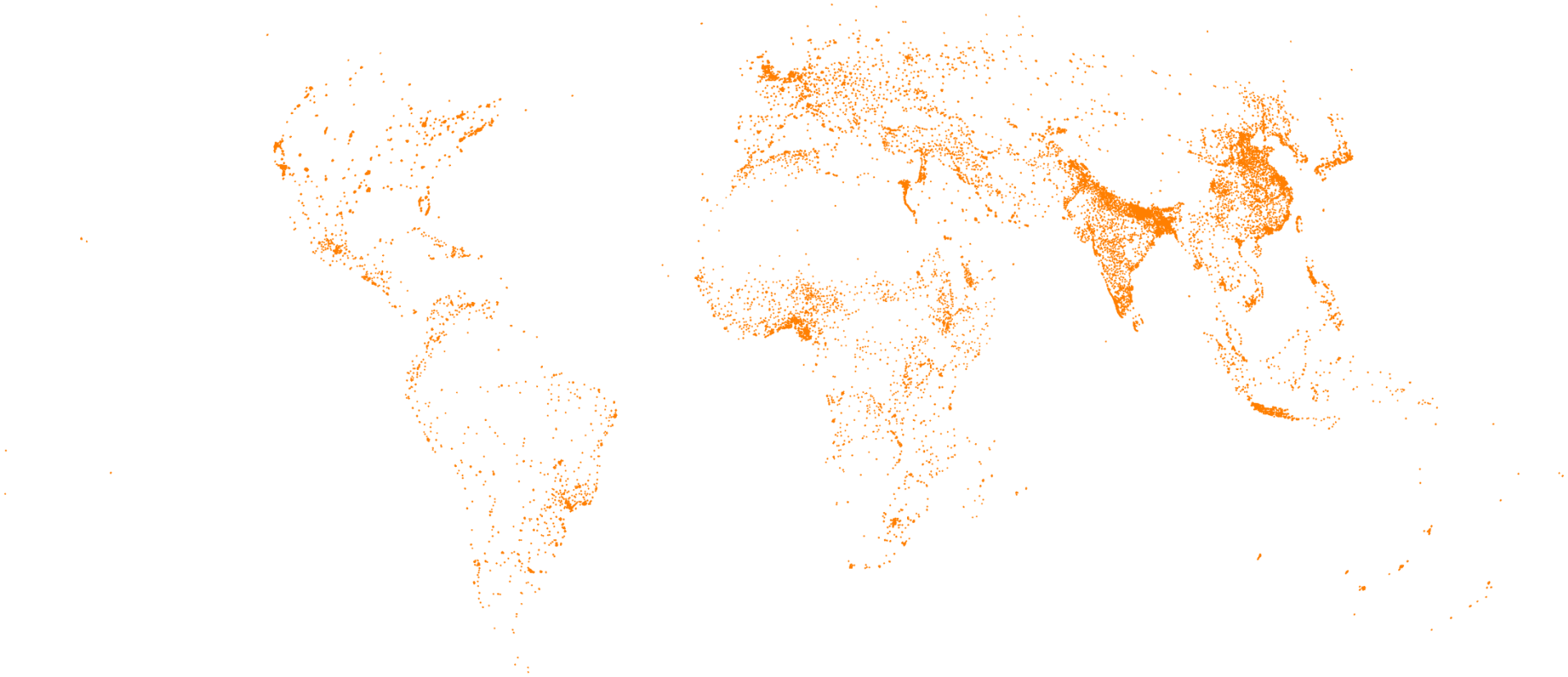


Where do people huddle



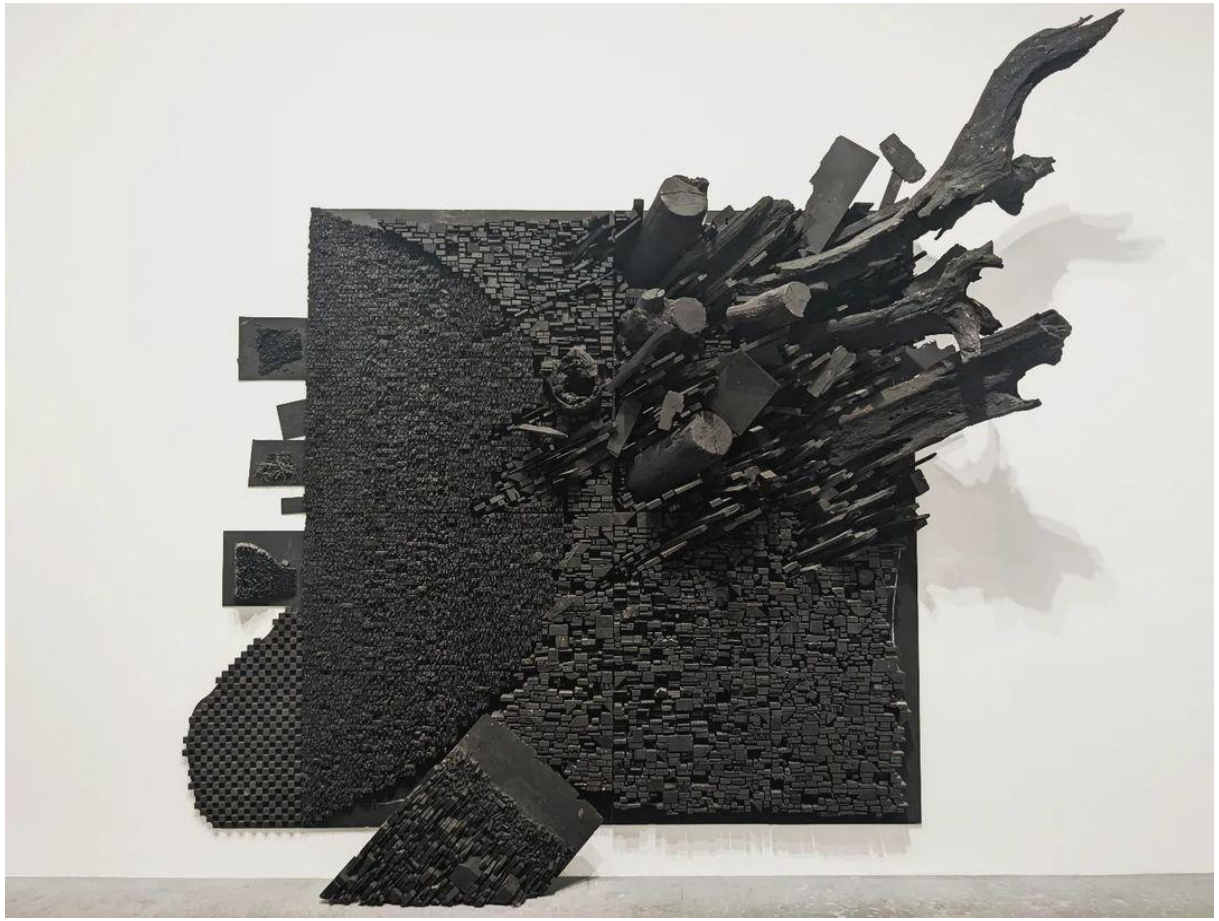
(1km^2 WorldPop)

Where do people huddle

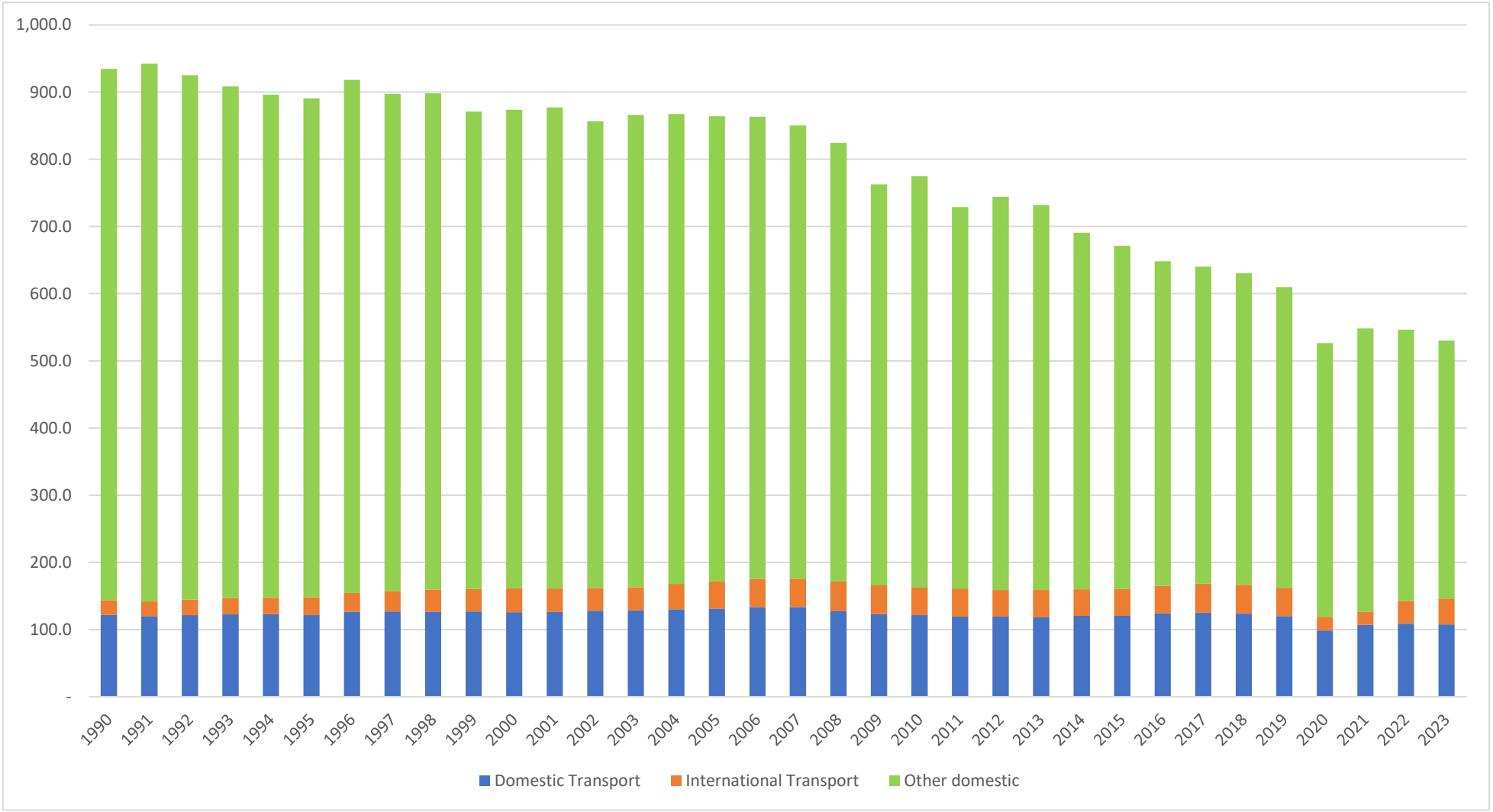


(Copernicus GHSL)

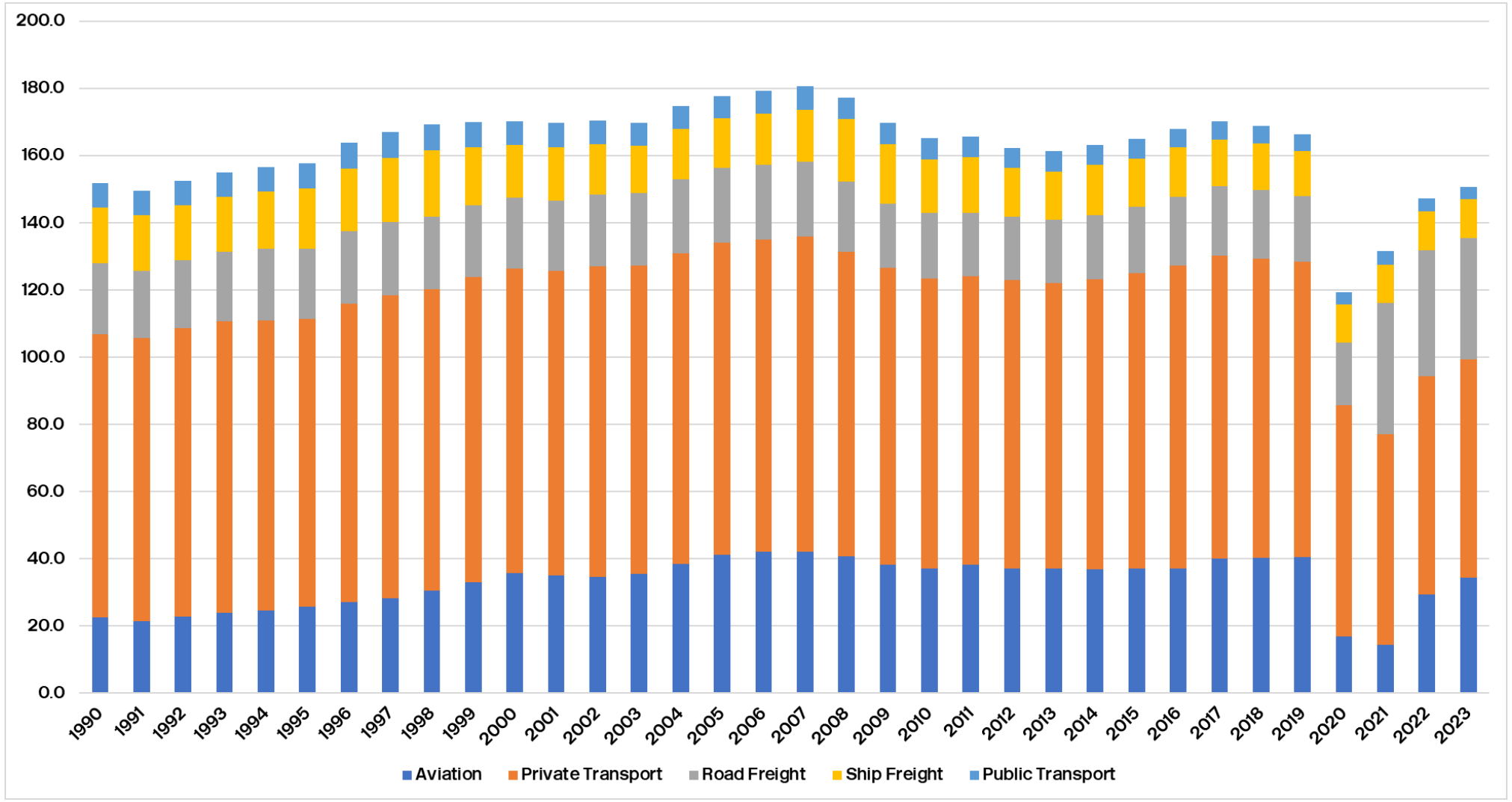
Emissions



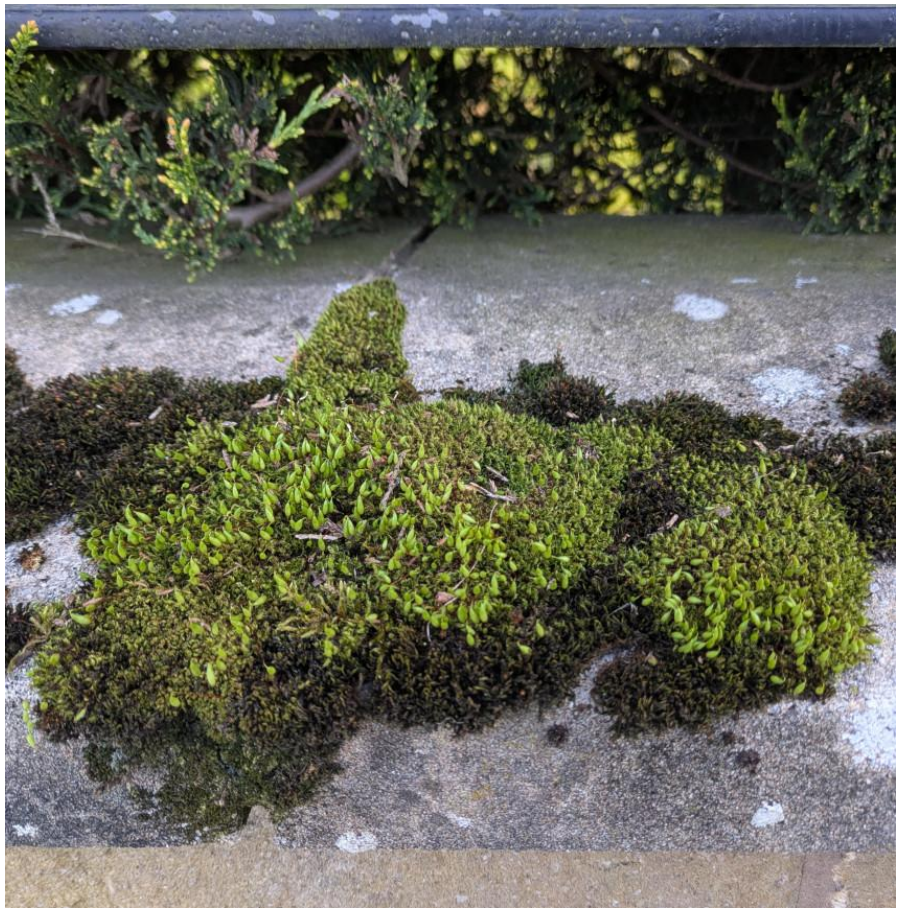
UK CO_2 Emissions 1990-2023



UK CO_2 Emissions 1990-2023



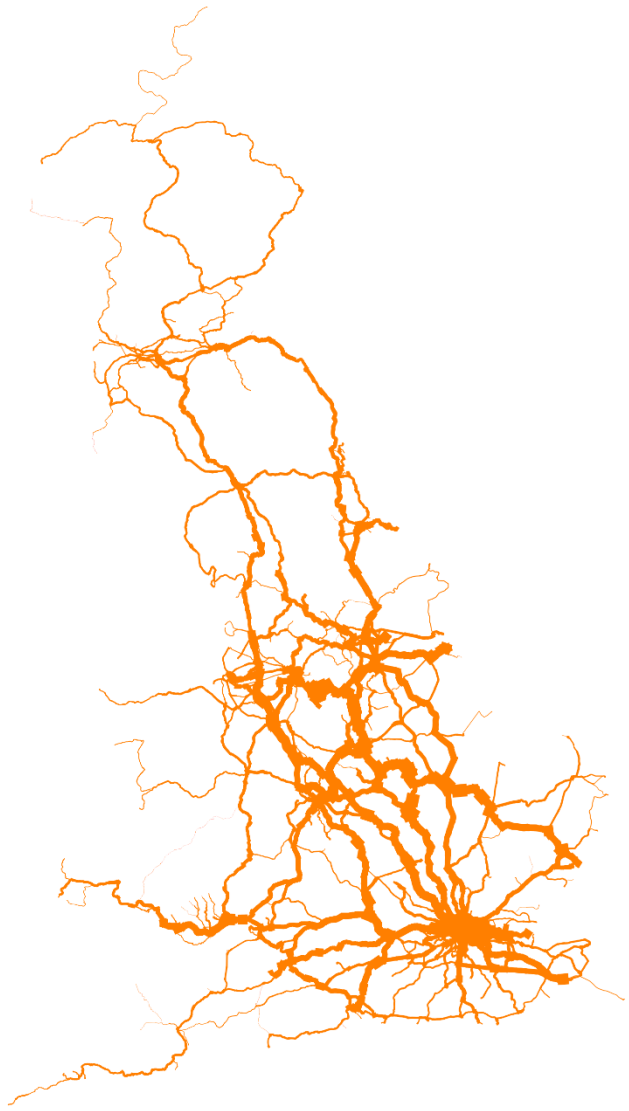
The Where

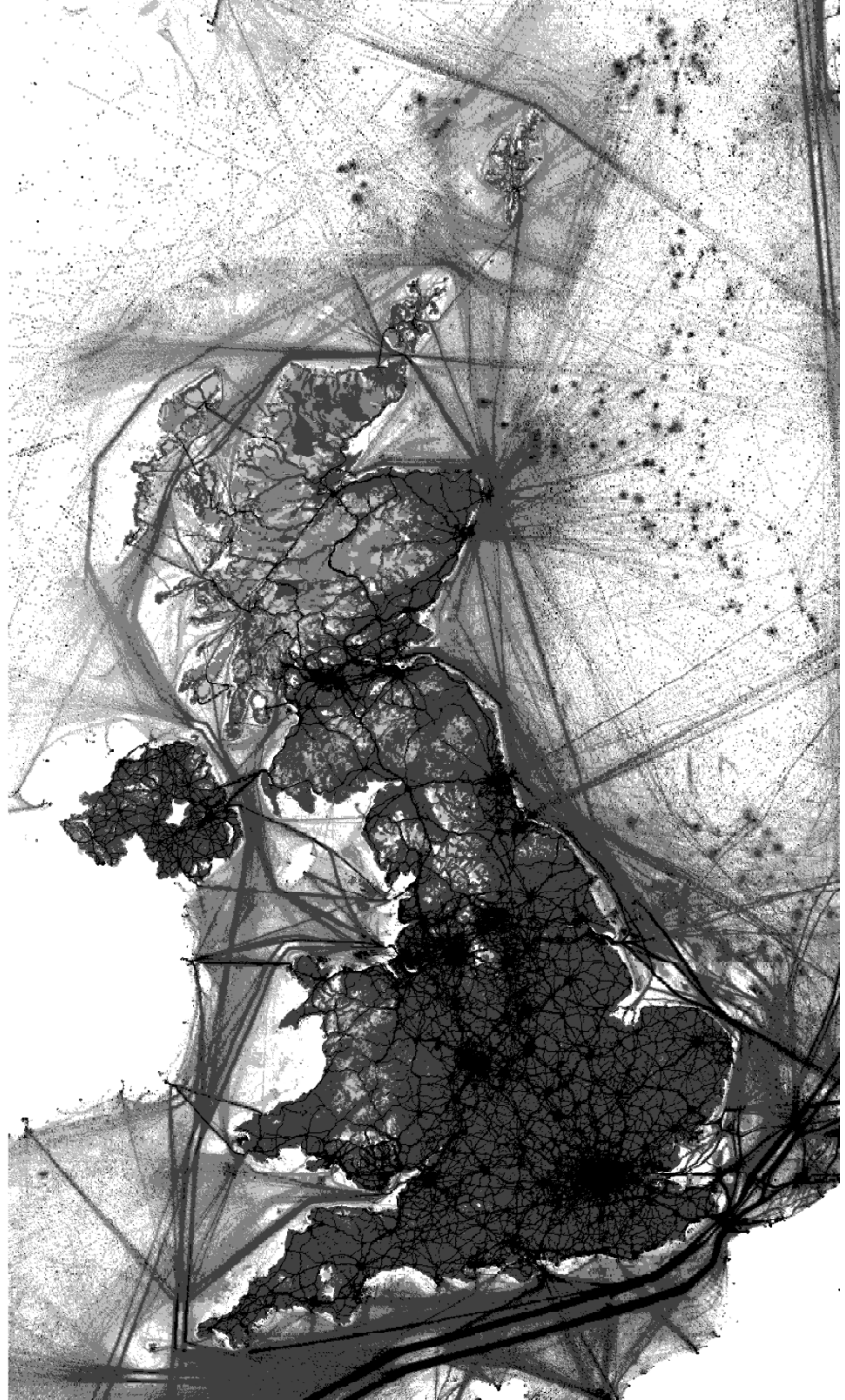


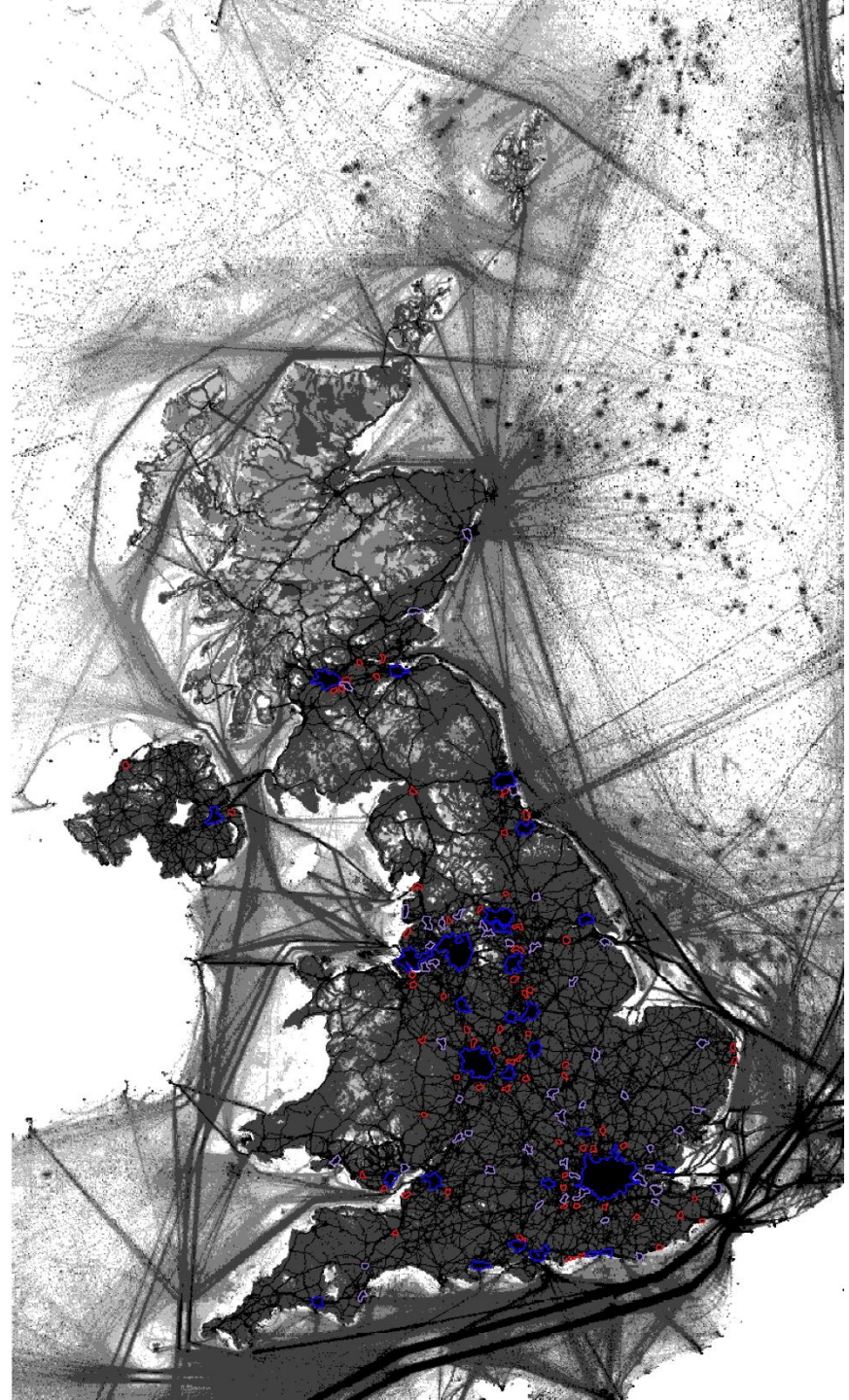
Road



Rail

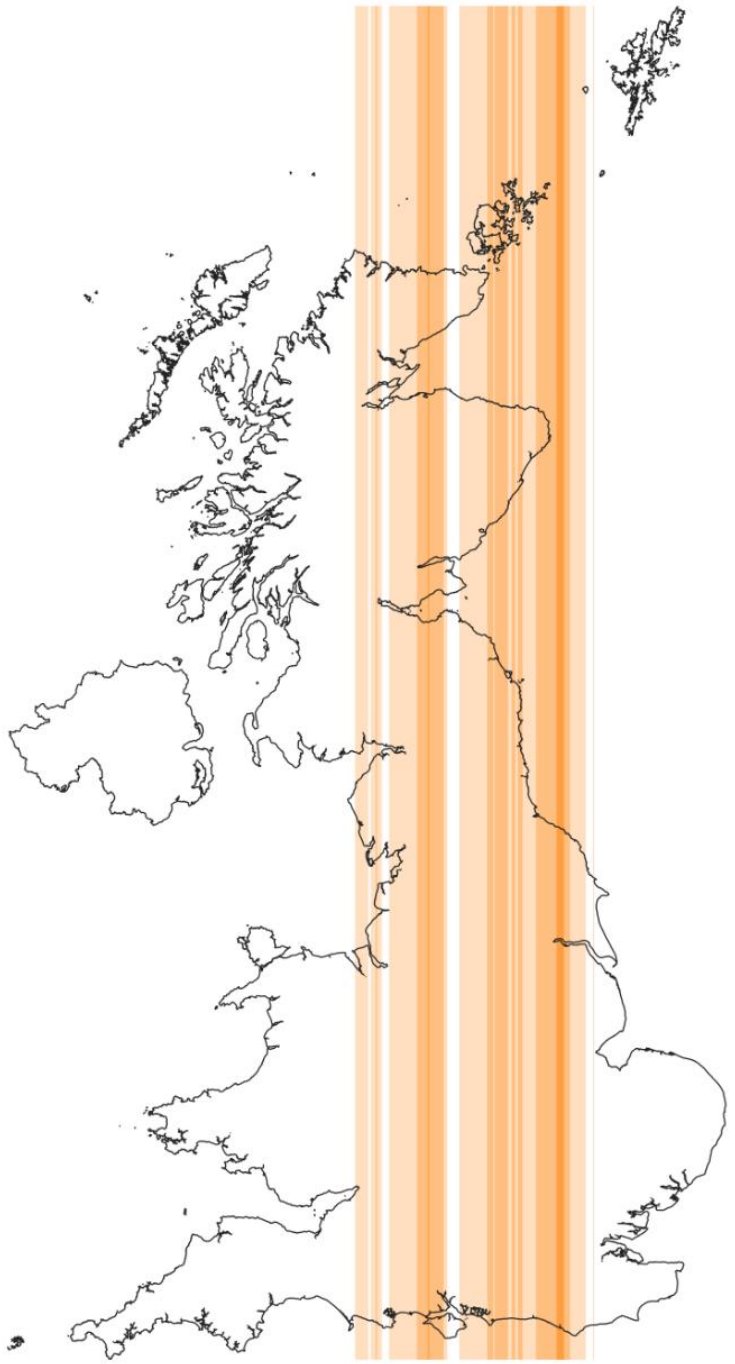




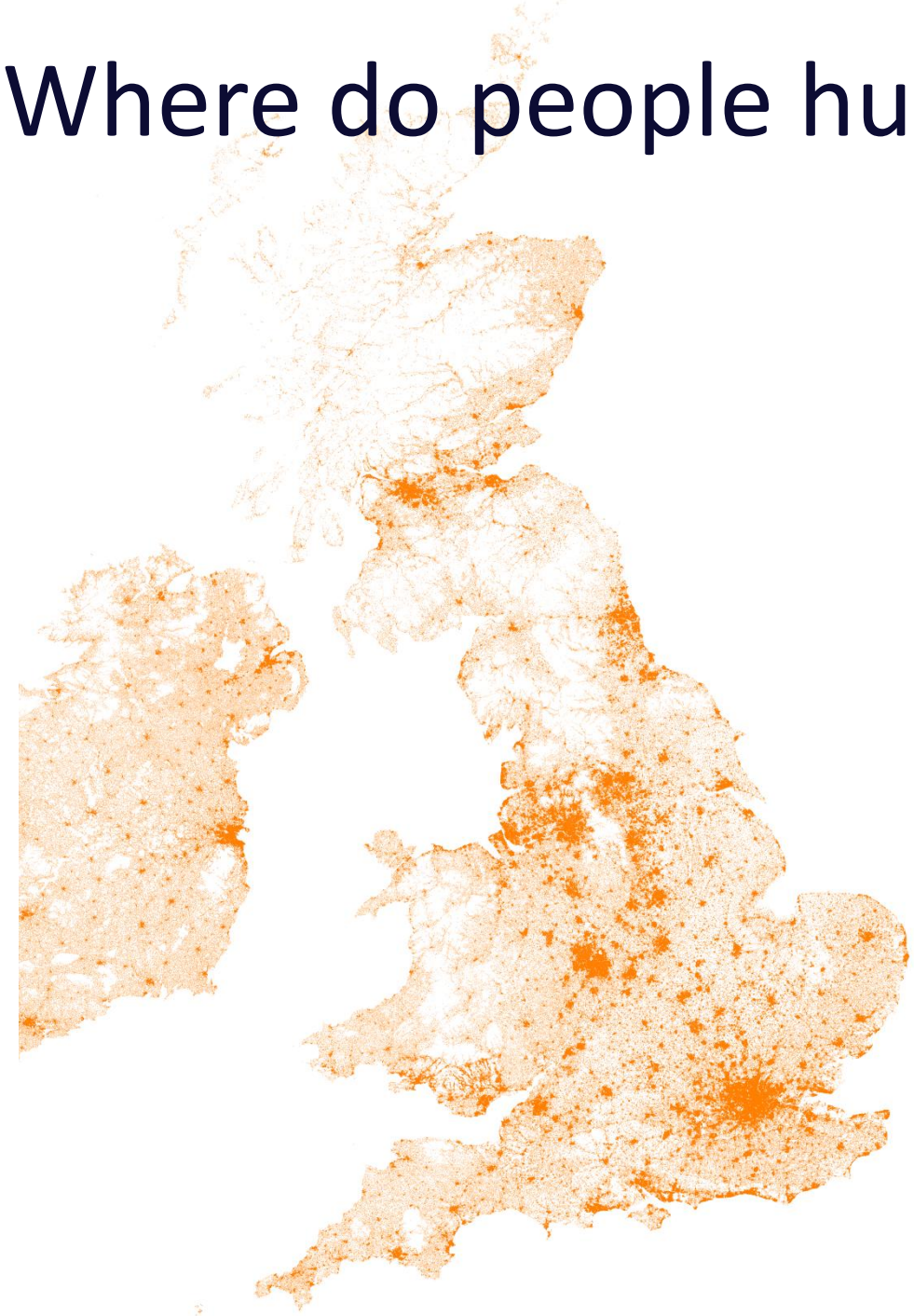


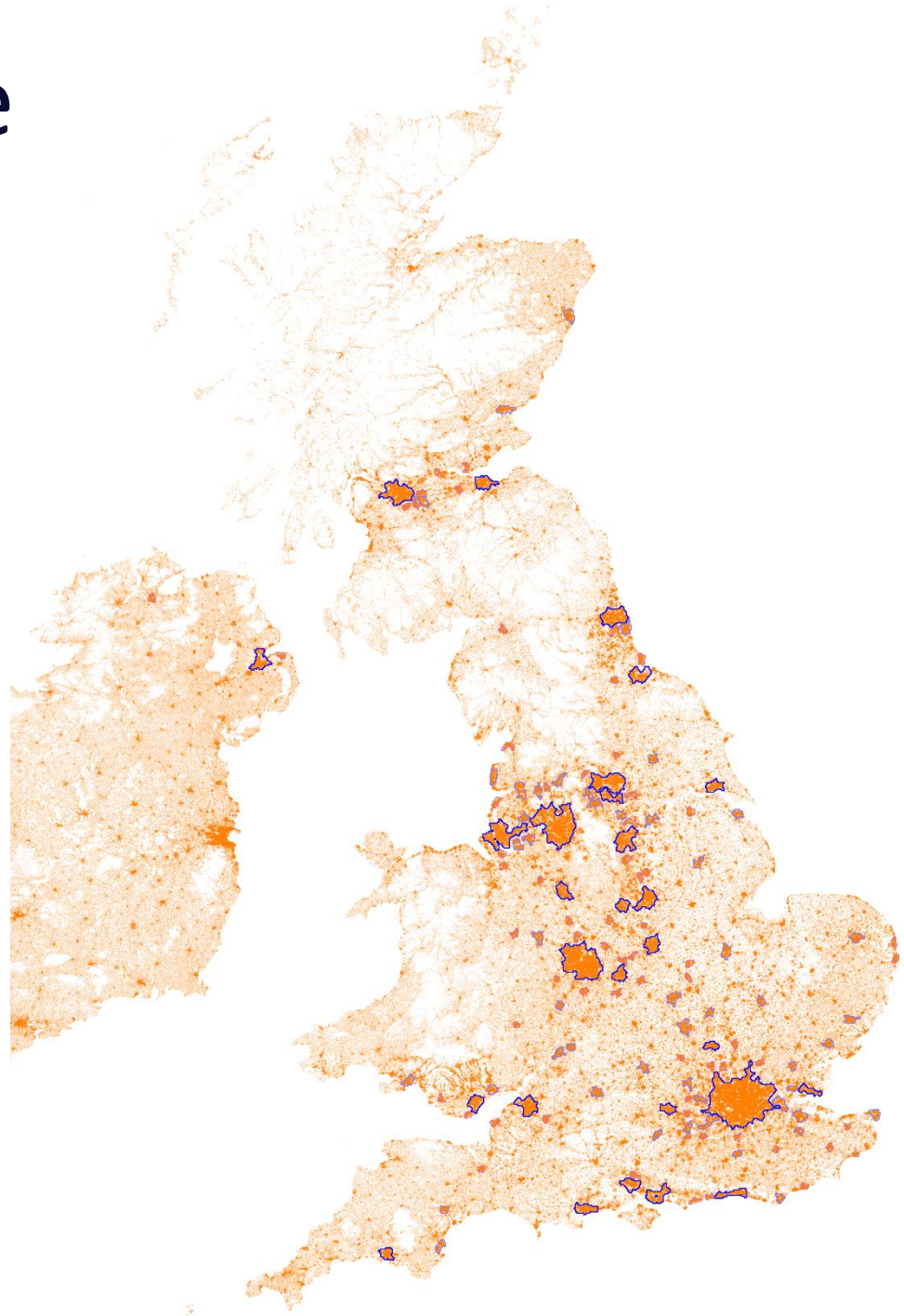
Where do people huddle





Where do people huddle





Freight



Green House Gases (CO_2)

UK produced 455 million tonnes CO_2 equivalent (mtCO2e) in 2019

Transport accounted for 122 mtCO2e (26.8%) of which

- HGV 19.5 mtCO2e (16.0%/4.2%)
- All rail 1.7 mtCO2e (1.4%/0.04%)

A freight train removes up to 76 HGVs from our roads



DfT Transport Statistics (2021)

CO_2 Comparison

Activity	Type	kg CO_2 / tonne km	Ratio
Cargo ship	General cargo	0.01323	0.52
Cargo ship	Container ship	0.01614	0.63
Rail	Freight train	0.02556	1.00
All Articulated	50% Laden	0.10775	4.22
All Articulated	100% Laden	0.06713	2.63
All HGVs	50% Laden	0.14606	5.71
All HGVs	100% Laden	0.0882	3.45



UK Government GHG Conversion Factors for Company Reporting

CO_2 Comparison

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UK Government GHG Conversion Factors for Company Reporting

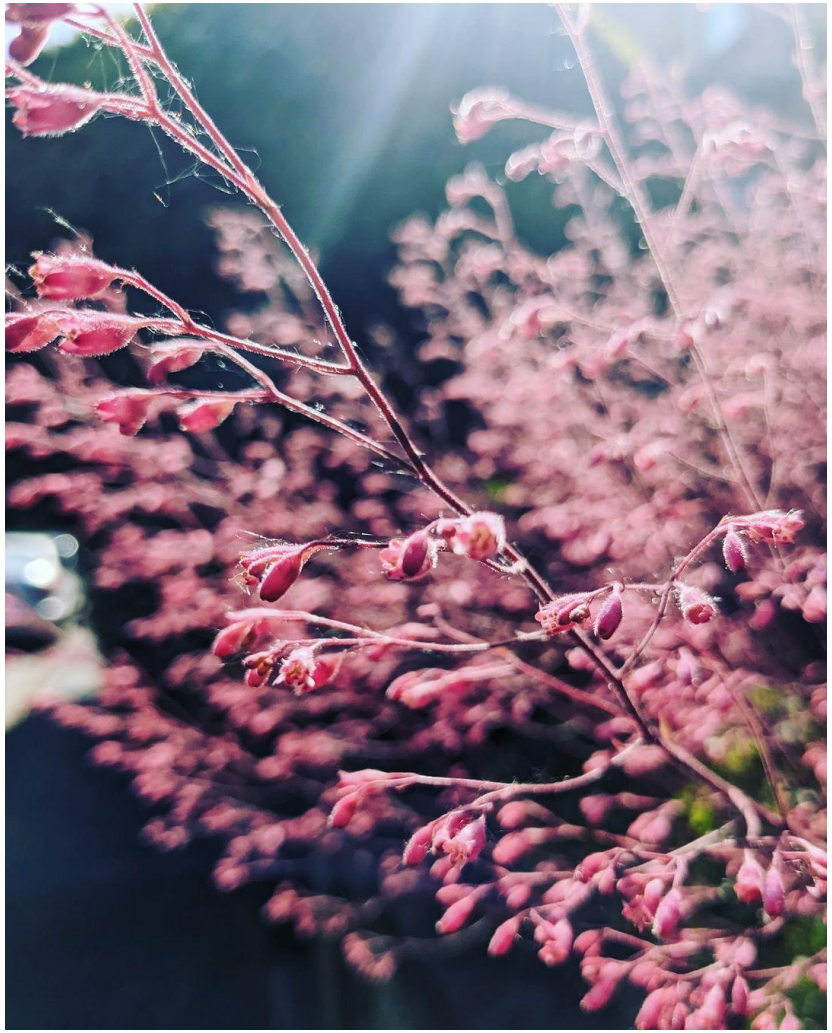
CO_2 Comparison

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All HGVs	100% Laden	0.0882	3.45



One freight train removes 76 HGVs from our roads

Passenger



Cars?

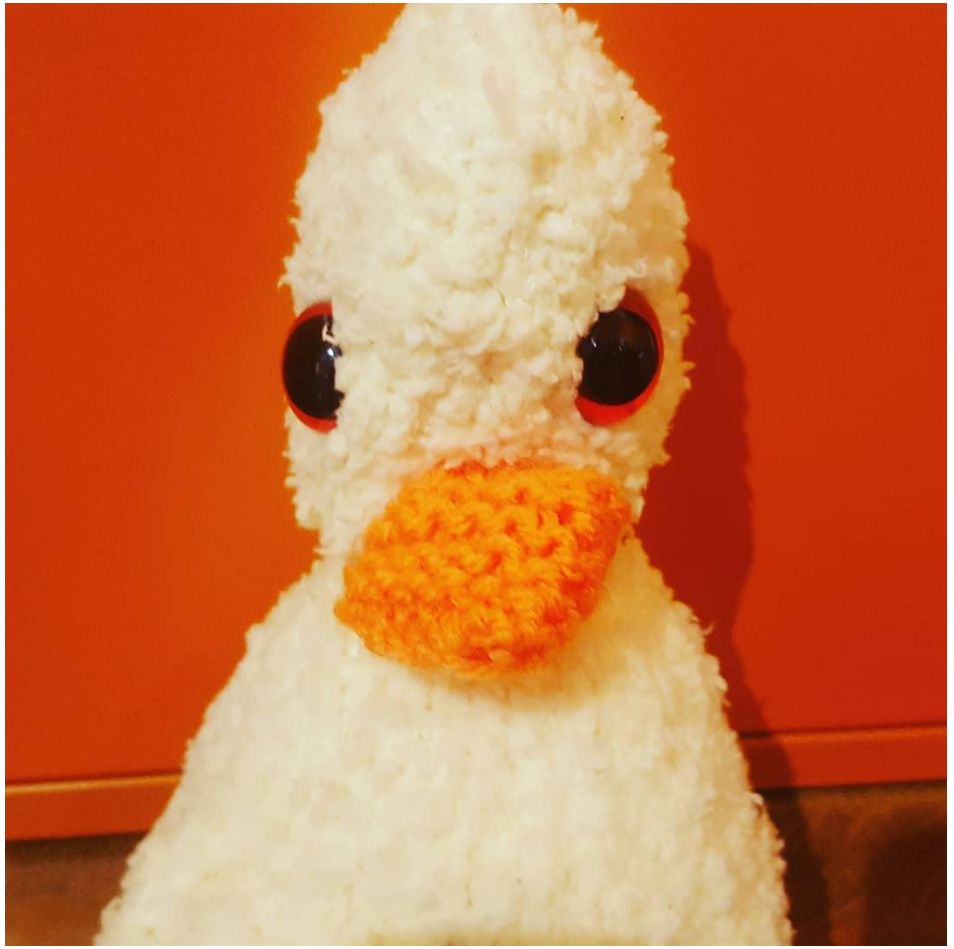
- Emissions
- Air pollution
- Noise Pollution
- Urban heating
- Flooding risk



Weather Impact



Motornormivity



Car Brain

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha



Why do cars get a free ride? The social-ecological roots of motonormativity

Ian Walker [a,*], Marco te Brömmelstroet [b]

[a] School of Psychology, Swansea University, Swansea SA2 8PP, United Kingdom
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ARTICLE INFO

Keywords:
Transportation
Travel mode change
Motonormativity
Social-ecological model
Pluralistic ignorance
Behaviour change

ABSTRACT

Motonormativity is a shared bias whereby people judge motorised mobility differently to other comparable topics. This works against societies addressing climate and public health crises effectively. A social-ecological explanation has been suggested for the phenomenon, in which motonormativity is shaped by people's environments, but this has not been tested. Here we used a large international sample (N = 2035) and novel within-participants testing to show, for the first time, at least two environmental pathways linked to judgement biases: one related to people's social surroundings and linked with their explicit views on transport, and a separate, more implicit pathway related to higher-level structural influences such as nationality, and living in rural areas. Additionally, respondents dramatically underestimated public support for non-motorised transport relative to their own, a pluralistic ignorance effect likely reflecting another facet of motonormativity. The social-ecological explanation, with its nested environmental influences, helps explain the 'stickiness' of automobility, and implies change will be most likely when multiple facets of a person's social, physical and cultural surroundings align in supporting non-motorised mobility.

Stop me if you've heard this one before



Why Public Transport?

- Social exclusion
- Physical problems
- Mental health issues
- Road violence



Health Impact



Road Violence

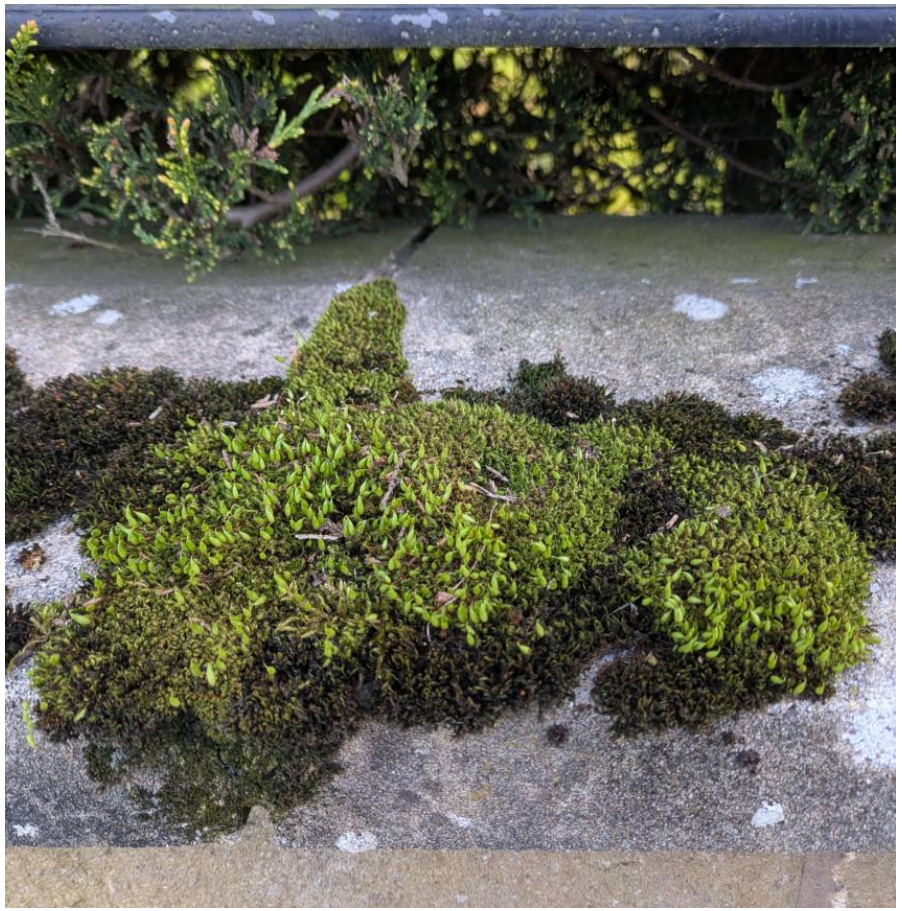
Vehicle	Fatality
Car	1,255
Motorcycle	336
LGV	196
HGV	188
Pedal cycle	92
Bus or coach	59
Total	1,624

Road User	Fatality
Car occupants	725
Pedestrians	405
Motorcyclists	315
Pedal cyclists	87
Other occupants	92
Total	1,624

29,711 killed or seriously injured (KSI) casualties
132,977 casualties of all severities

From reported road casualties Great Britain, 2023 (Department for Transport)

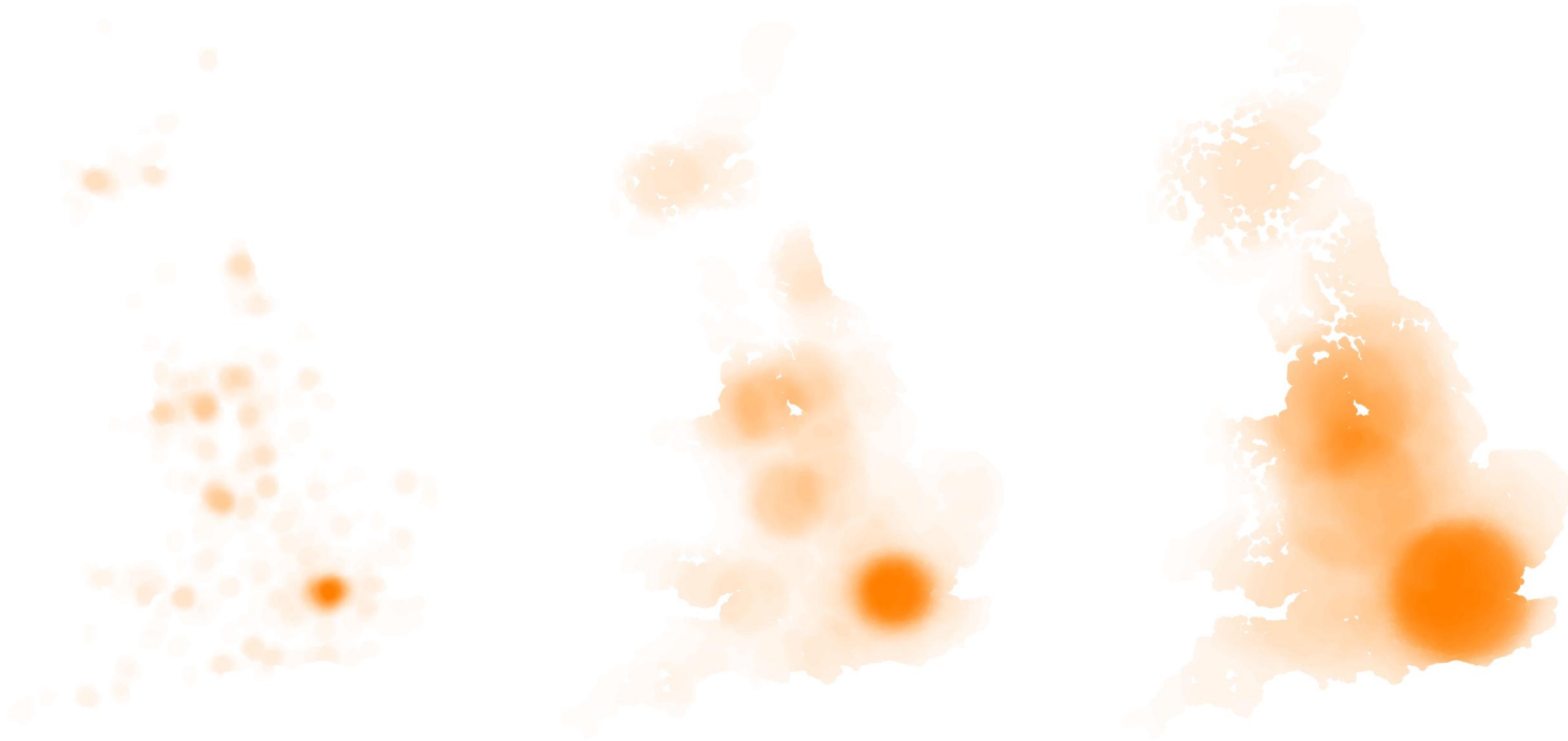
The Where



Hidden Hinterlands

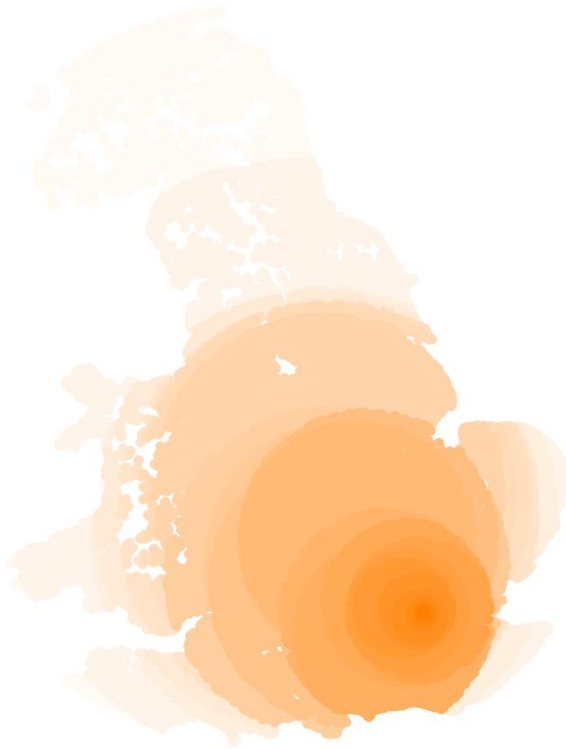


Travel Hinterland



Travel Hinterland

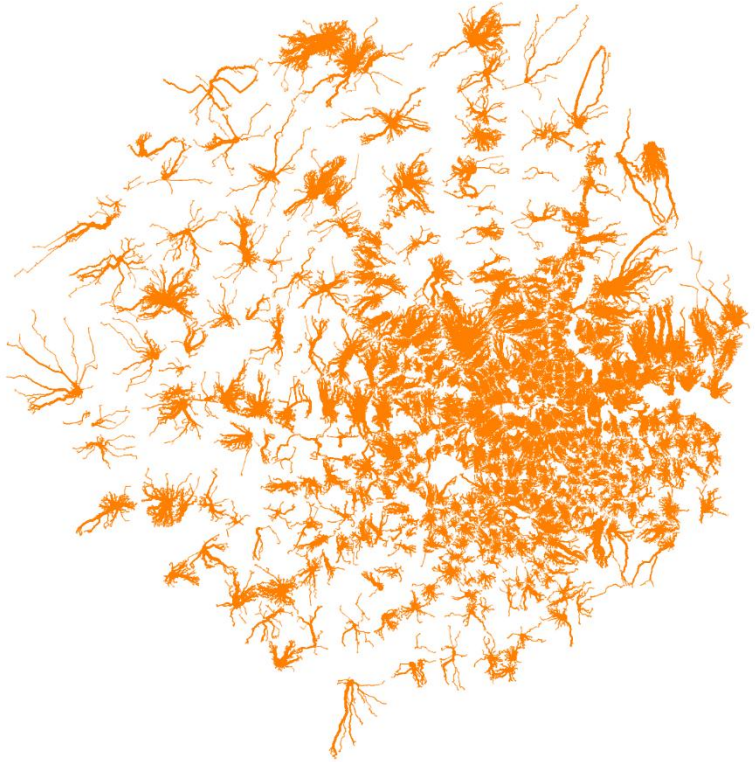


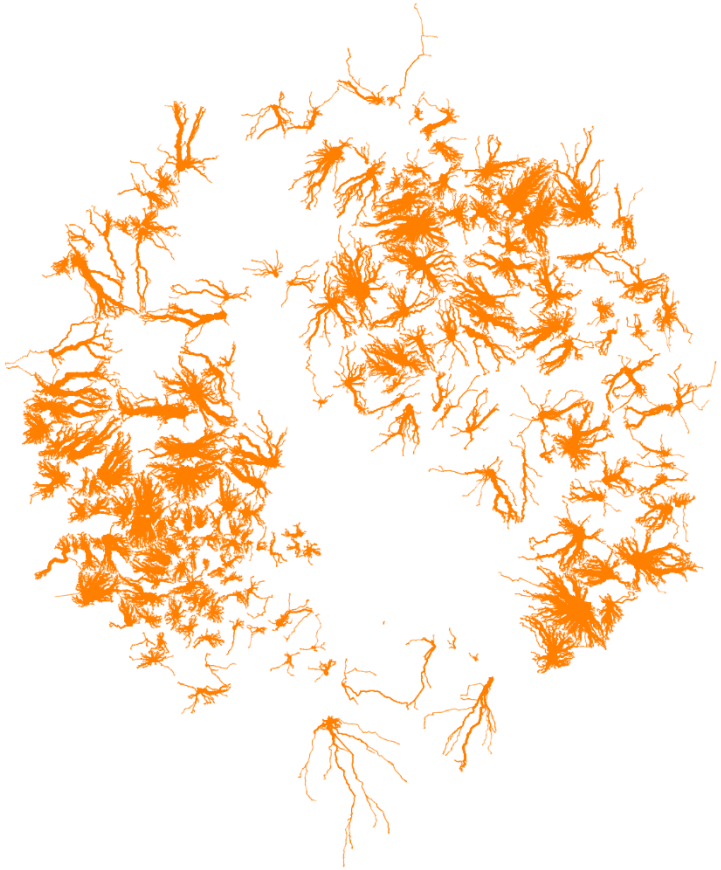


Dorthin

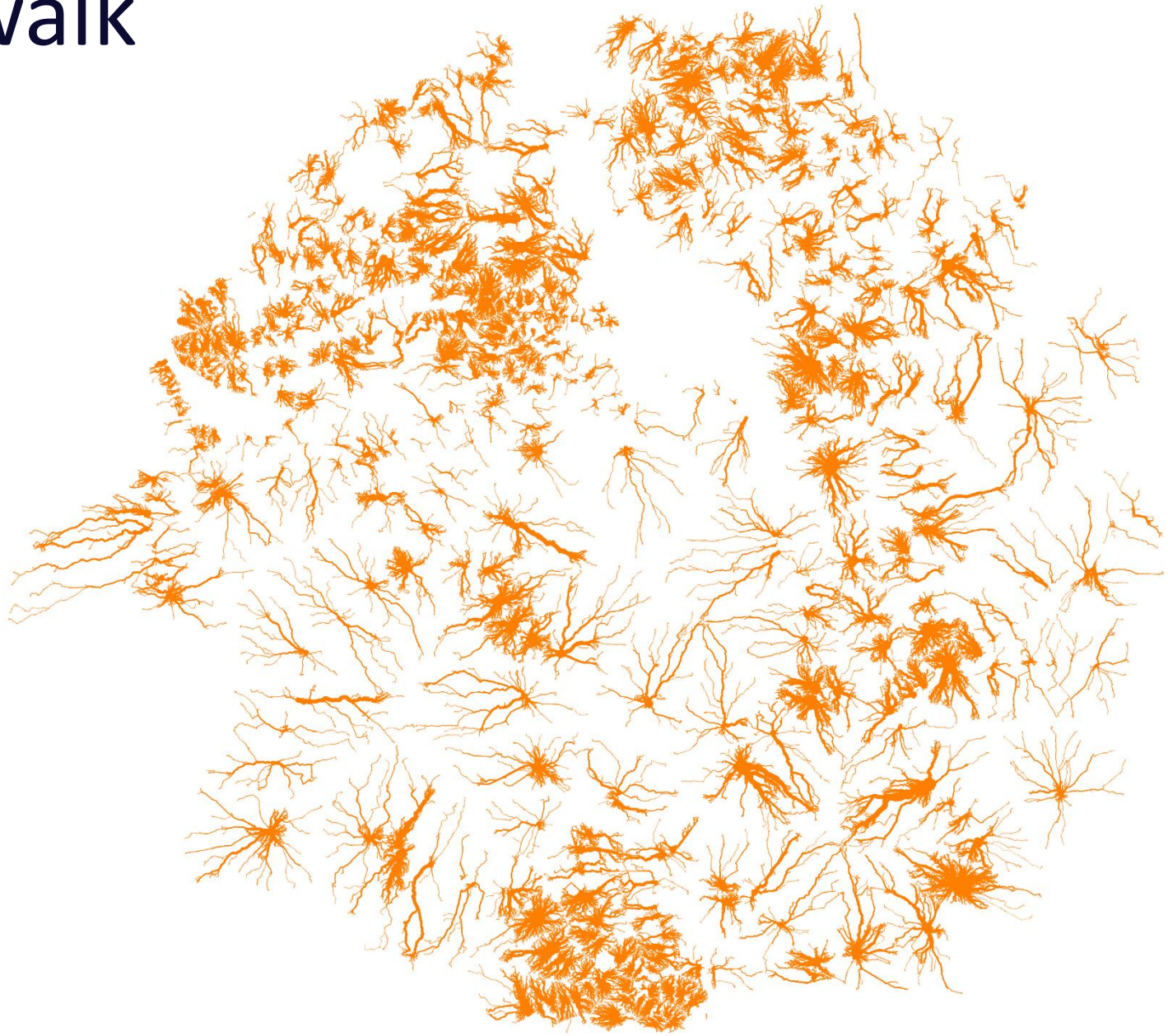


Let’s walk

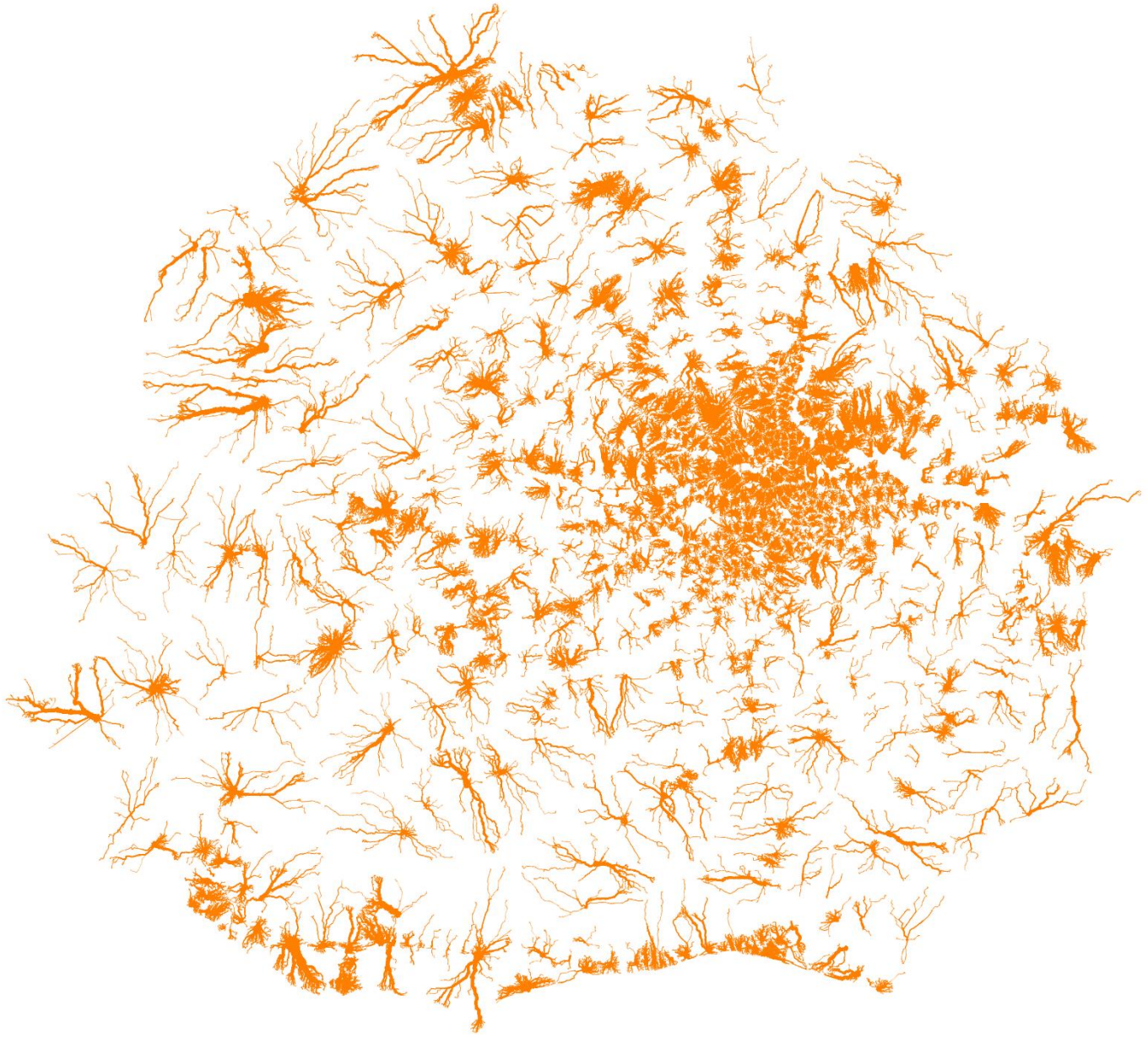




Let’s walk



Let’s walk



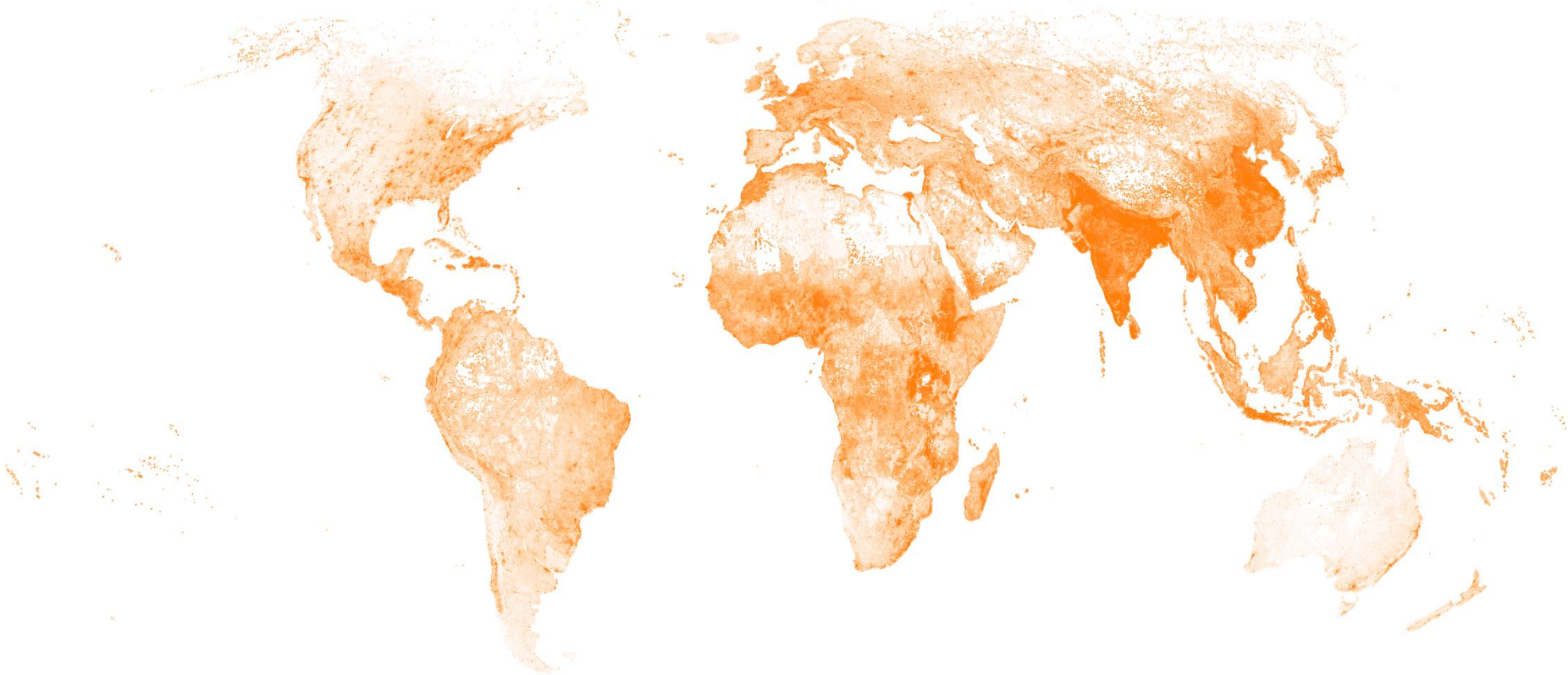
Tomorrow
and
Tomorrow
and
Tomorrow



The Approach

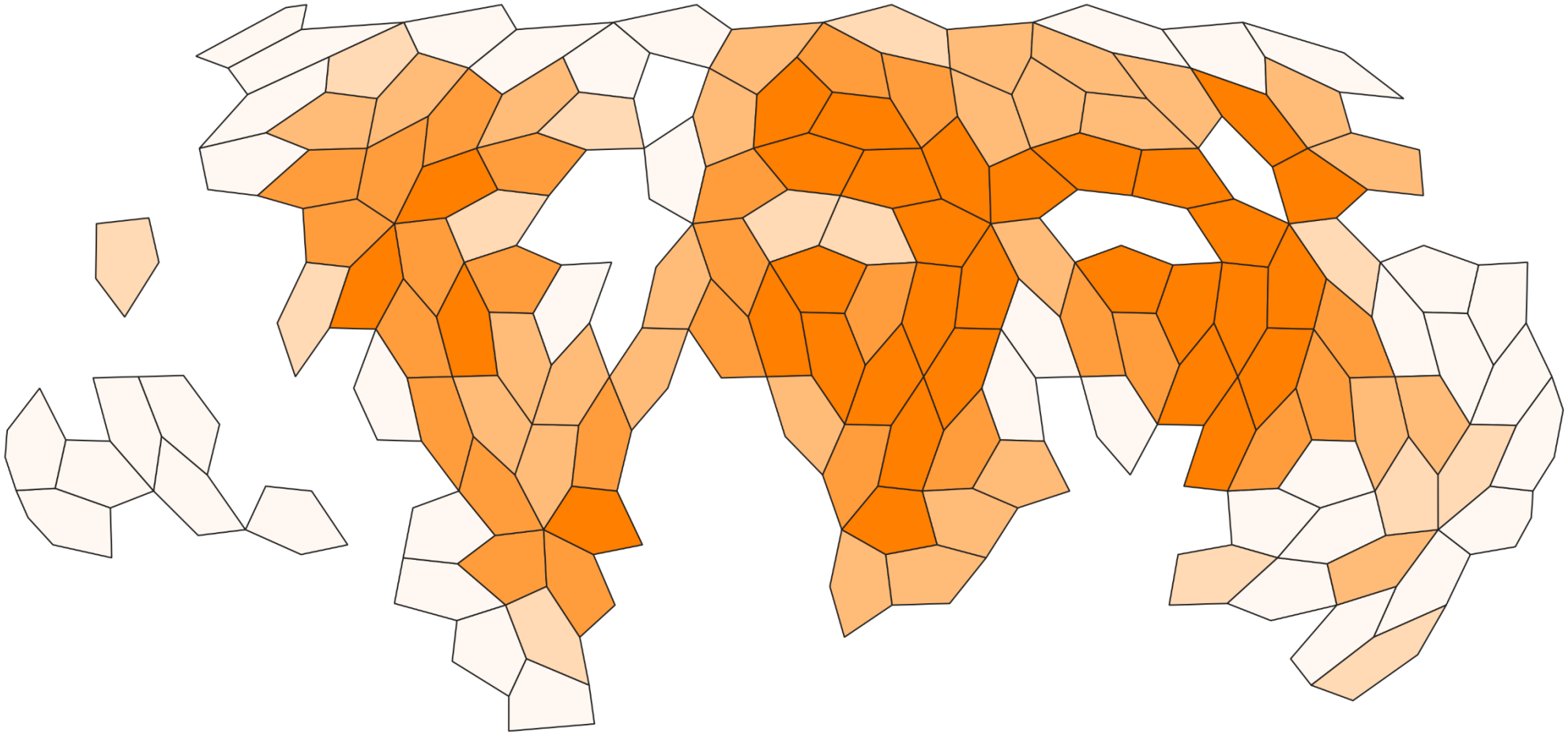


Where do people huddle

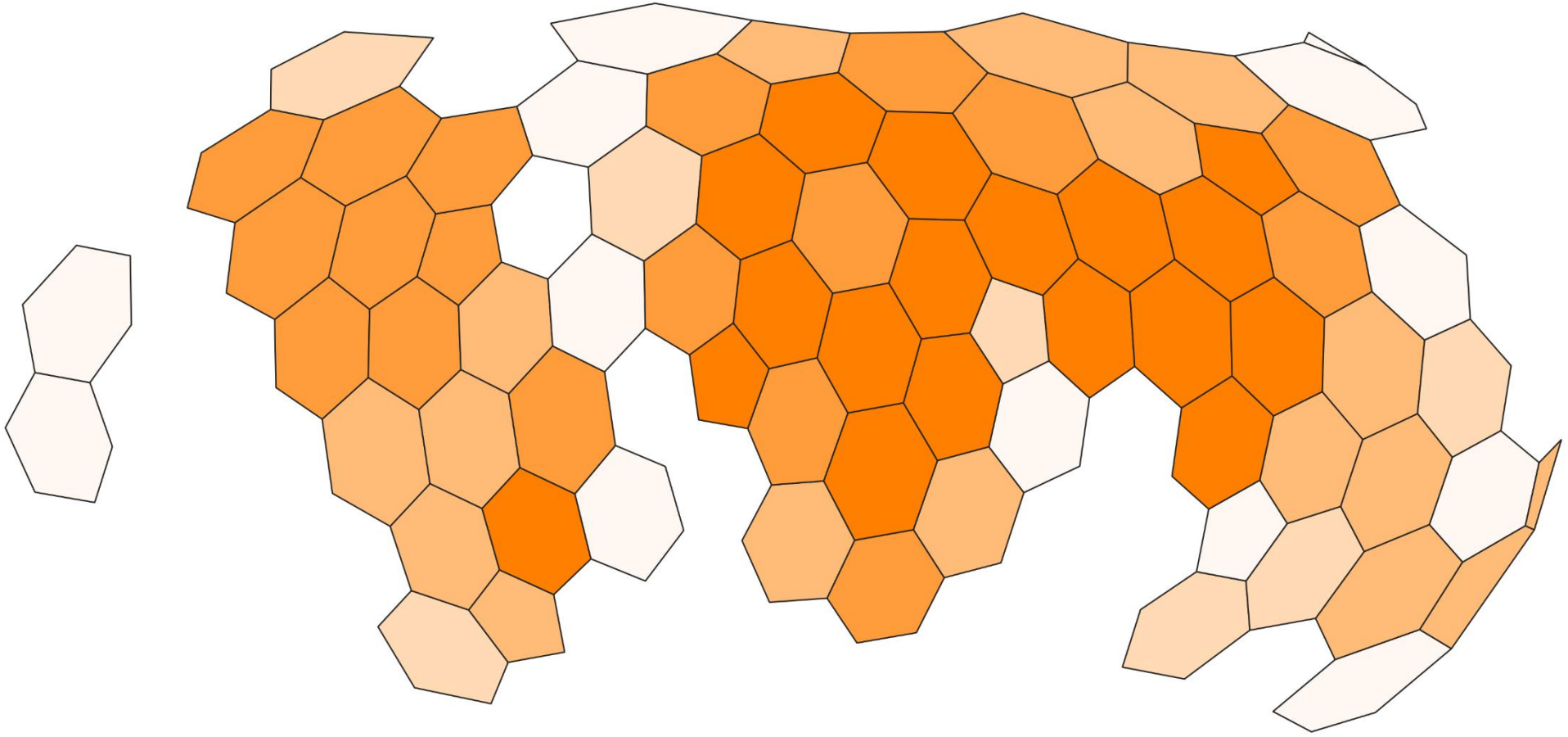


(1km^2 WorldPop)

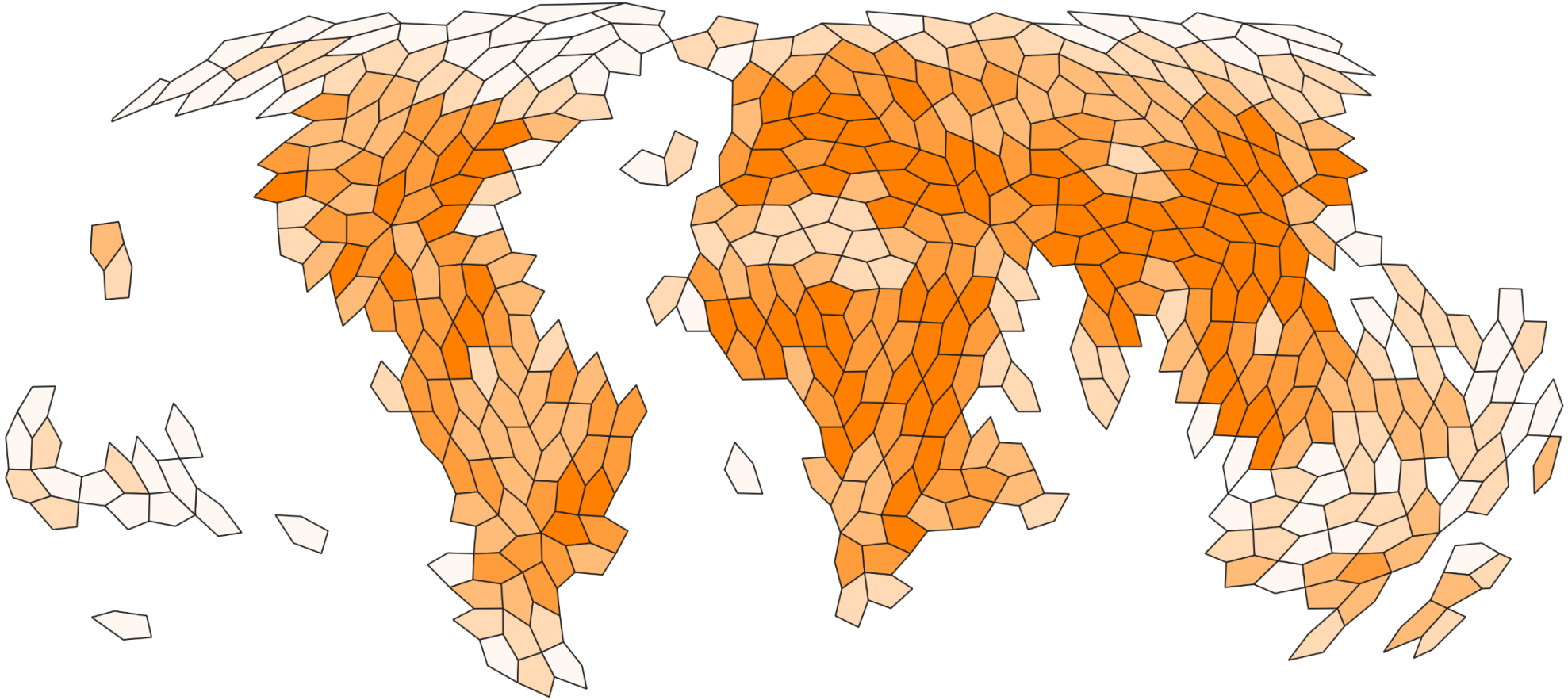
Where do people huddle



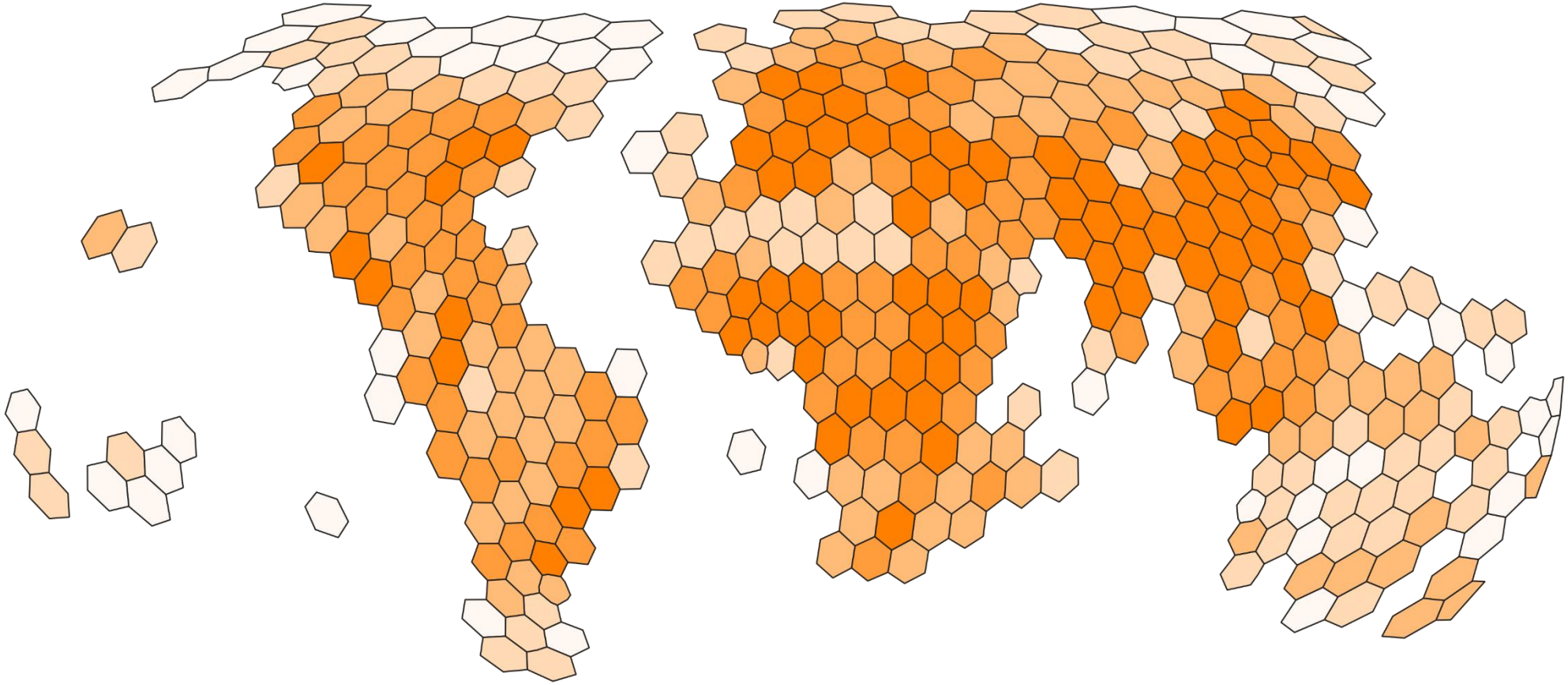
Where do people huddle



Where do people huddle



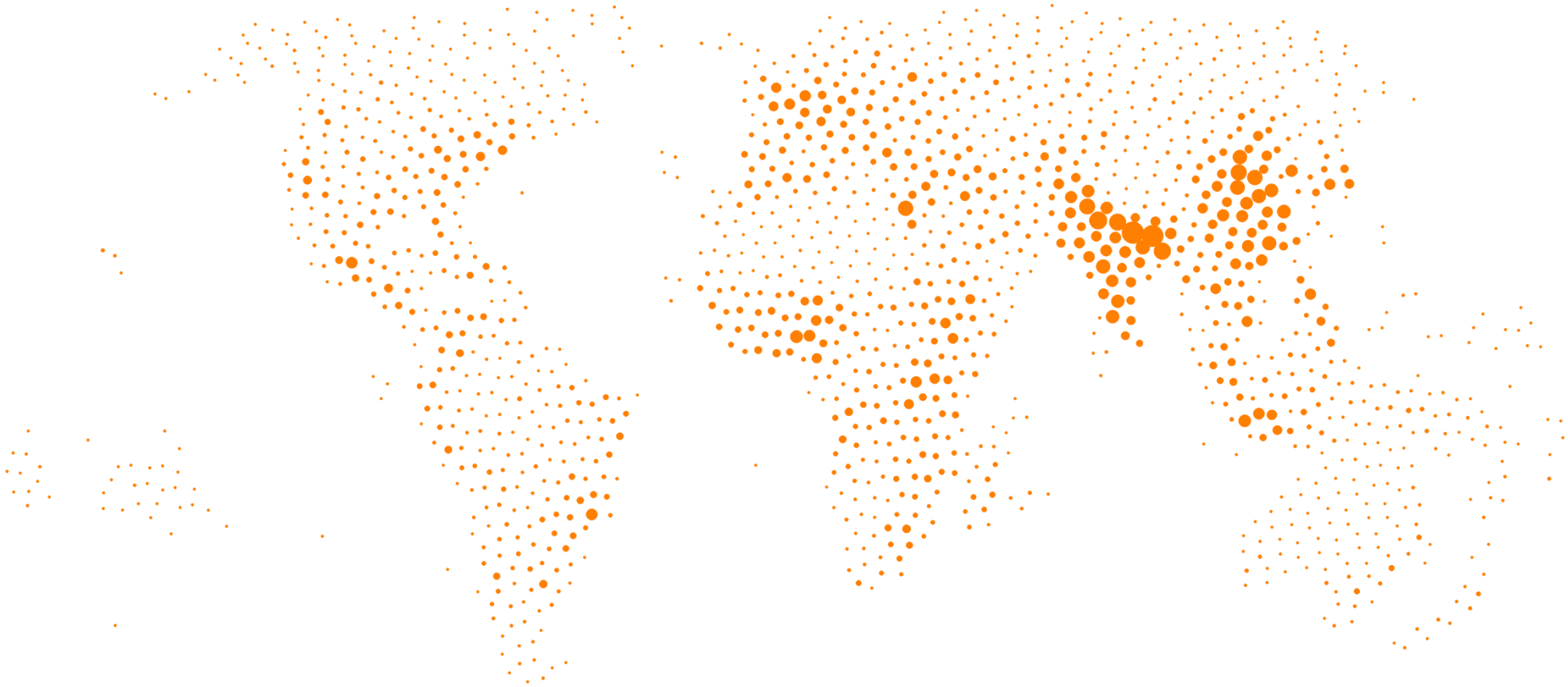
Where do people huddle



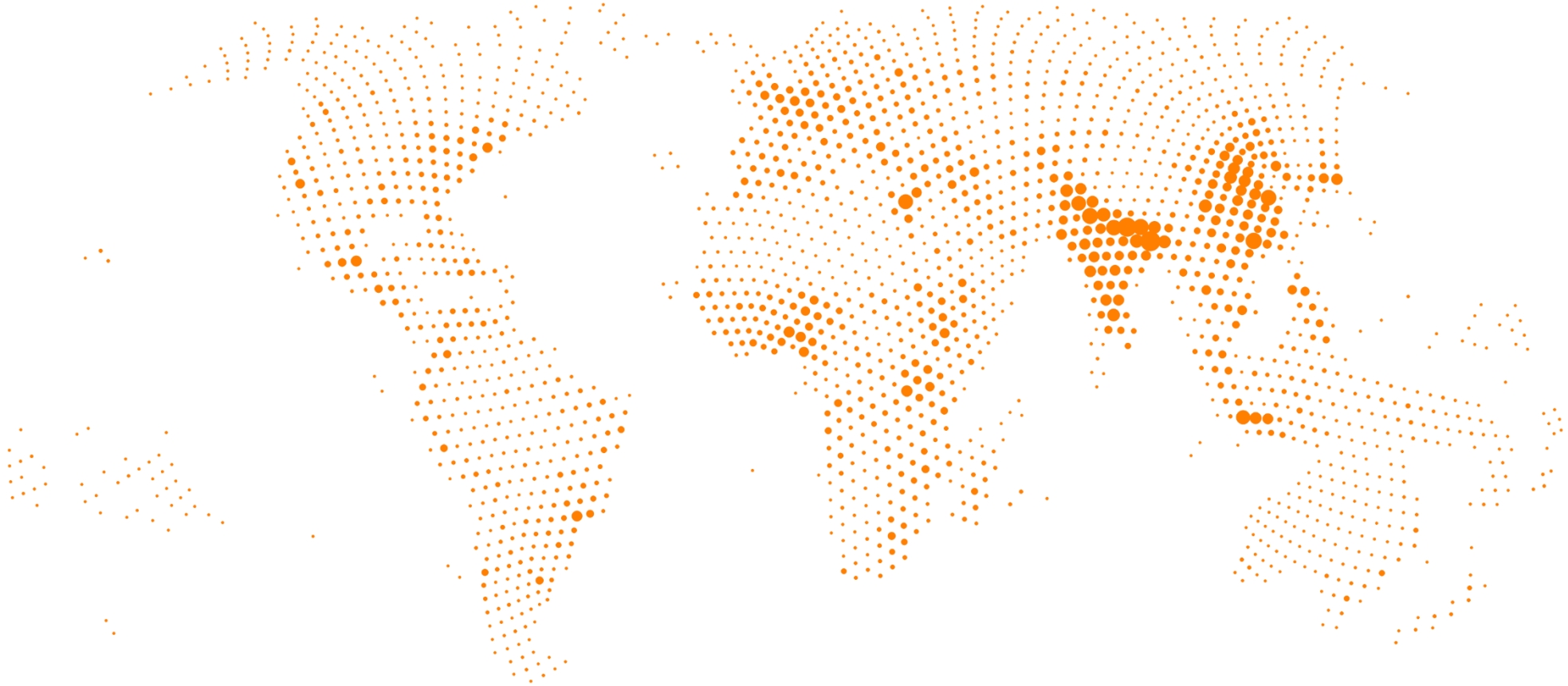
Network Building



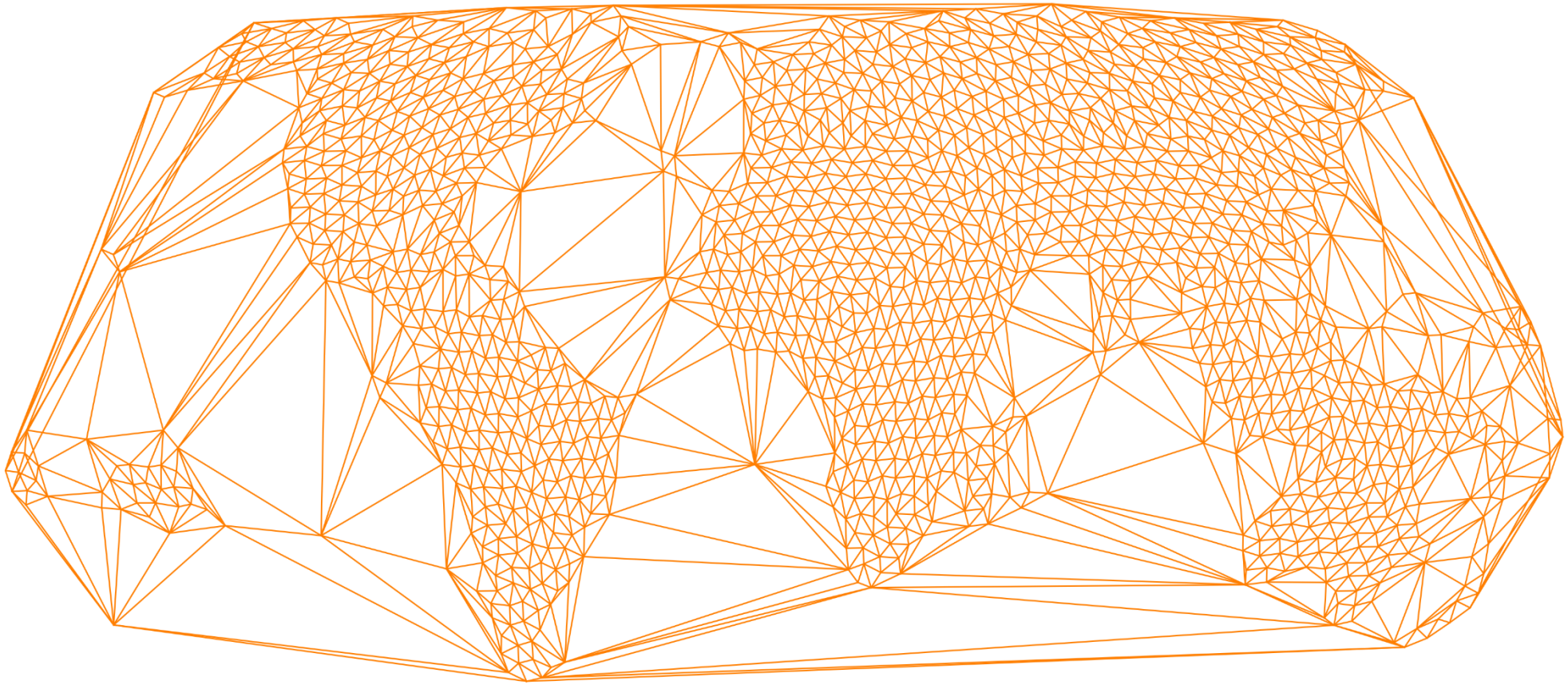
A5 Population



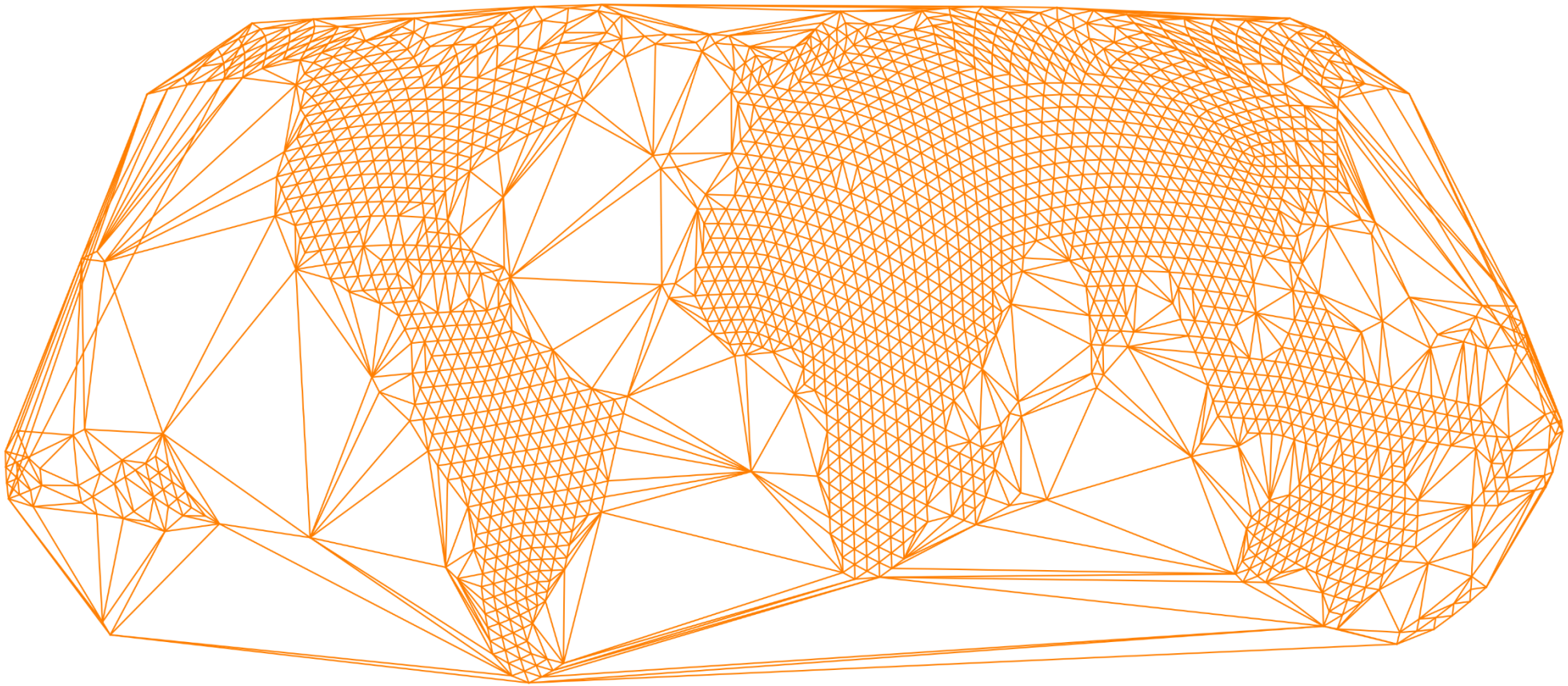
H3 Population



A5 Network



H3 Railway



Network Simplification



Network Simplification

Route network simplification for transport planning

AUTHORS
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Zhao Wang
Will Deakin
Josiah Parry

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Digital, Data and Technology services, Network Rail, UK
Environmental Systems Research Institute, Redlands, CA, USA

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Abstract
1 Introduction
2 Problem definition
3 Data and Methods
4 Application to Edinburgh City Centre
5 Discussion and Conclusion
6 Data Availability
7 References

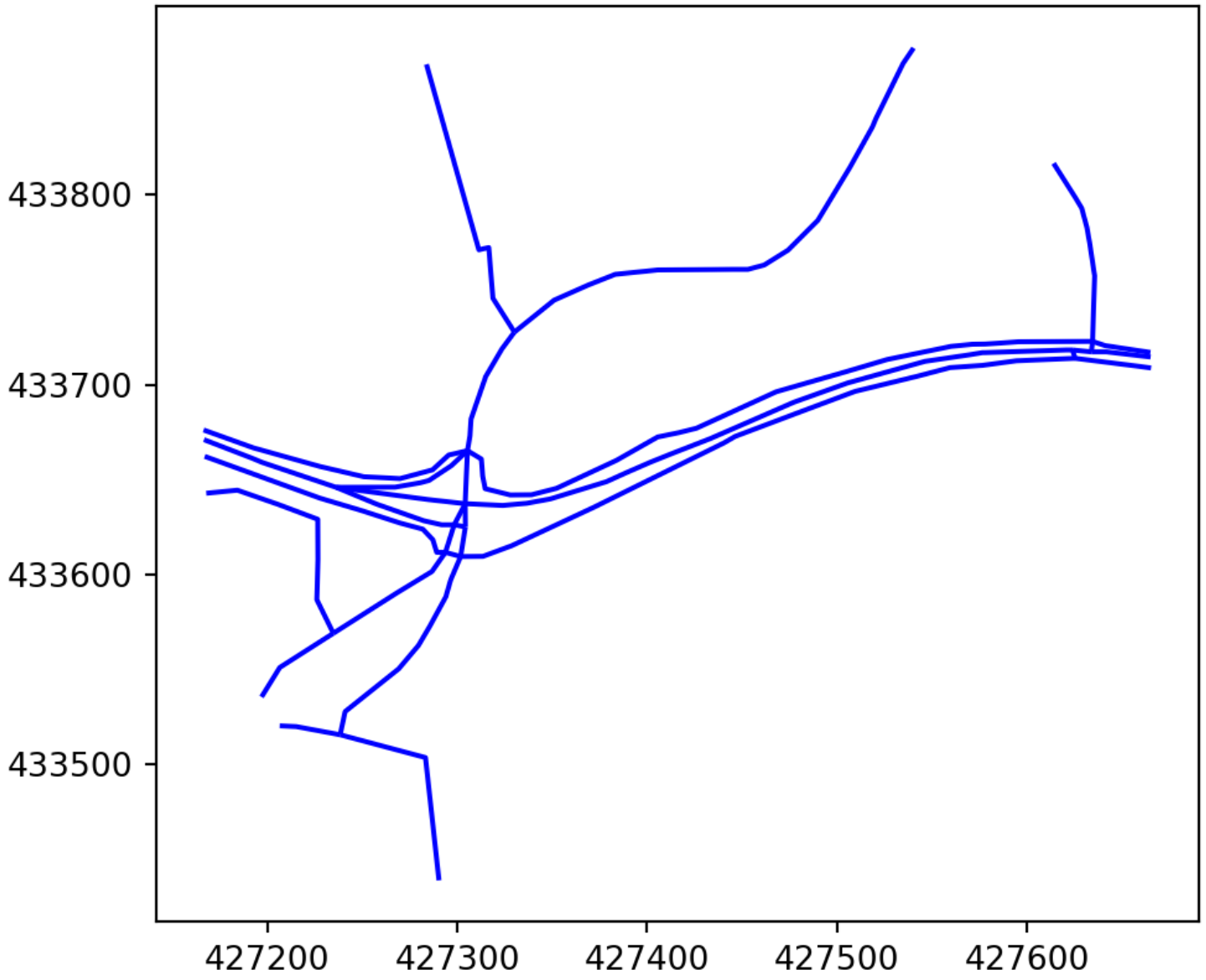
Abstract

Route network datasets are central to transport models as key inputs and outputs. The complexity of route network inputs from sources such as OpenStreetMap has increased over time, enabling more precise modelling of sustainable modes such as walking and cycling. However, this complexity can affect the visualisation of model results. A common issue is the presence of multiple parallel ways on the same corridor, which can lead to visual artefacts and misinterpretation of model outputs. To address this challenges, we present and compare two methods for *simplifying* route network datasets: 1) image skeletonization and 2) Voronoi diagram-centreline identification. These methods have real-world applications, as illustrated in the “Simplified network” layer in the Transport for Scotland funded Network Planning Tool, which is publicly available at www.npt.scot. Based on open access data and the open source `parenx` Python package, available on the Python Package Index, these methods are not only reproducible but also adaptable, enbabling their use in new contexts.

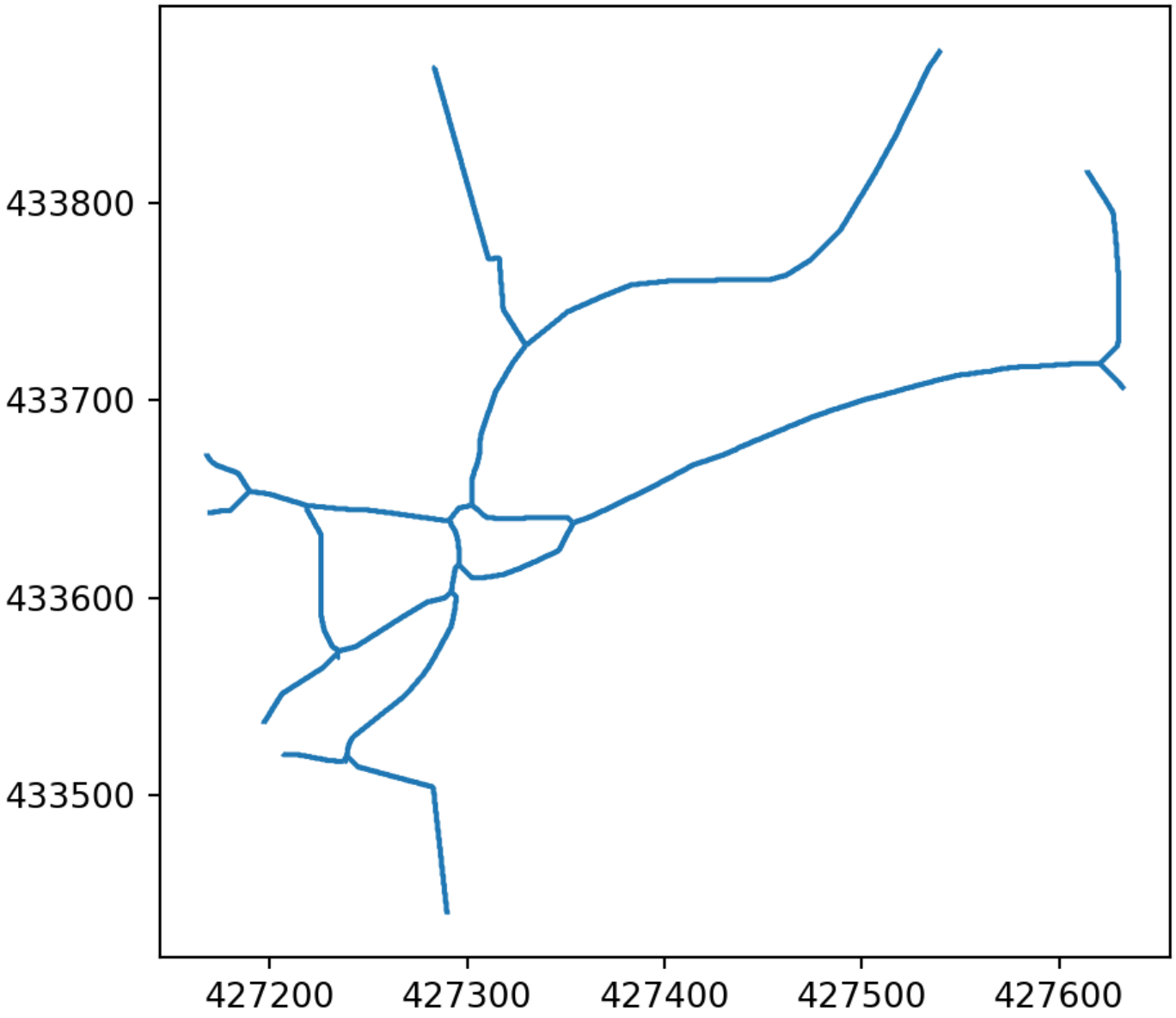
1 Introduction

Datasets representing route networks are important in every stage of transport planning. Transport network datasets are *spatial networks* composed of nodes and edges, in which each edge has an associated edge cost (its weighted or unweighted length) (Barthélemy 2011). Nodes (points connecting edges) and the edges that connect them (lines between nodes representing ways) are located in space, with the edges representing the physical infrastructure of the transport network, often with attributes such as the type of way, its physical characteristics,

Armley


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Armley


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Network Simplification

How to use the `parenx` module scripts to simplify linear network features

AUTHORS

Will Deakin
Robin Lovelace
Zhao Wang
Josiah Parry

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Leeds Institute for Transport Studies, University of Leeds, UK
Leeds Institute for Transport Studies, University of Leeds, UK
Environmental Systems Research Institute, Redlands, CA, USA

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Reproducibility
1 Introduction
2 Set up and run
3 Simplification: TL;DR
4 Helper script
5 Acknowledgement

Reproducibility

▸ Details

1 Introduction

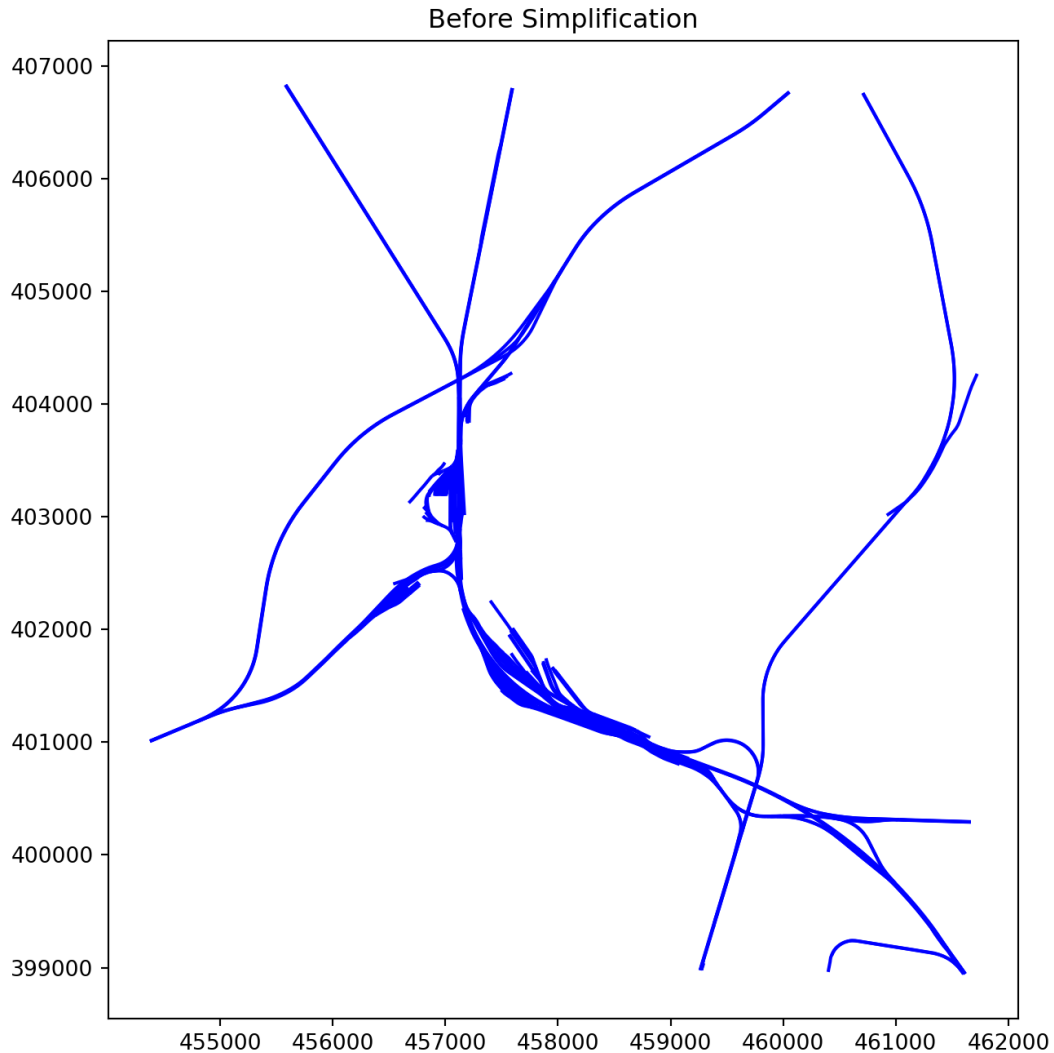
This cookbook is an addendum of the network merge paper[1], and consists of a number of examples based on real datasets used in the development and testing. As part of this for the paper the standalone `parenx` module[2] was developed and deployed to `pypy`. However, noting this is **beta software**, this module is neither well documentmed nor intuitive to use. So the hope is that by sharing these examples will make using these scripts a bit less painful.

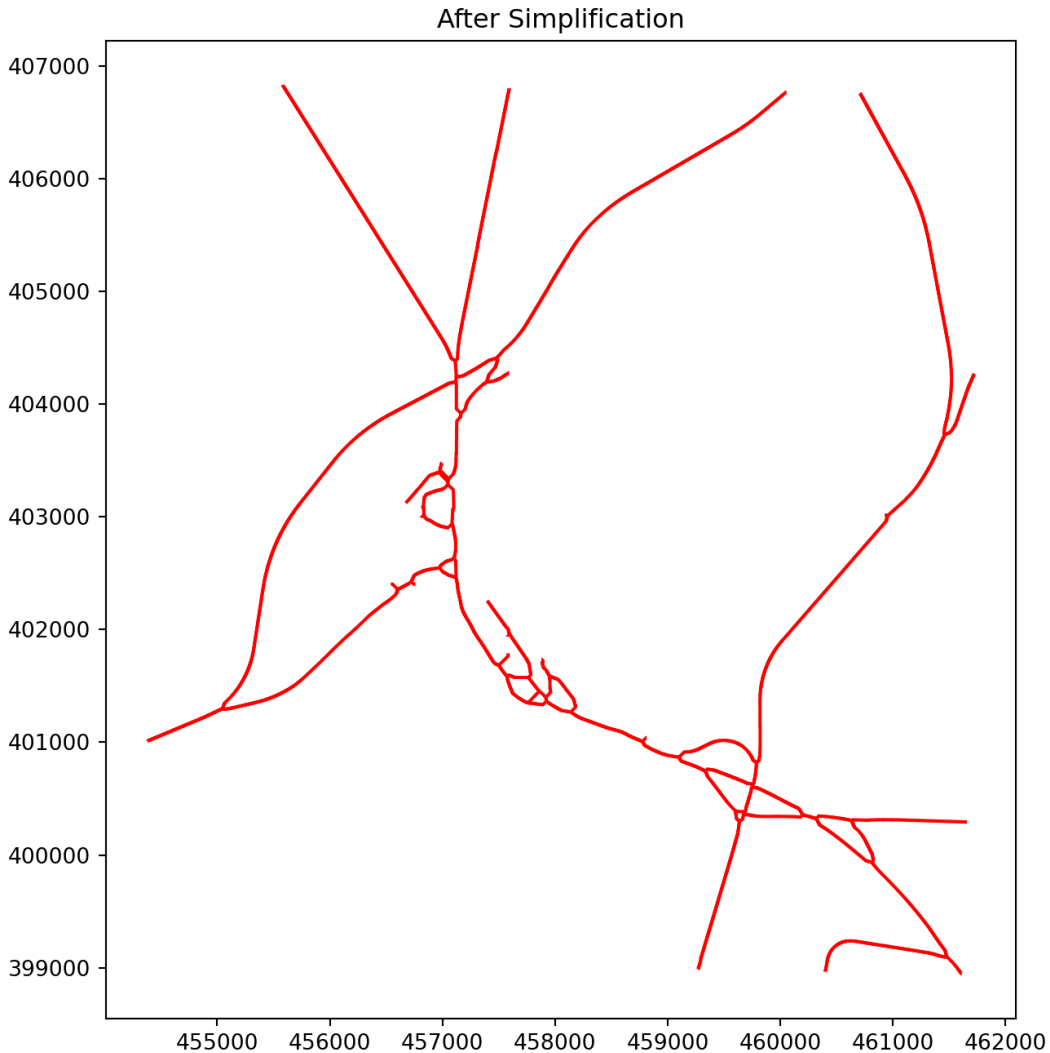
This was developed and tested on a Debian Linux variant[3] and run on the command-line interface with various versions of `python3`. While not tested on other environments they should work on under environments and operating systems.

2 Set up and run

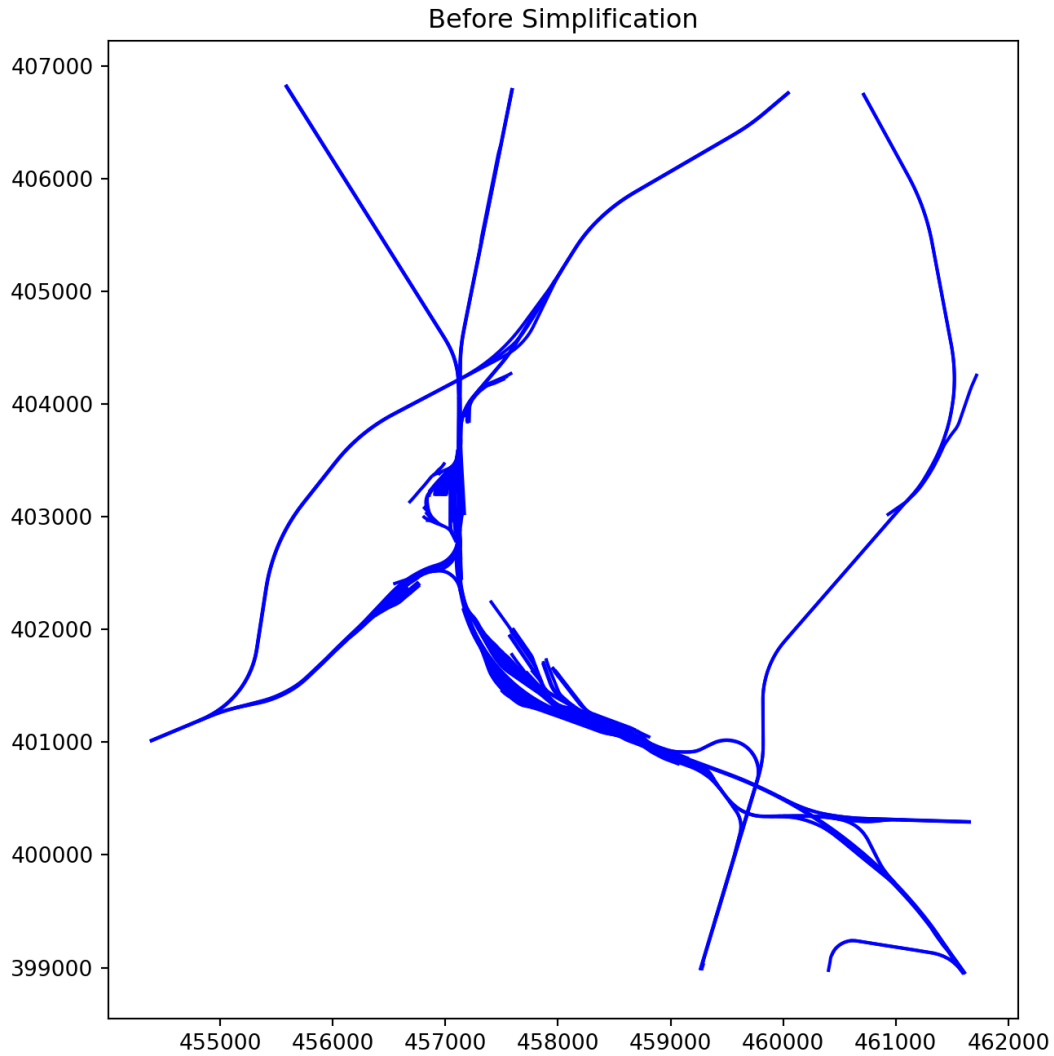
In this example create a working project directory, say `elegant-tern`, and set a virtual-environment and simplify data there. This assumes you have `bash` and a working base `python3` installation.

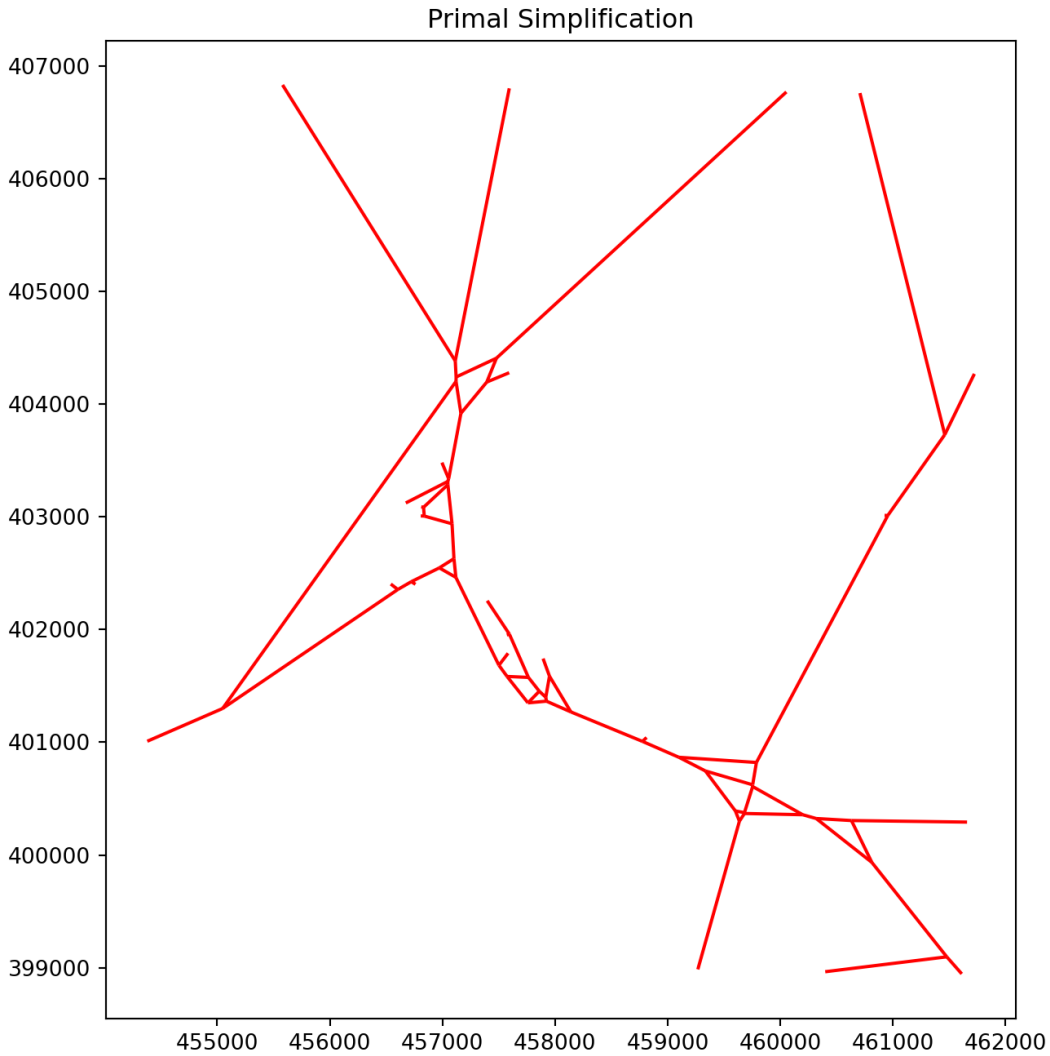
Doncaster


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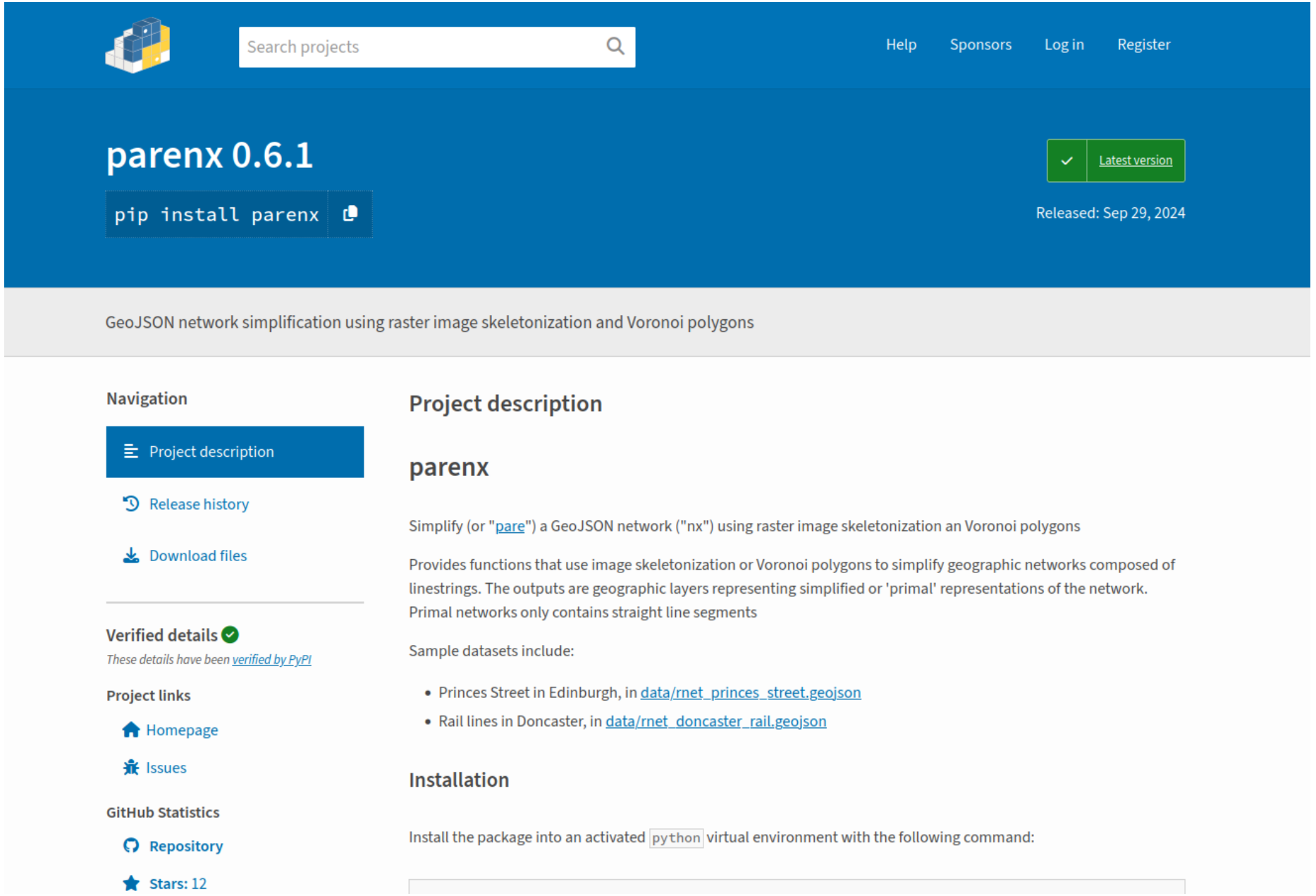

After Simplification
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Doncaster


Before Simplification
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Primal Simplification
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PyPI


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GeoJSON network simplification using raster image skeletonization and Voronoi polygons
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Project description
parenx
Simplify (or "pare") a GeoJSON network ("nx") using raster image skeletonization an Voronoi polygons
Provides functions that use image skeletonization or Voronoi polygons to simplify geographic networks composed of linestrings. The outputs are geographic layers representing simplified or 'primal' representations of the network. Primal networks only contains straight line segments
Sample datasets include:
Princes Street in Edinburgh, in data/rnet_princes_street.geojson
Rail lines in Doncaster, in data/rnet_doncaster_rail.geojson
Installation
Install the package into an activated python virtual environment with the following command:

Paper

Environment and Planning B: Urban Analytics and City Science

Impact Factor: **3.1** / 5-Year Impact Factor: **3.8**

Open access | Other | First published online October 22, 2025

Route network simplification for transport planning

Will Deakin, Zhao Wang, [...], and Robin Lovelace +1 View all authors and affiliations

OnlineFirst | https://doi.org/10.1177/23998083251387986

Contents | PDF/EPUB | Cite | Share options | Information, rights and permissions | Metrics and citations

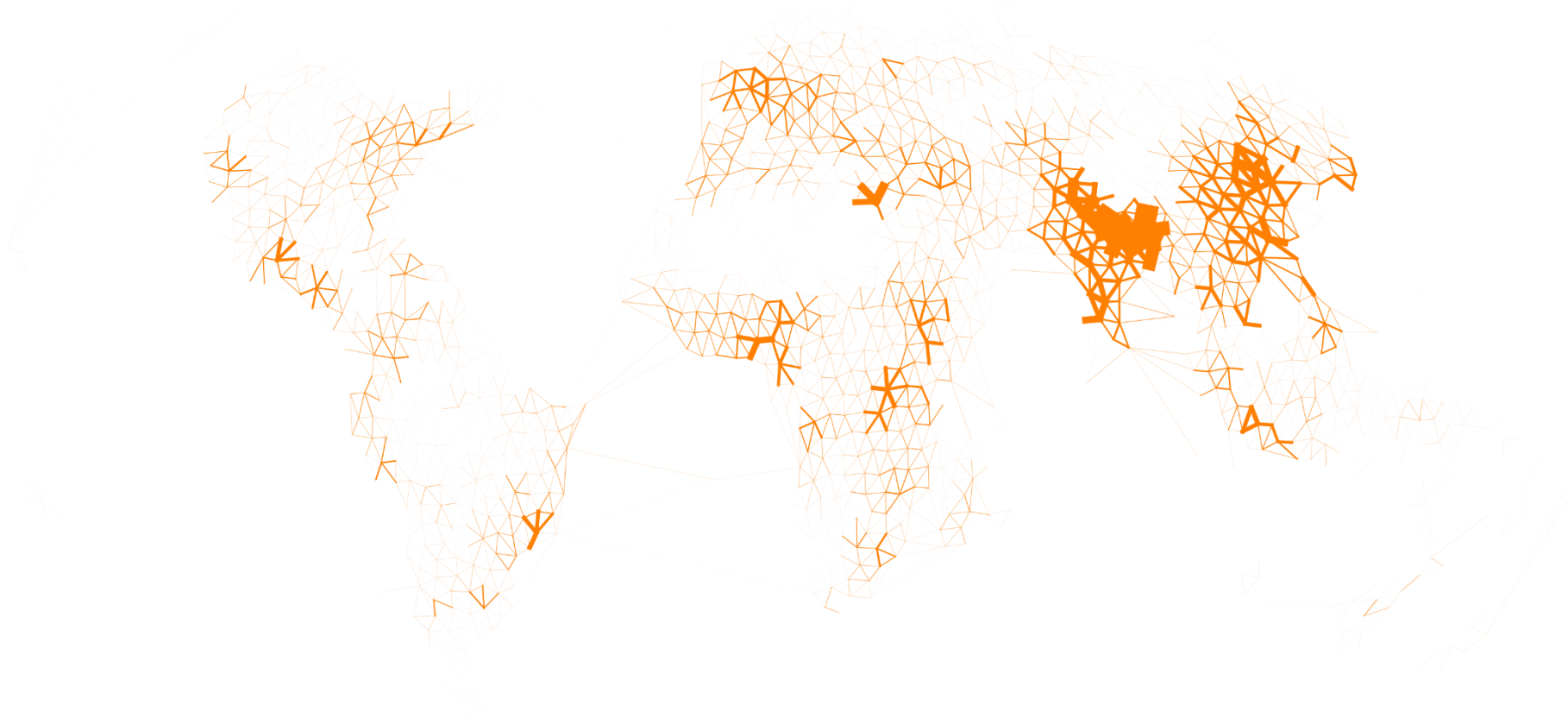
Abstract

Route network datasets are fundamental to transport models, serving as both inputs for analysis and outputs for visualization and decision-making. The increasing complexity of route network data from sources like OpenStreetMap allows for more detailed modelling of sustainable transport modes such as walking and cycling. However, this level of detail can introduce challenges for the clear visualization and interpretation of model results. A common problem is the representation of single transport corridors by multiple parallel lines, which can create visual clutter and obscure important patterns in transport flows. The purpose of the work presented in this paper is to provide a basis for computationally efficient analysis and visualization of route networks for strategic transport planning, where intricate geometries, such as parallel or 'braided' linestrings, are unhelpful. We present and evaluate two distinct methods for simplifying complex route networks that are intended to be used as a 'pre-processing' step to speed up and improve the results of strategic transport network analysis, modelling, and visualization workflows. First, we present skeletonization, an approach that uses 'thinning' of rasterized network data to extract a simplified representation of the network. Second, we present a Voronoi-based approach using Voronoi diagrams to identify centrelines. We demonstrate the practical application of these methods using the 'Simplified network' layer in the Transport for Scotland-funded Network Planning Tool, a publicly accessible resource at https://www.npt.scot. To support reproducible research, we implement the methods in the open-source parenx Python package, enabling their use alongside other open source tools for transport planning, research, and educational applications.

Network Simplification



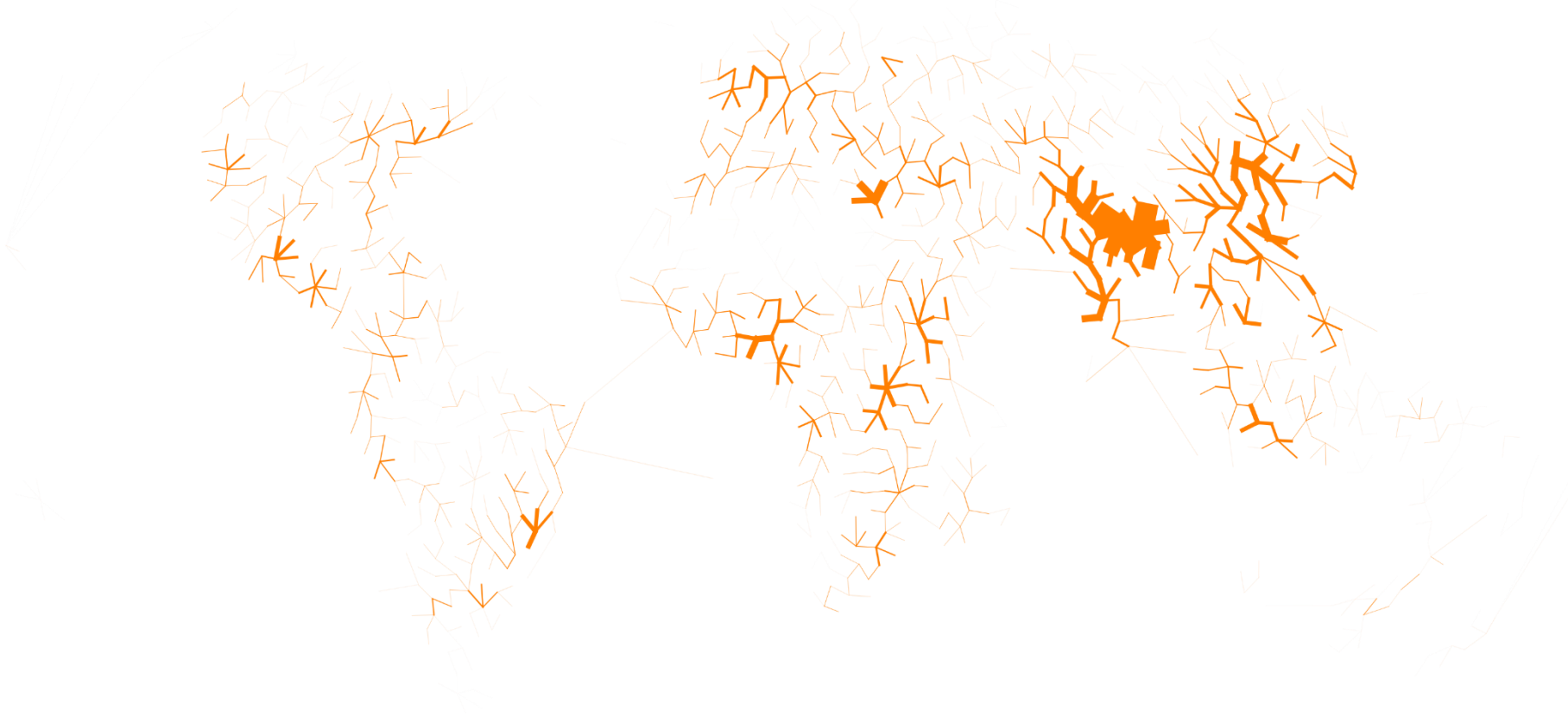
A5 Gravity Model



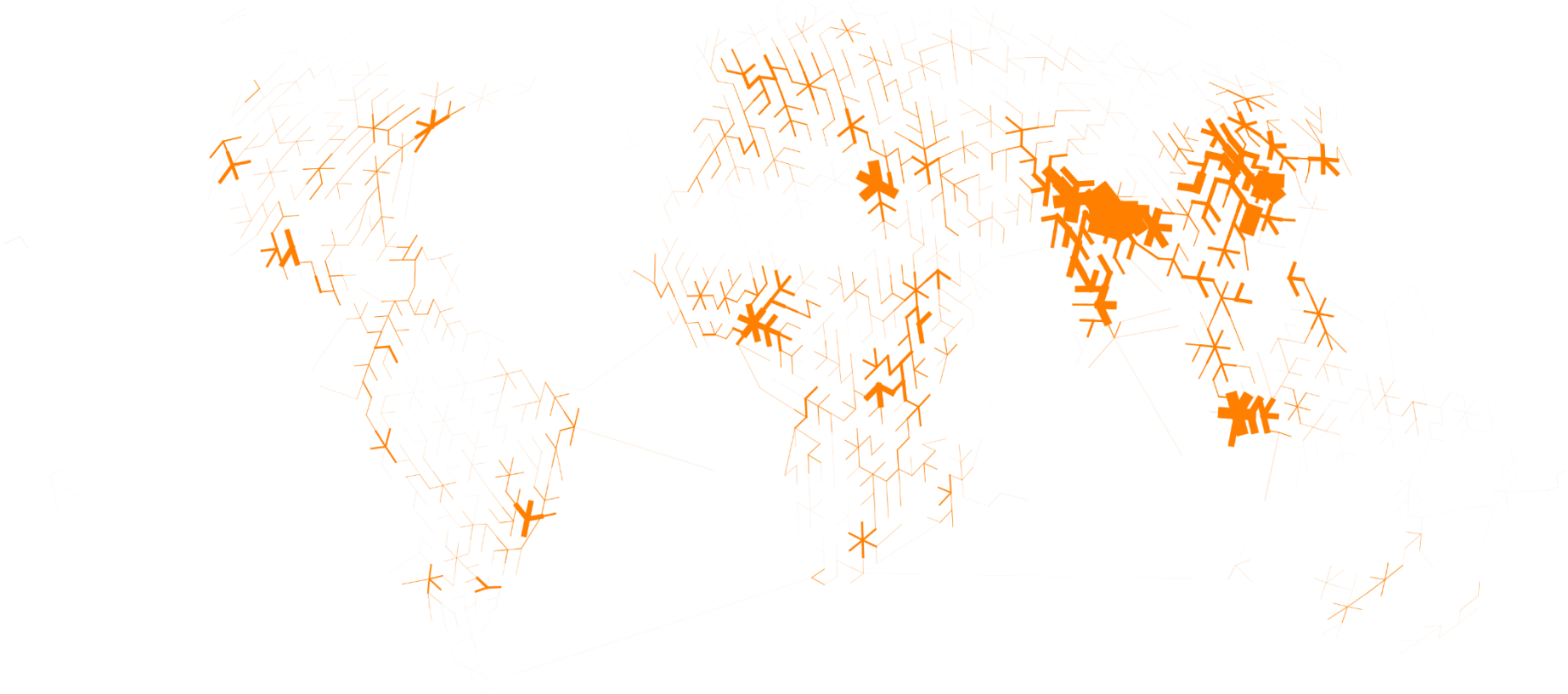
H3 Gravity Model



A5 Spanning Tree



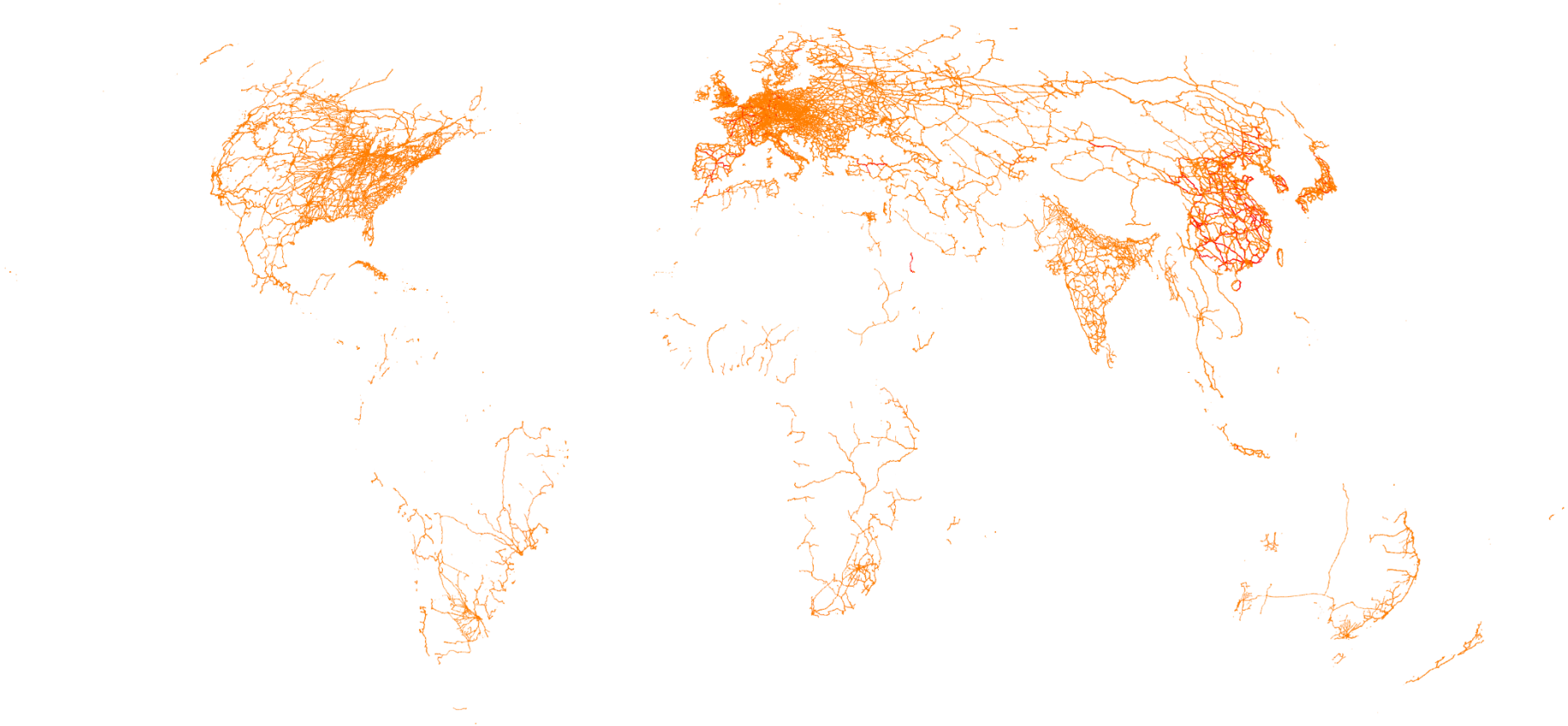
H3 Spanning Tree



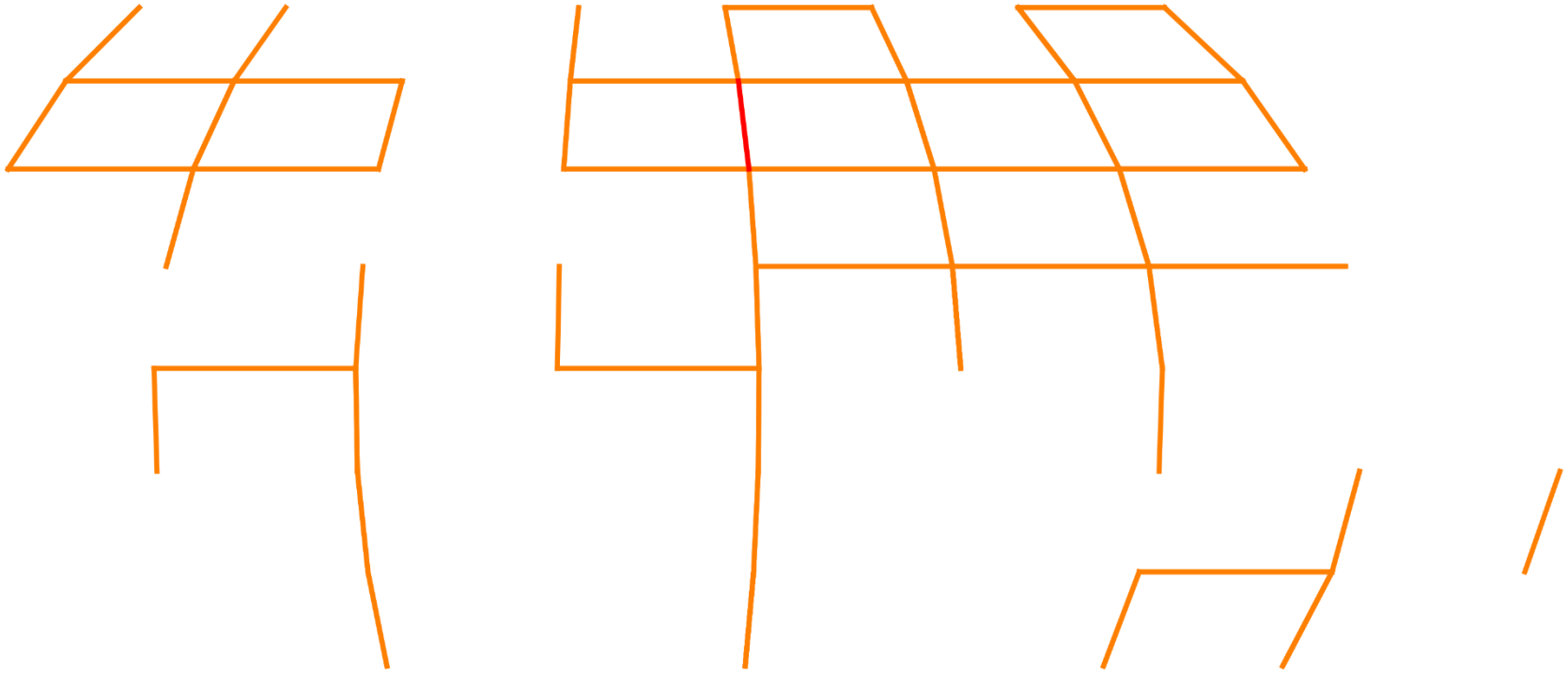
Rail Infrastructure



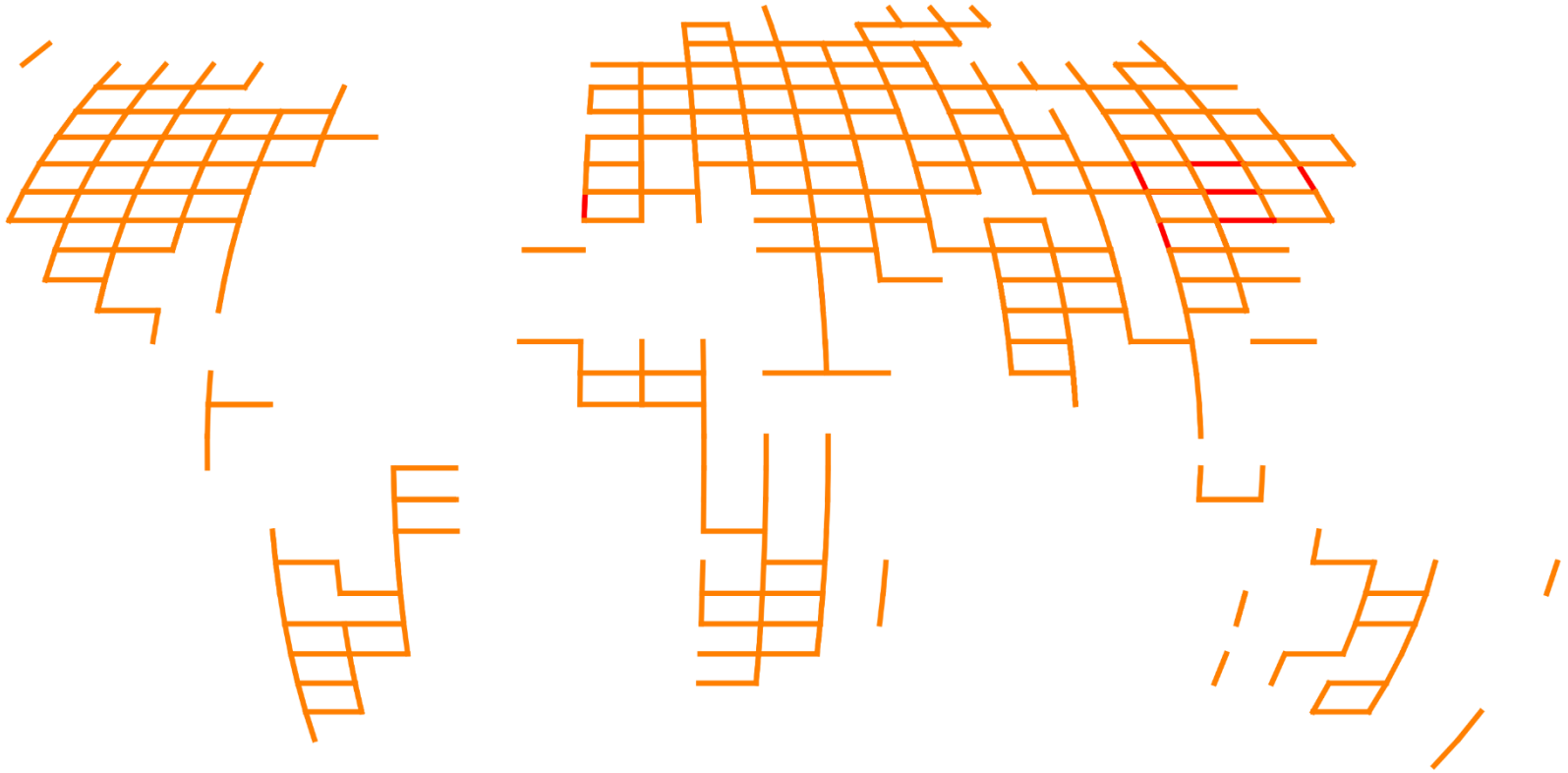
Railway



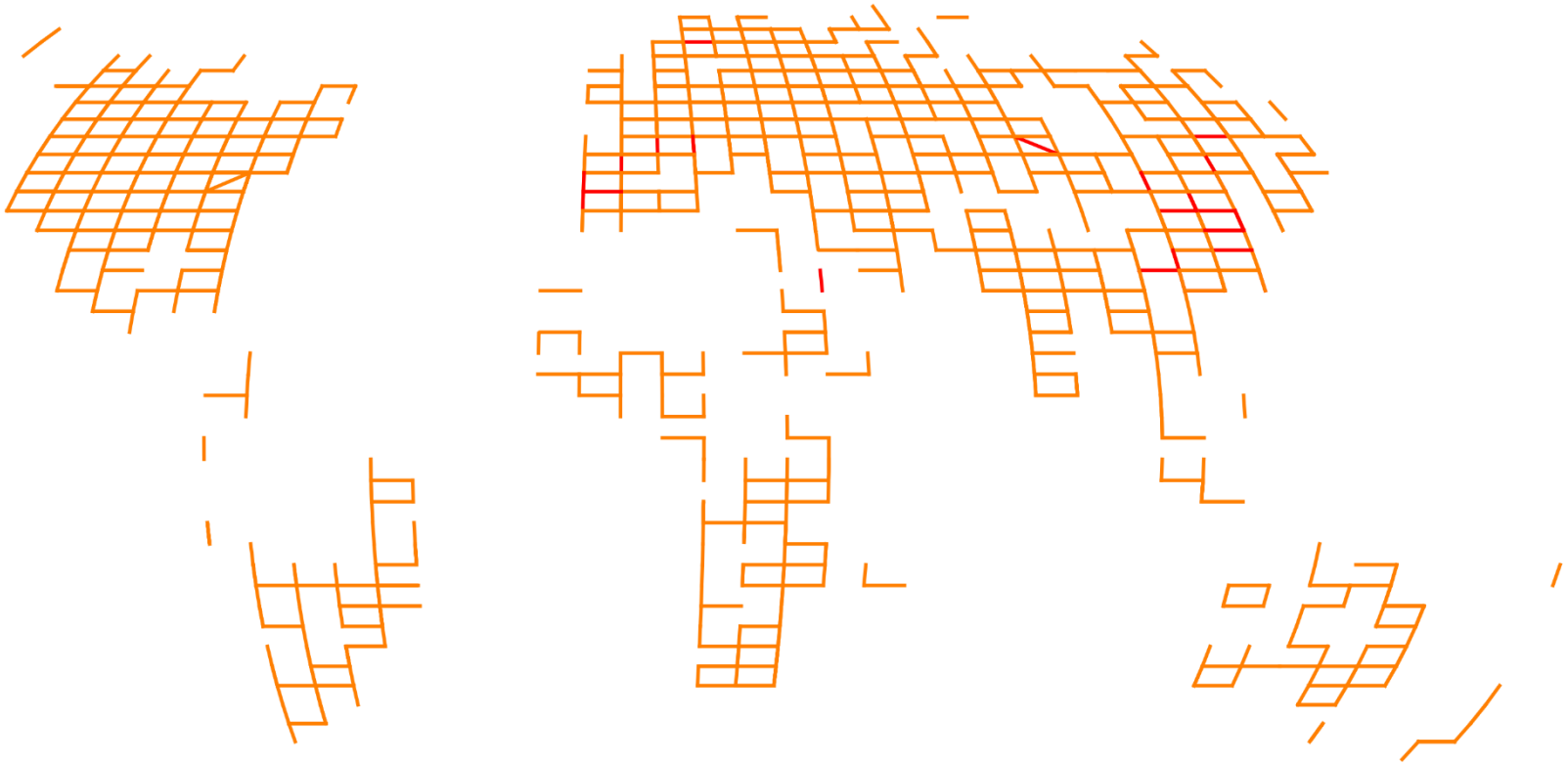
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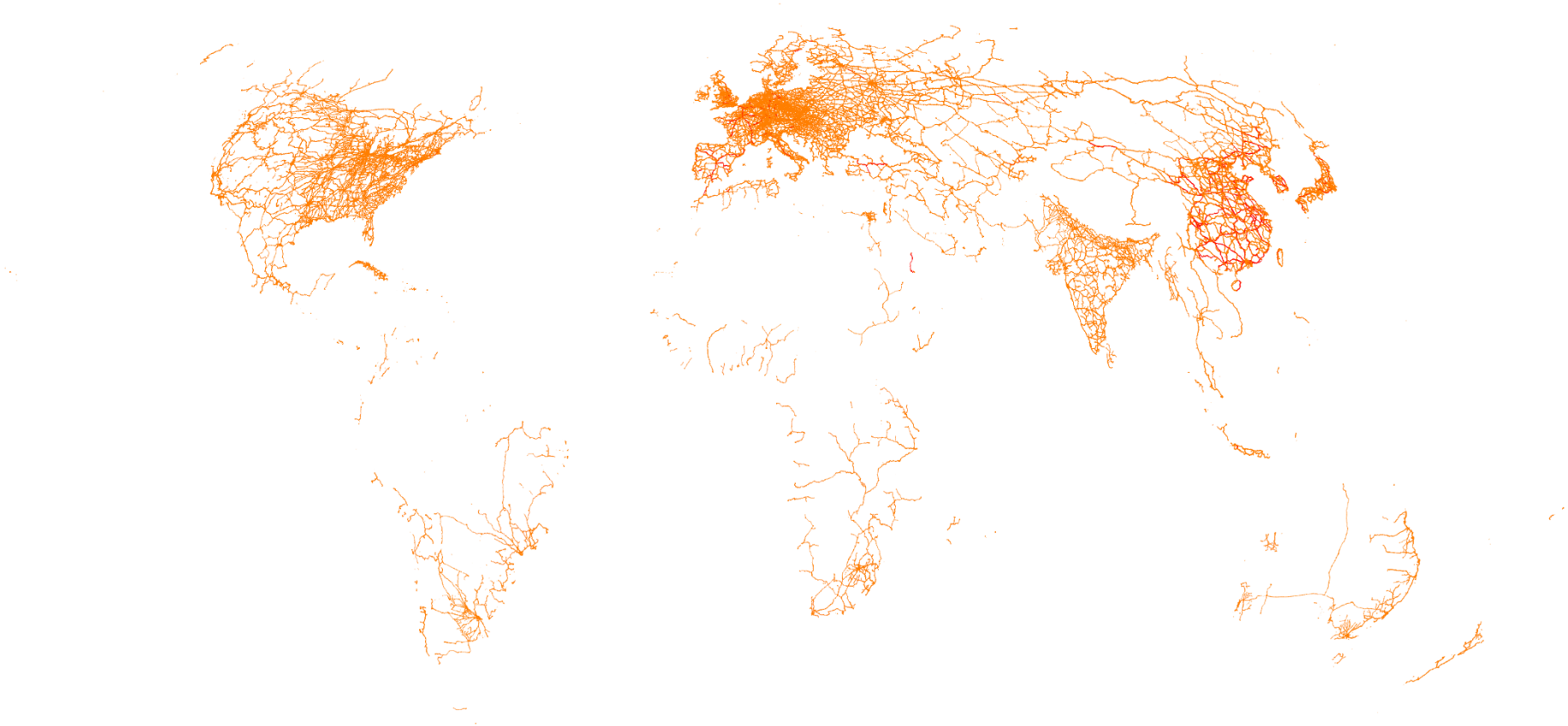
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Railway



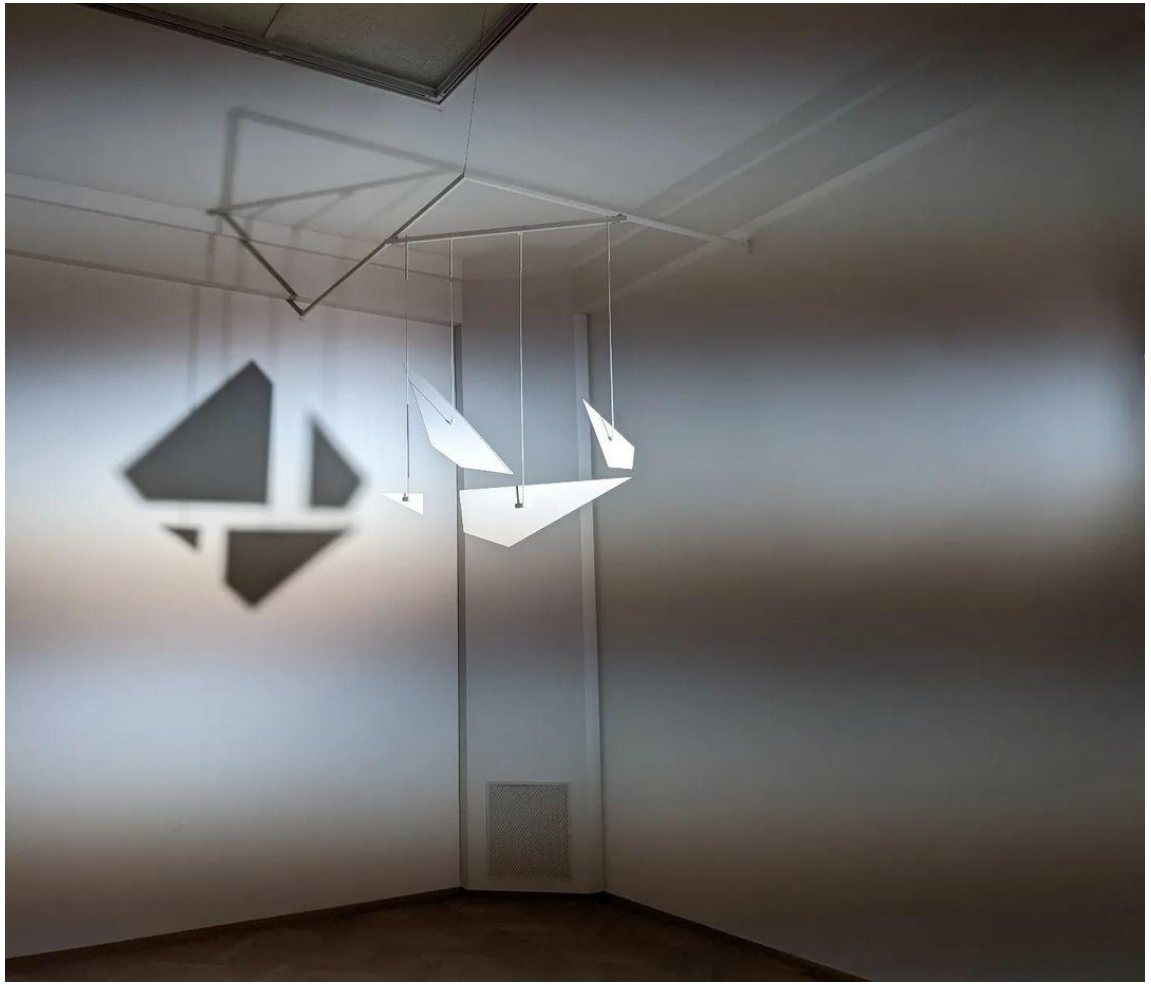
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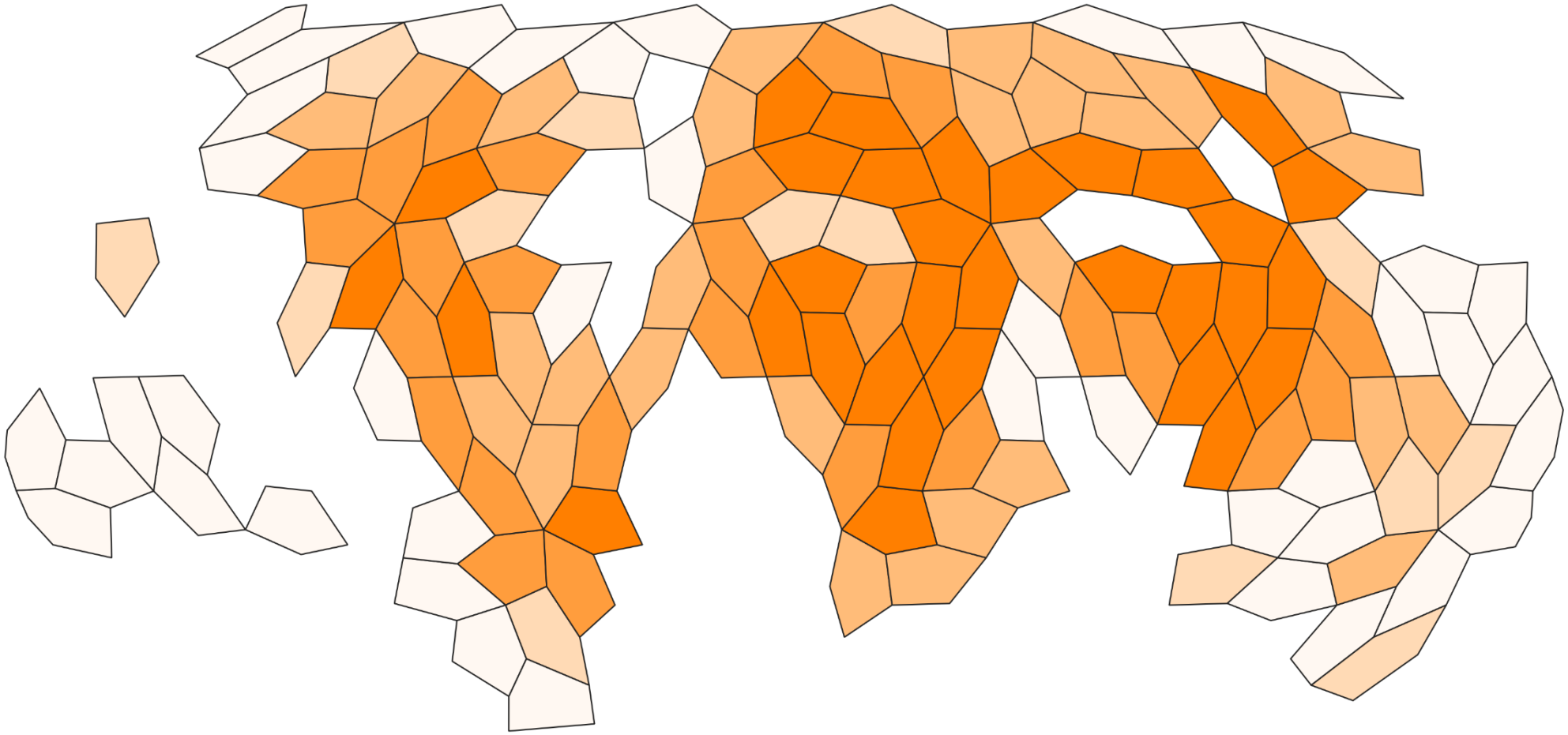
Global Rail



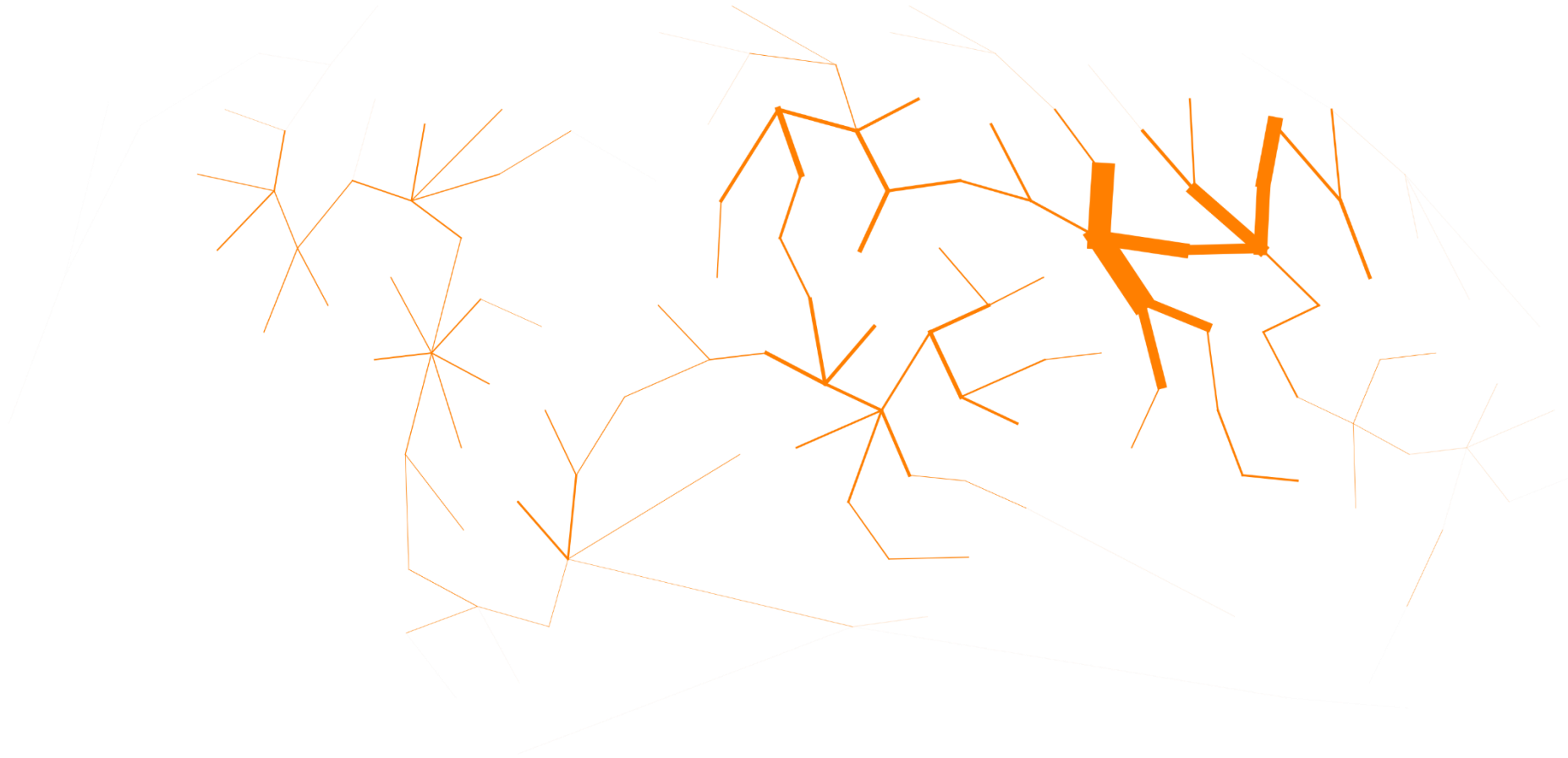
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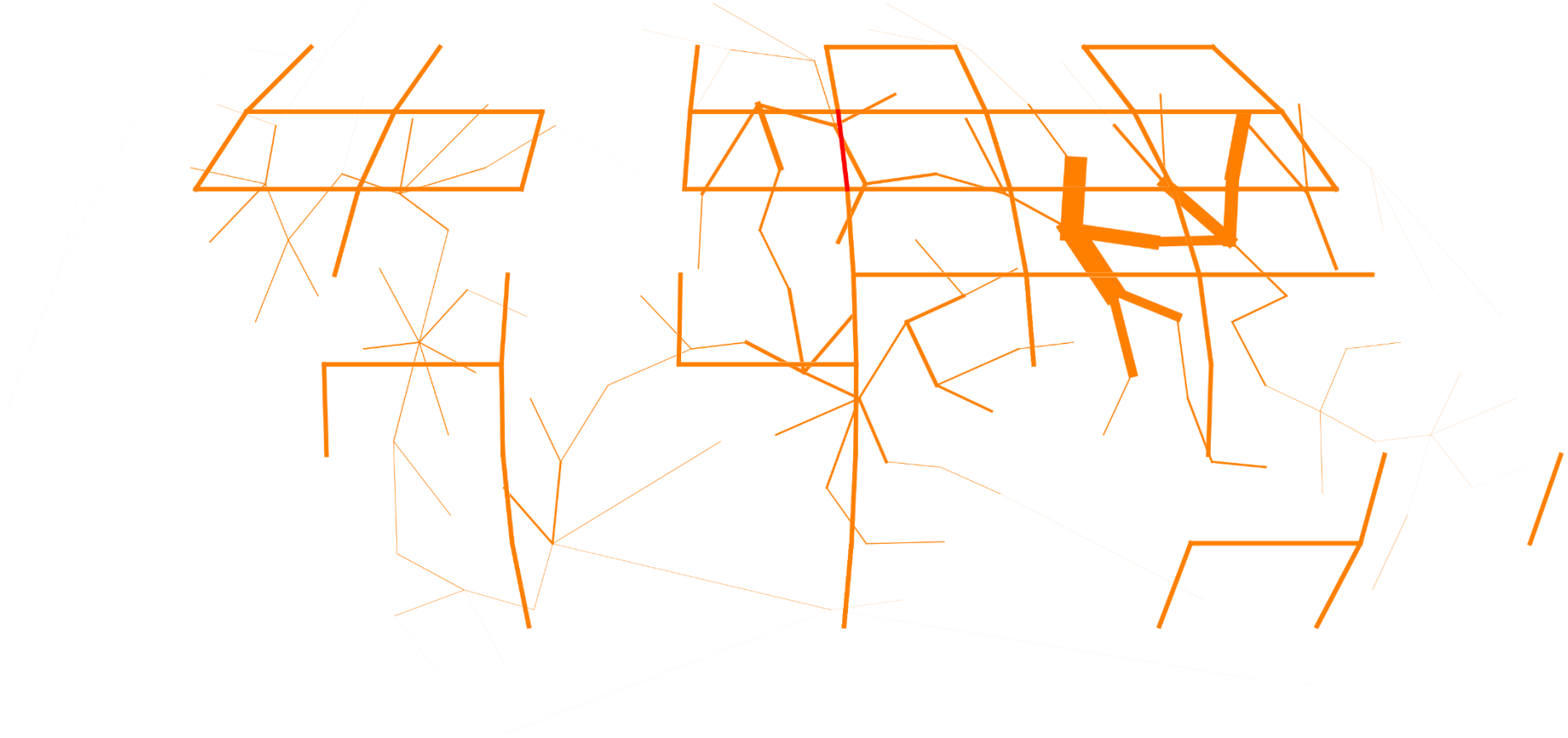
Railway



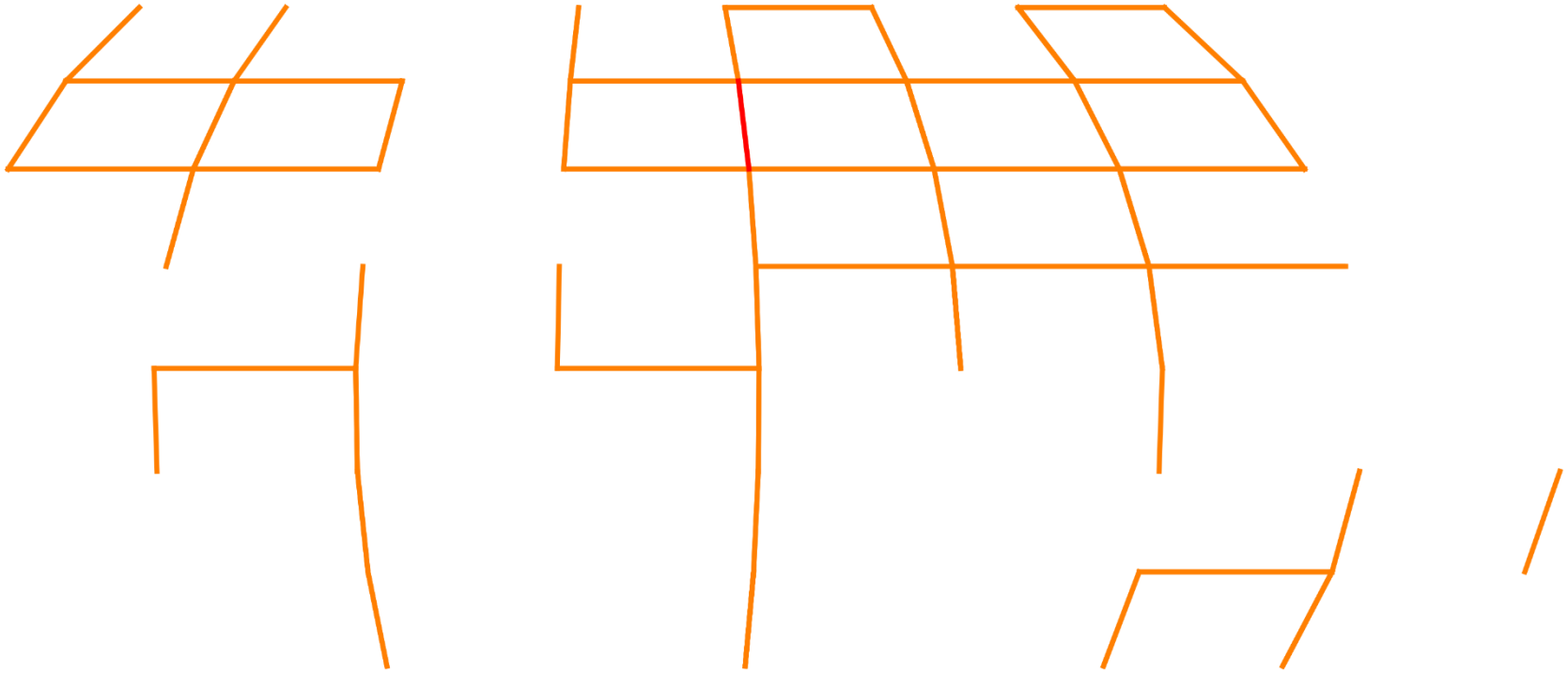
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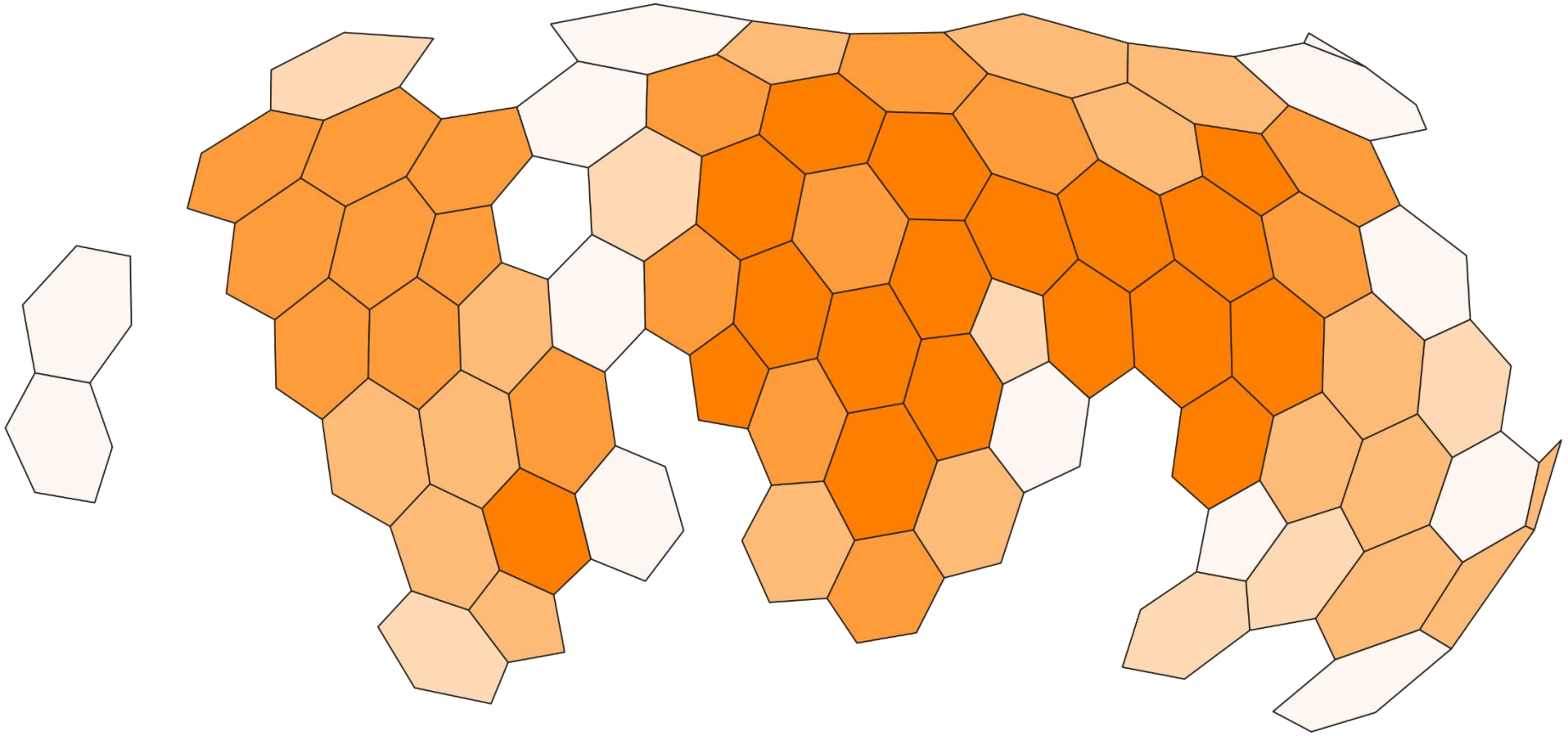
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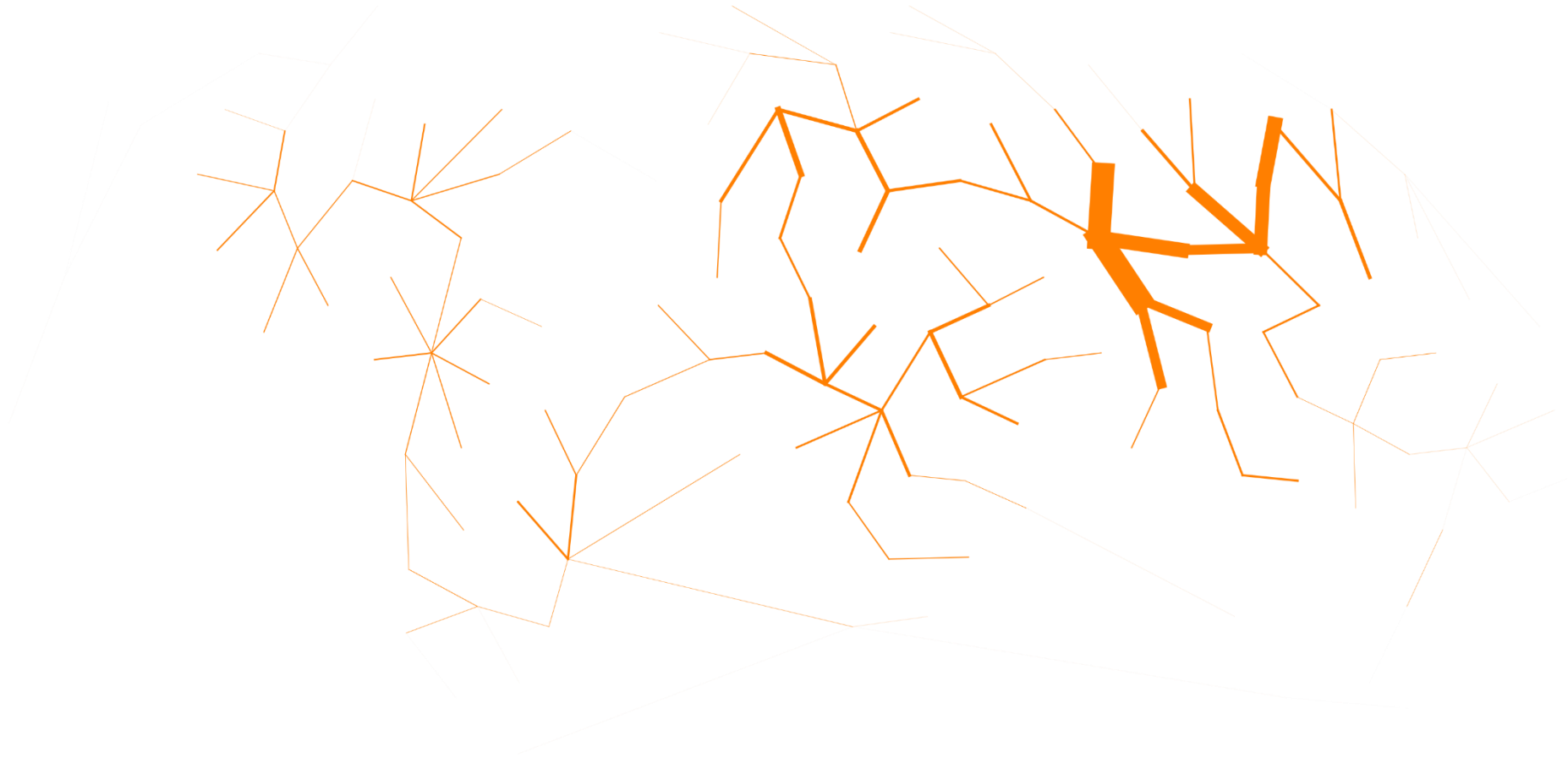
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Railway



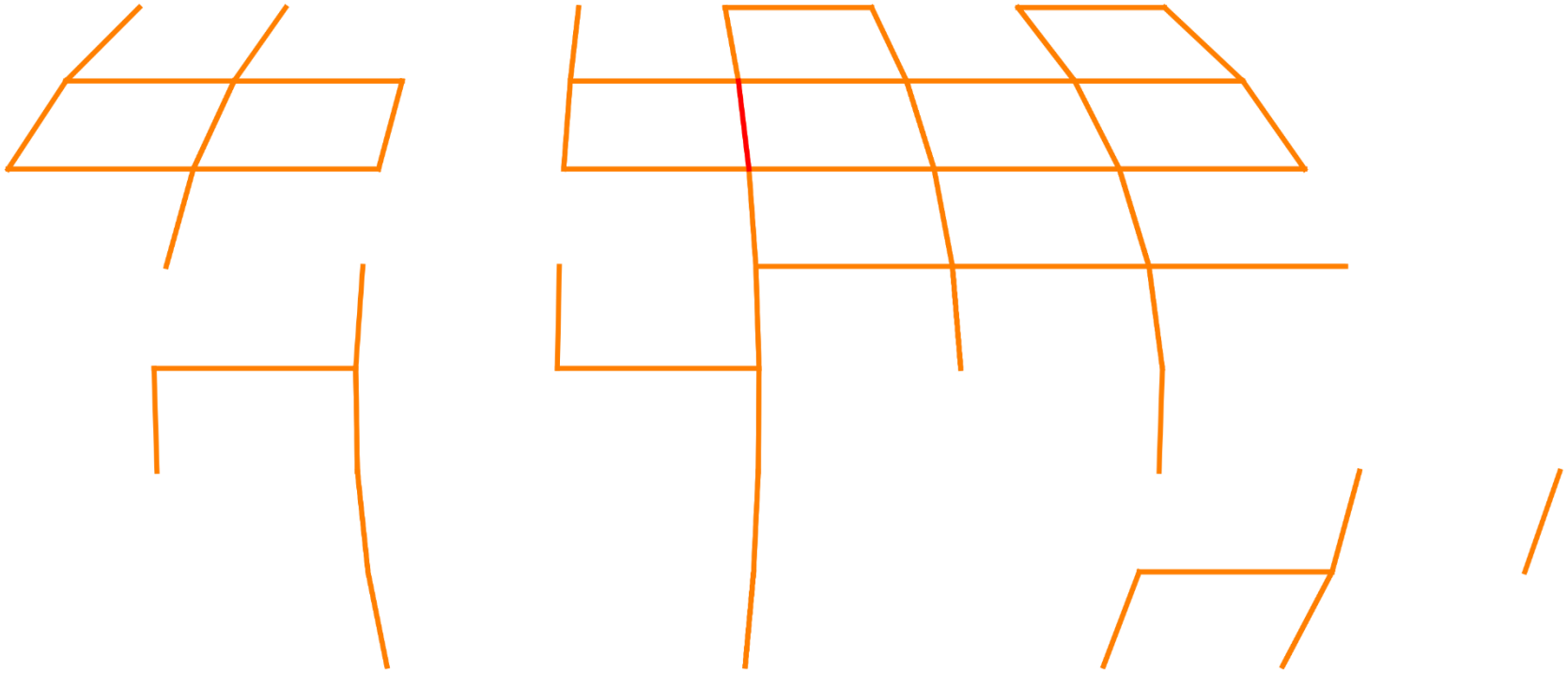
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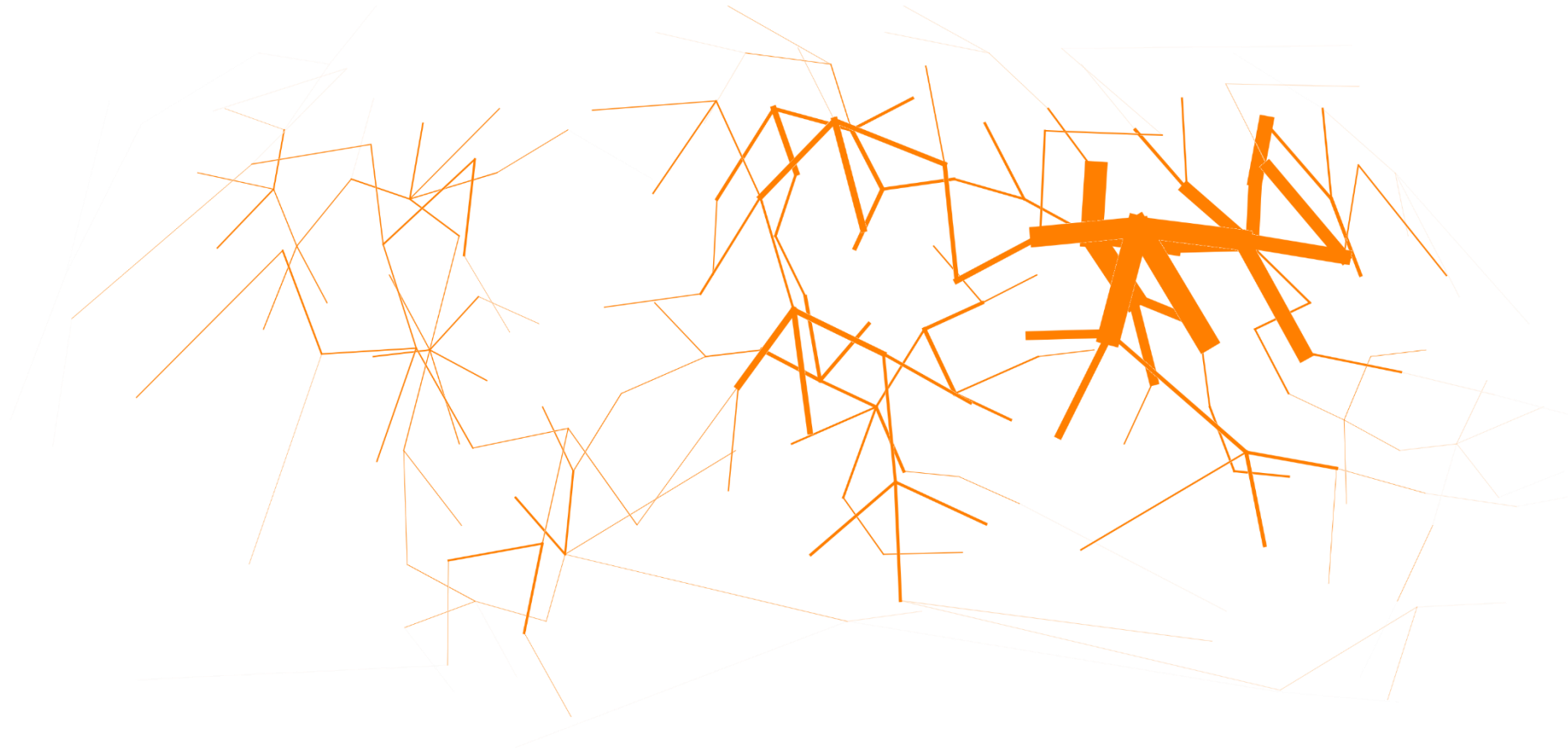
Railway



Railway



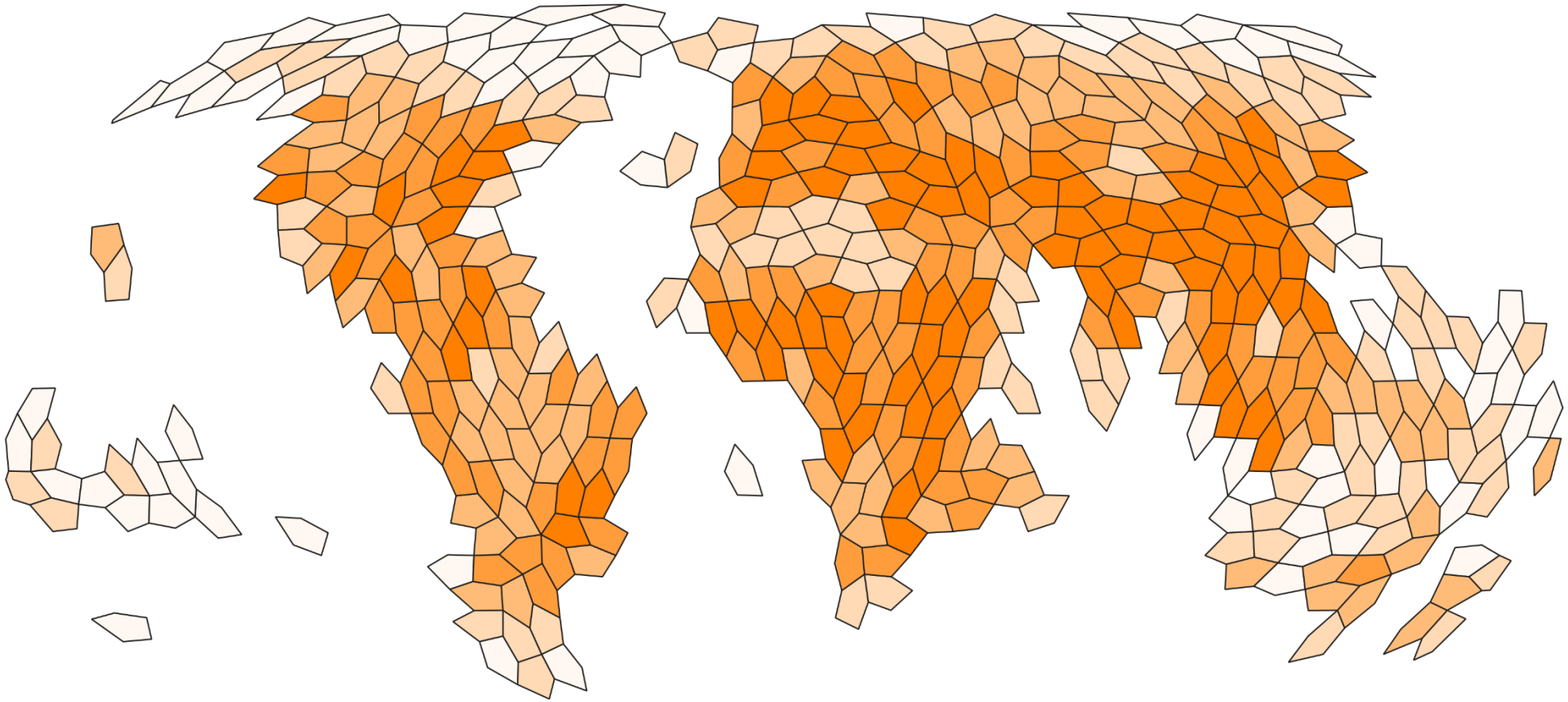
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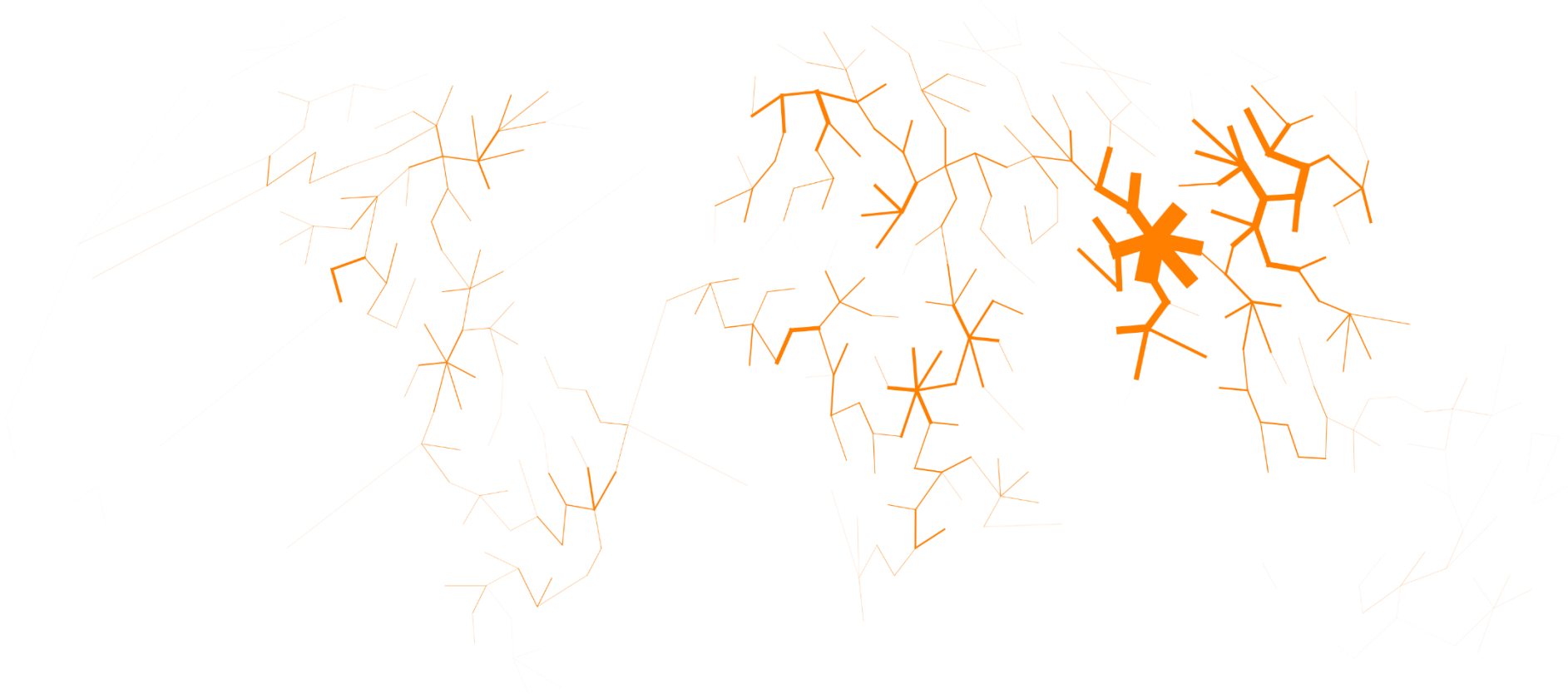
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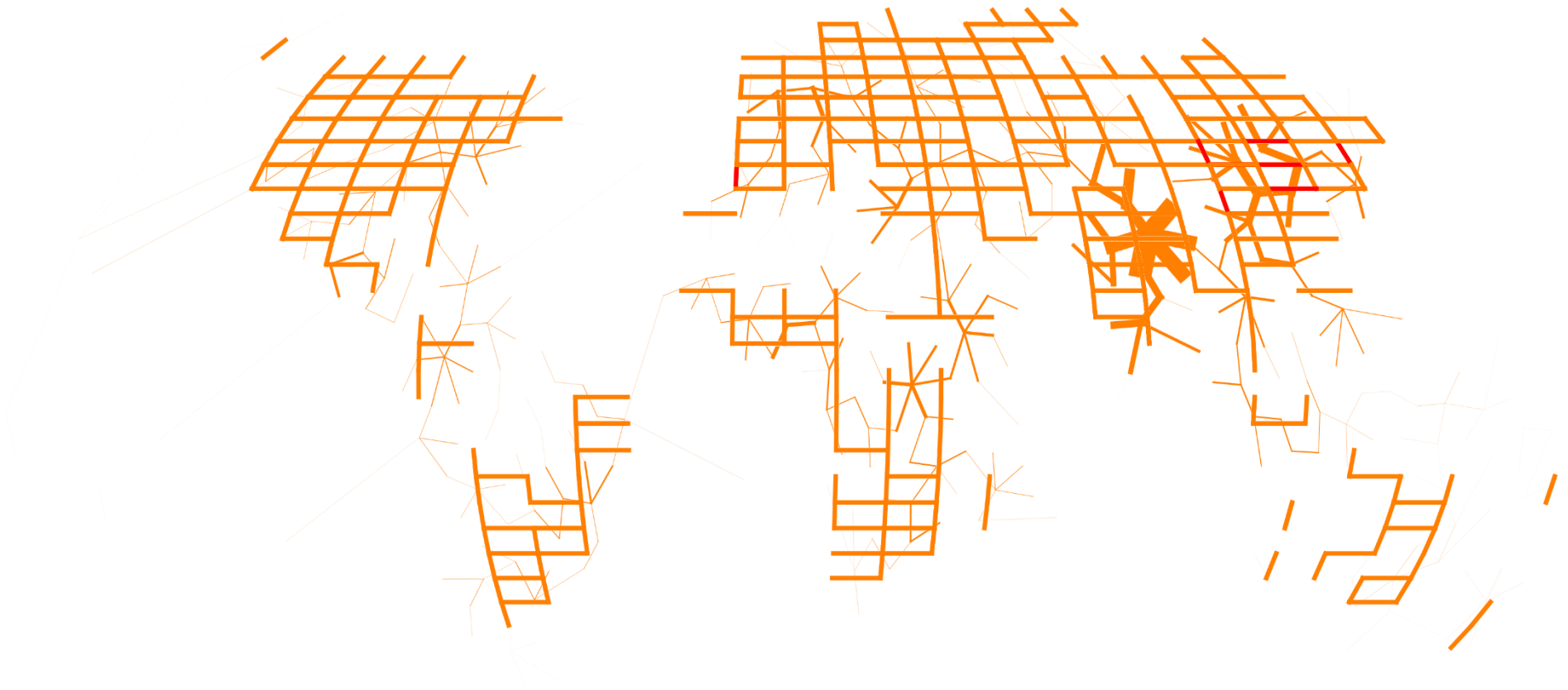
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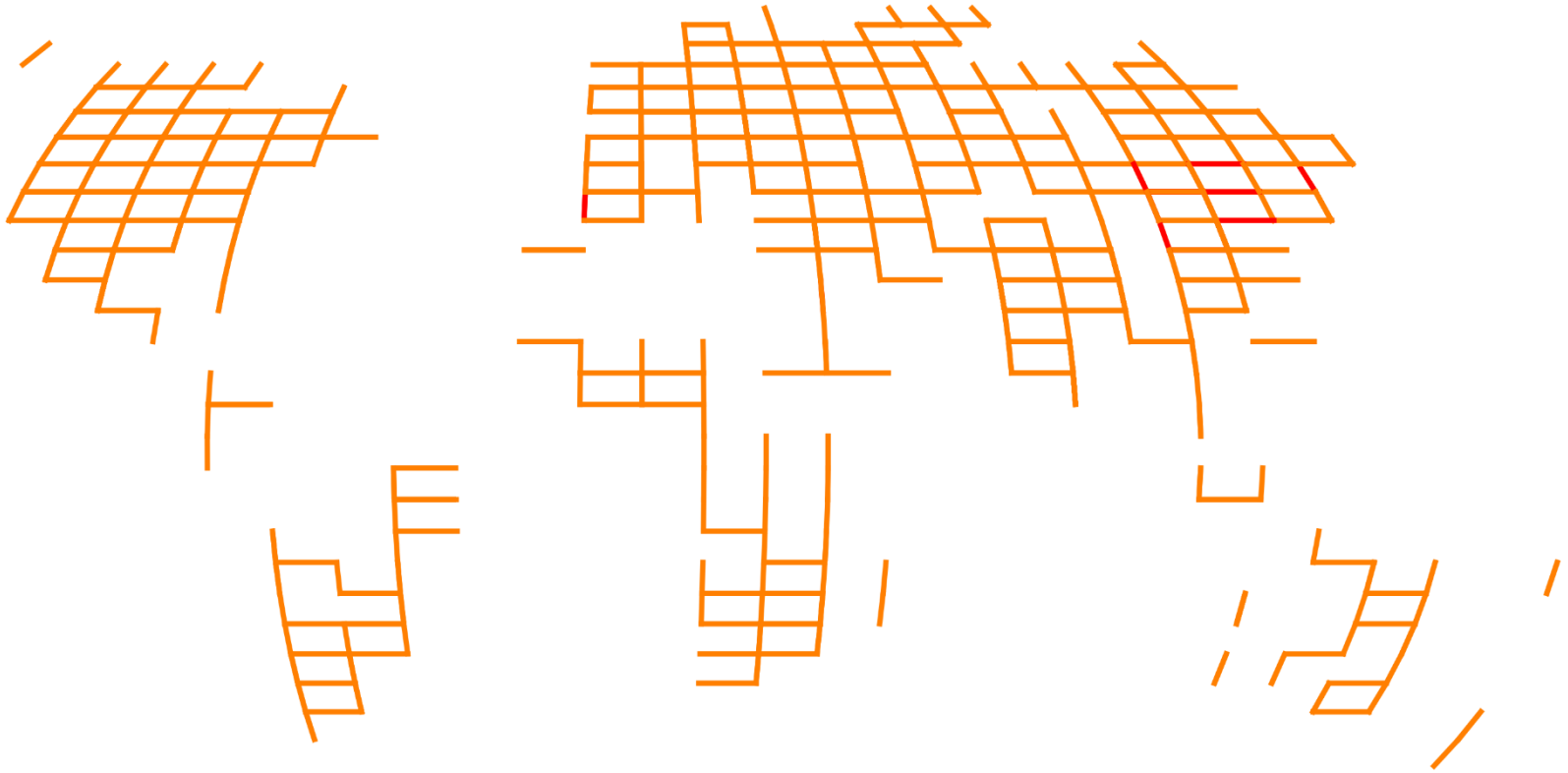
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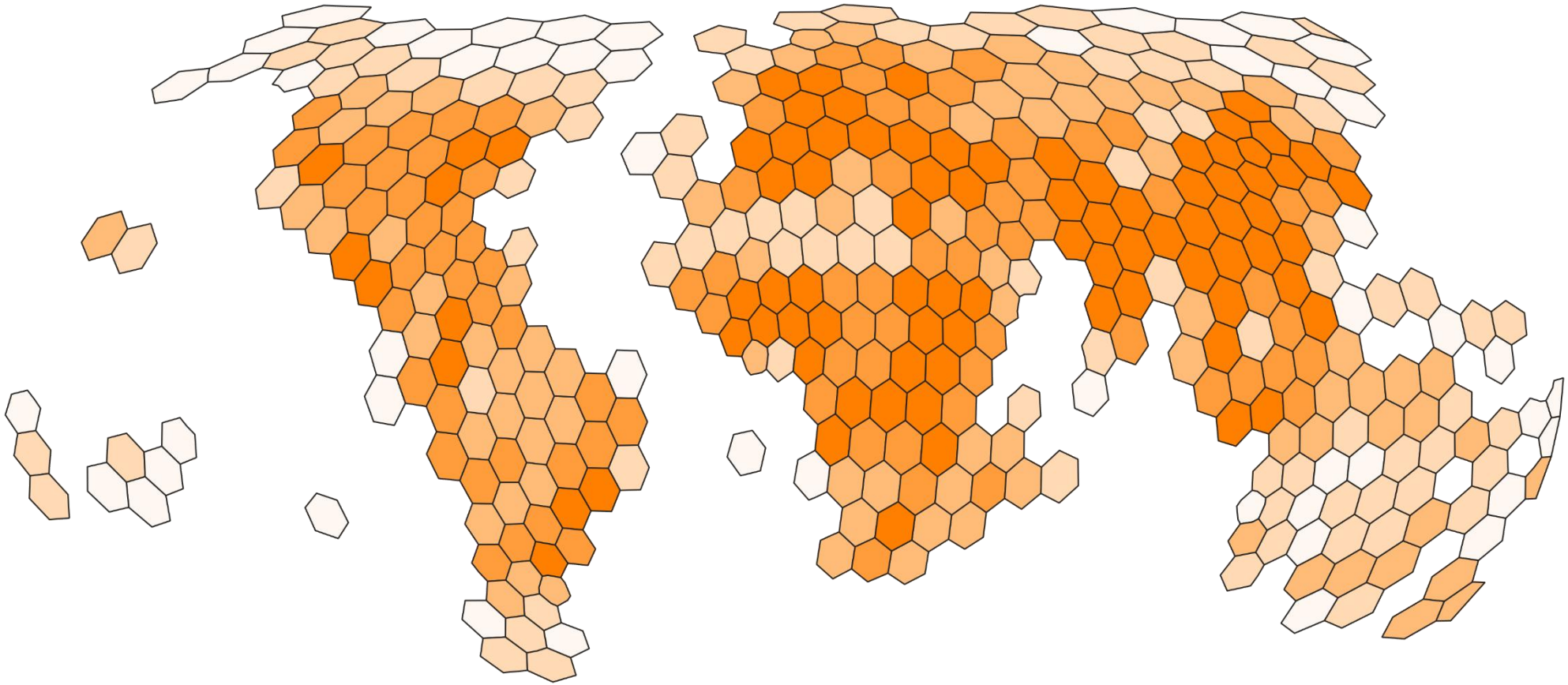
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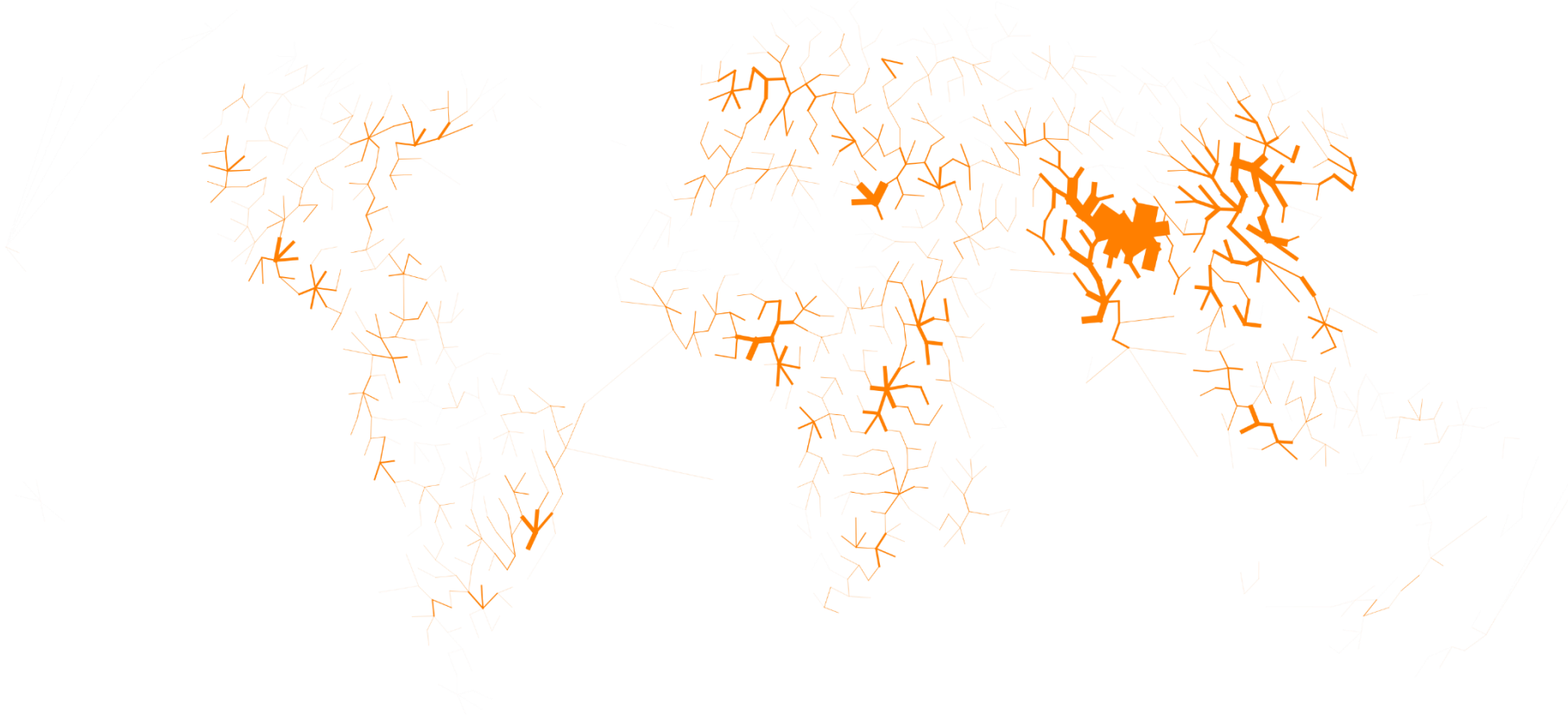
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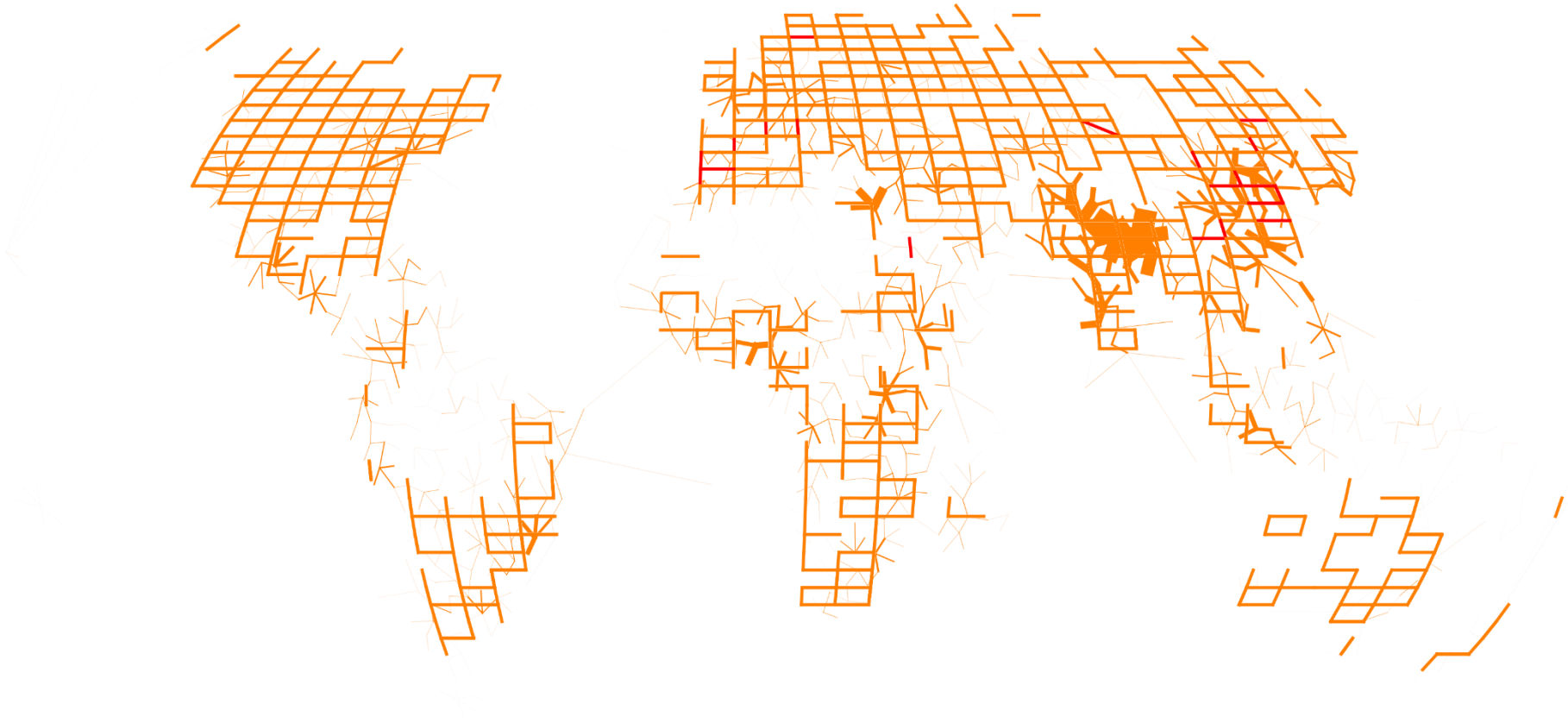
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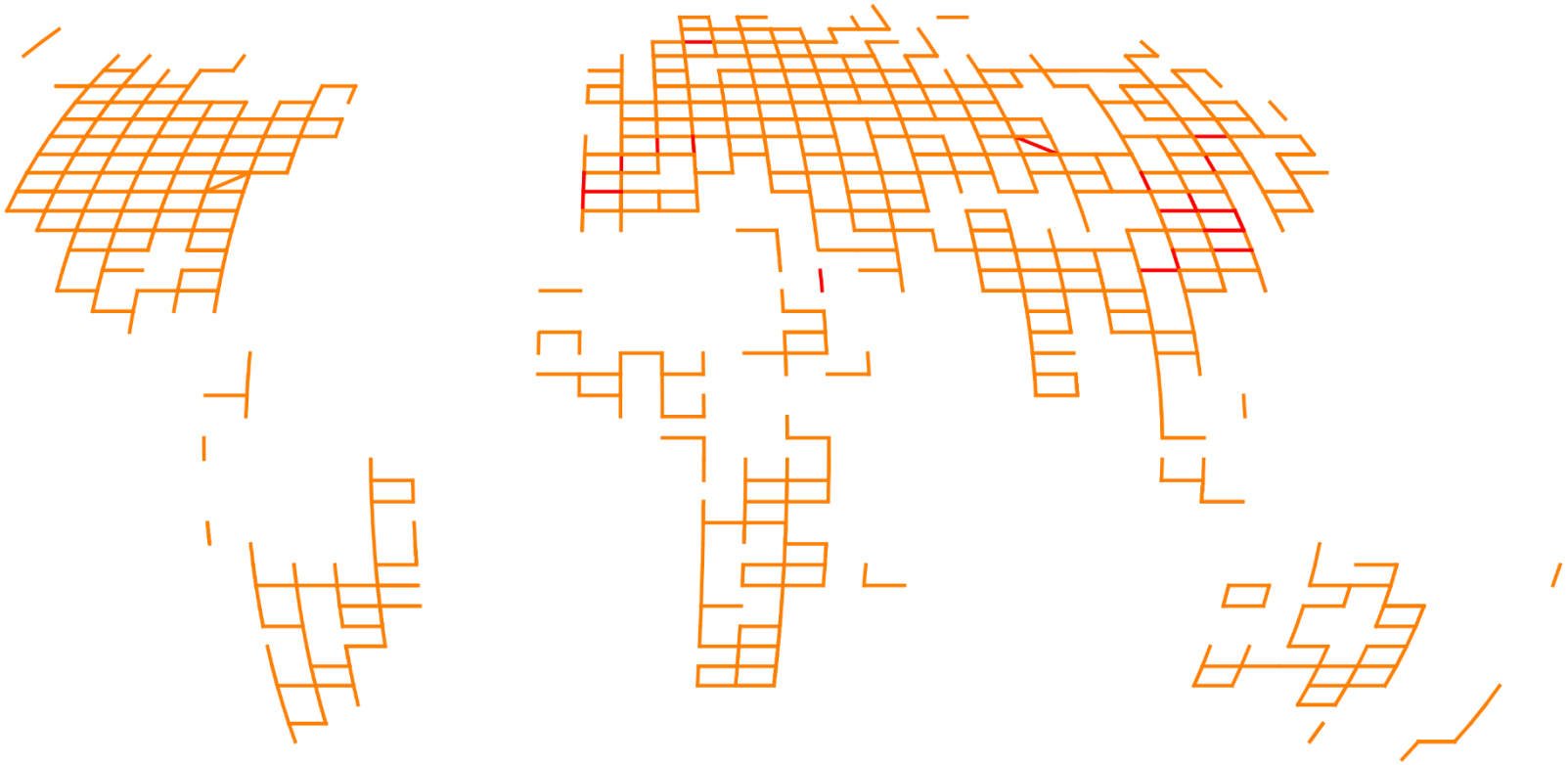
Railway



Railway



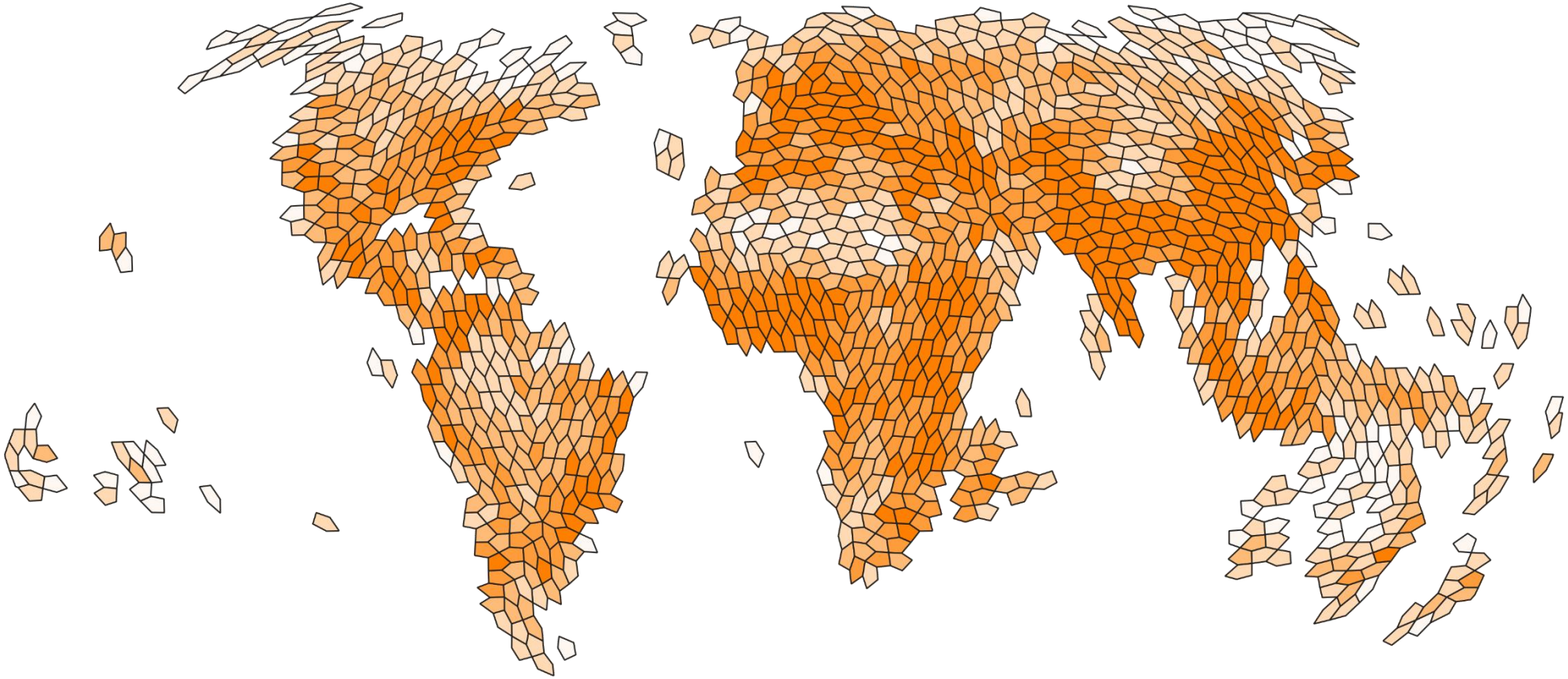
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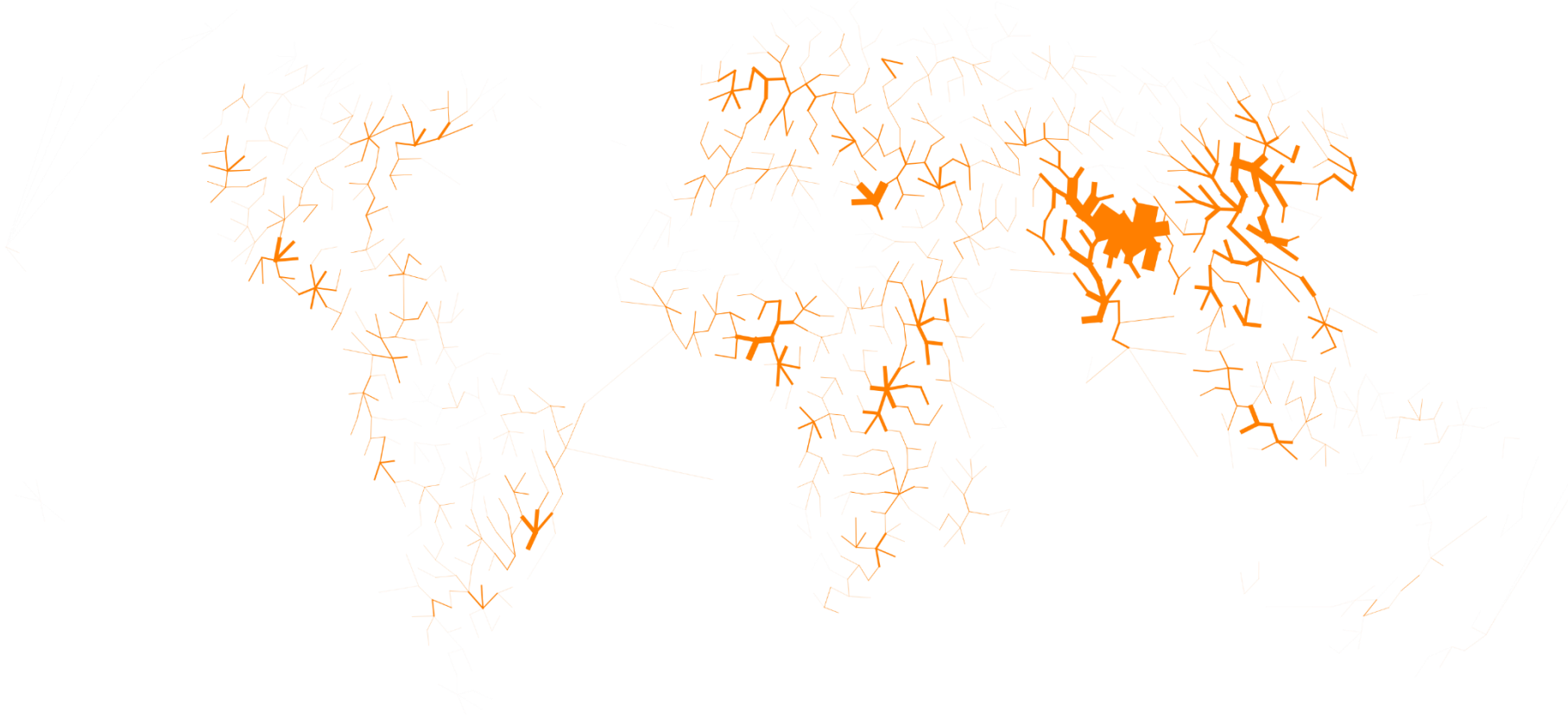
Level 2



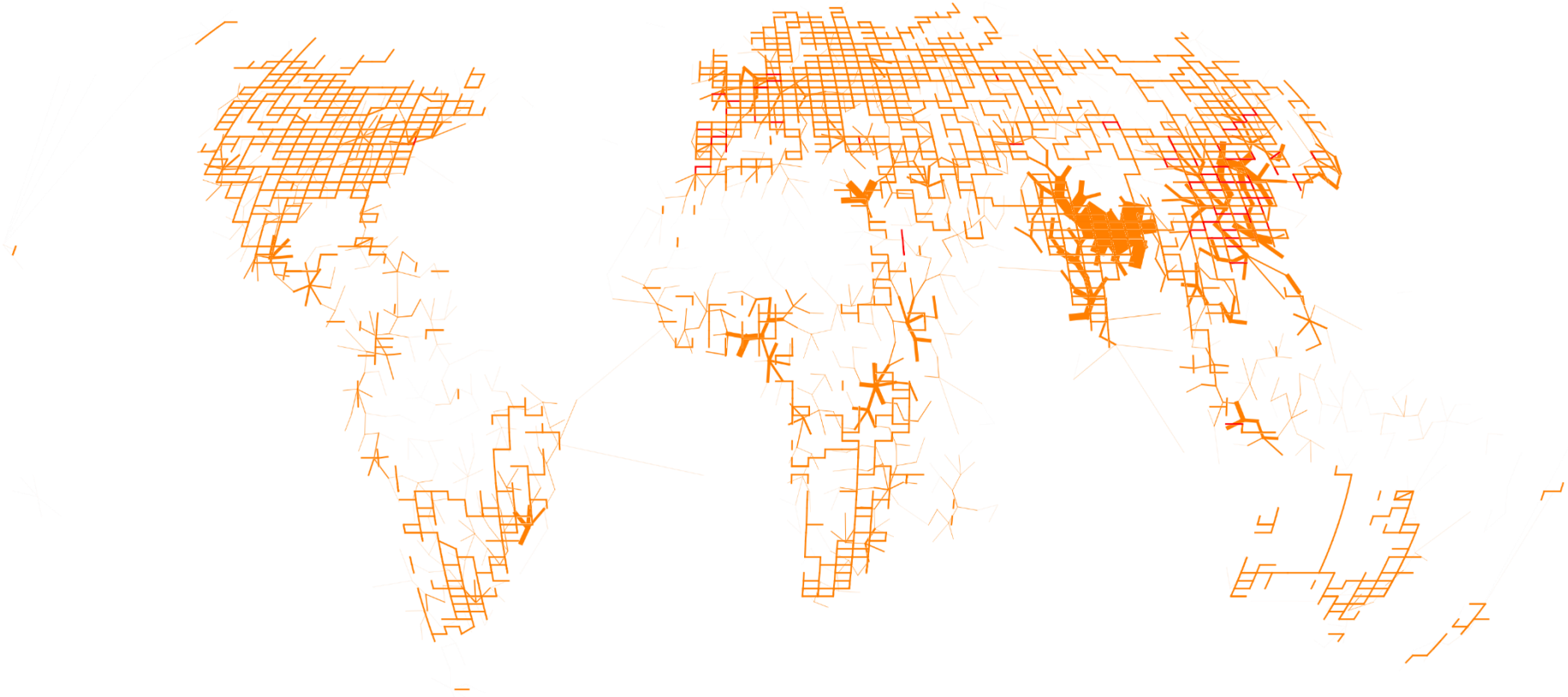
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Railway



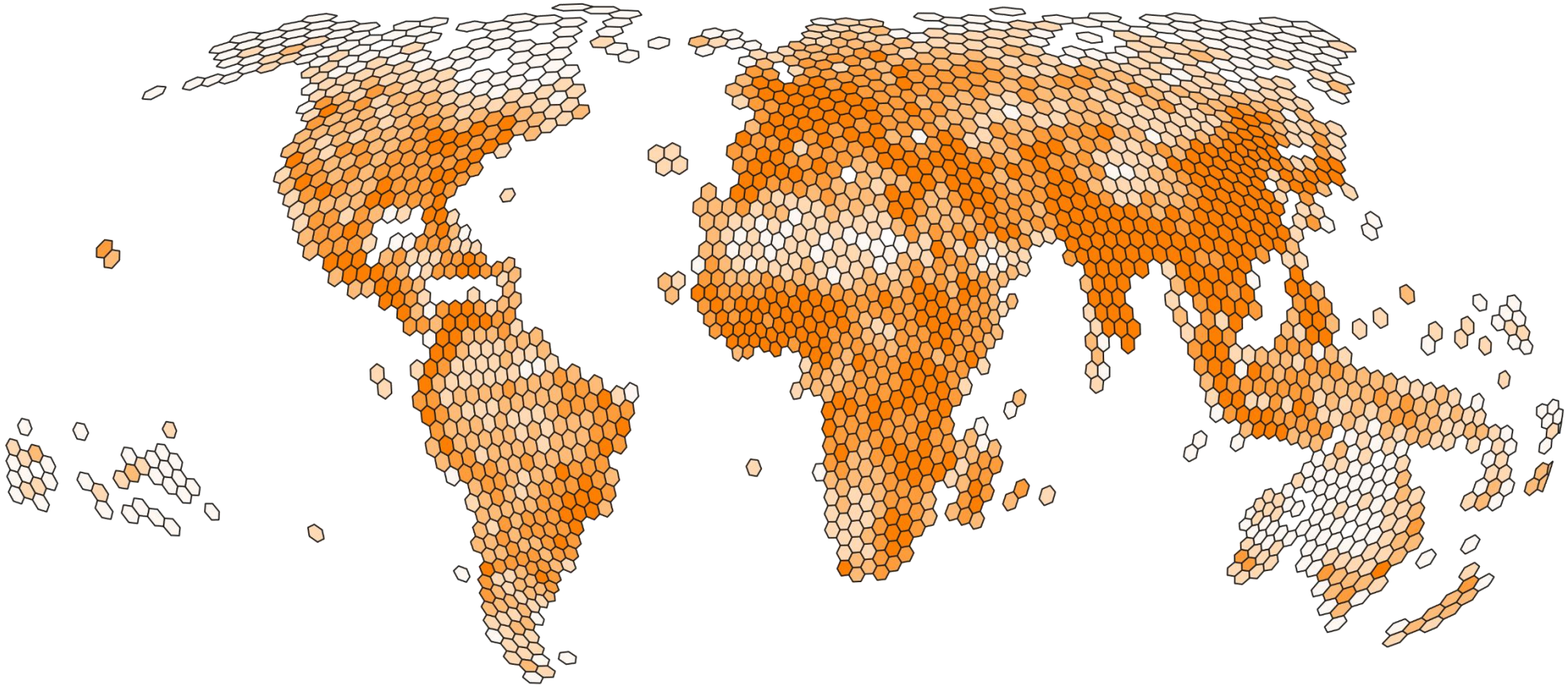
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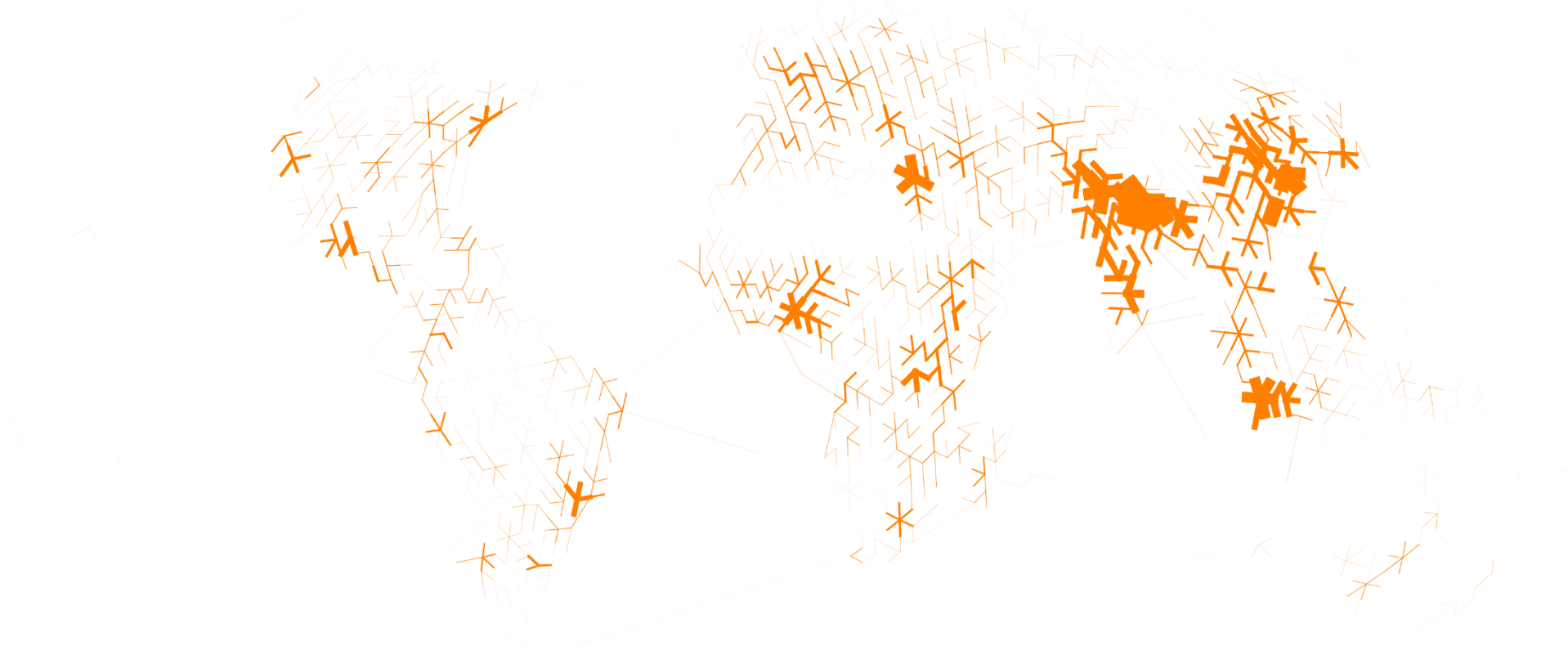
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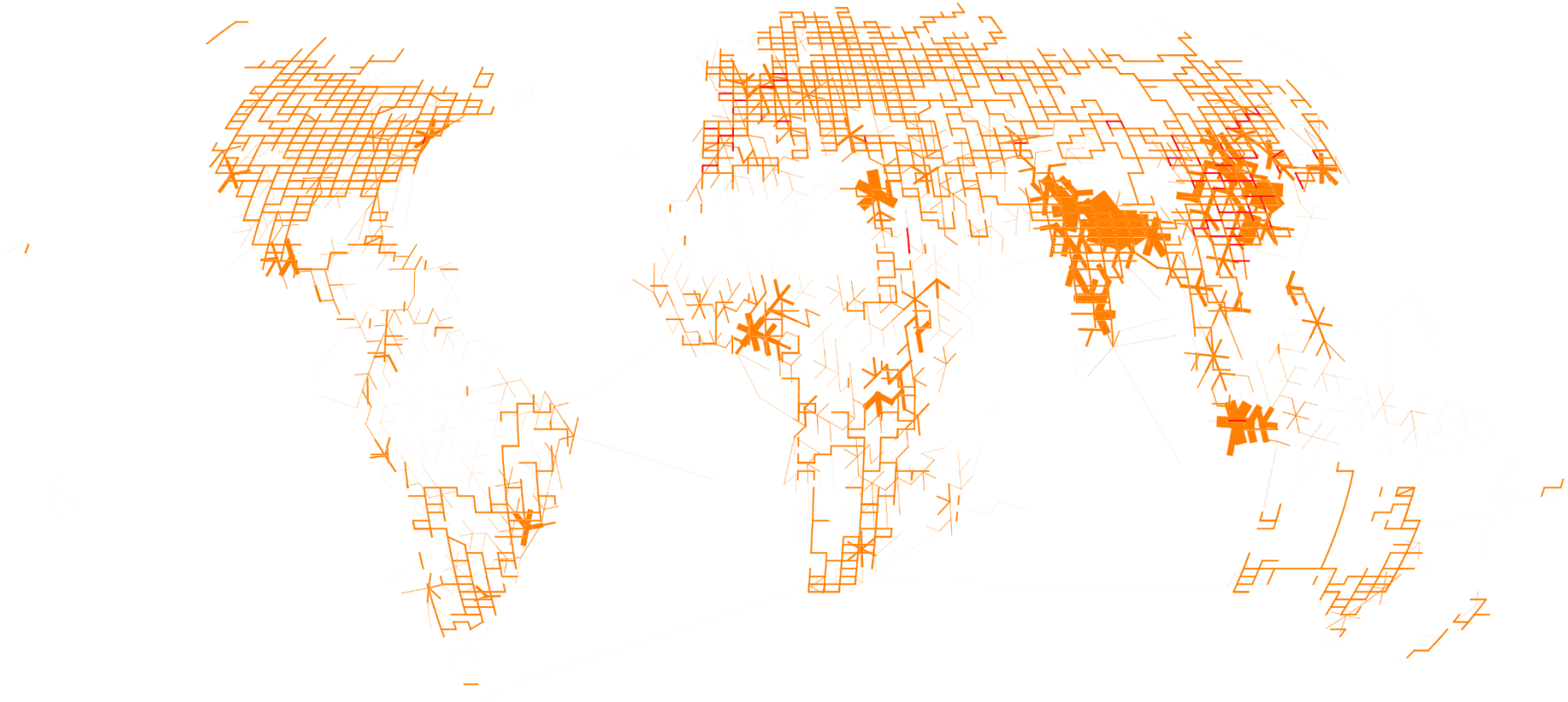
Railway



Railway



Railway



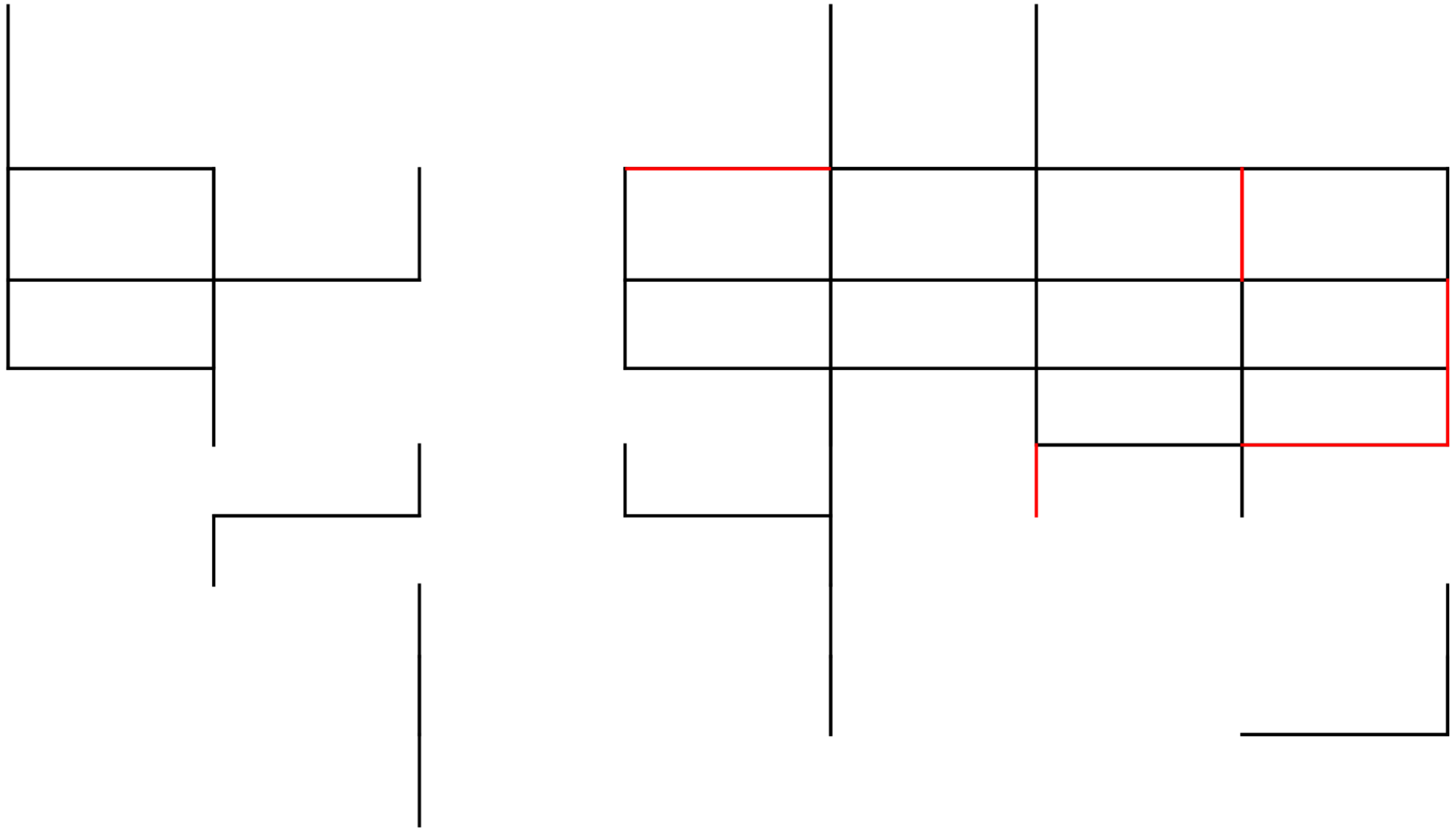
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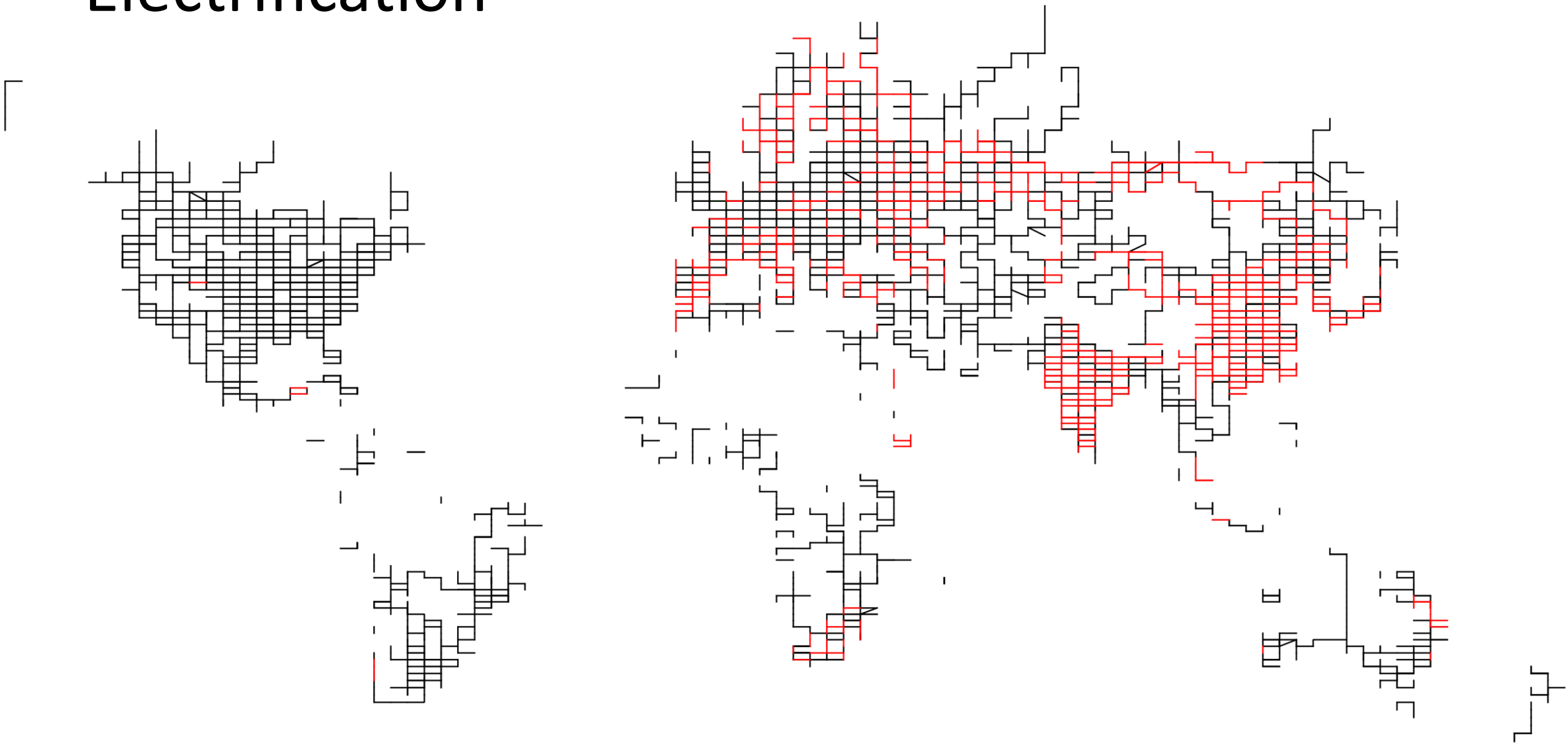
Electrification



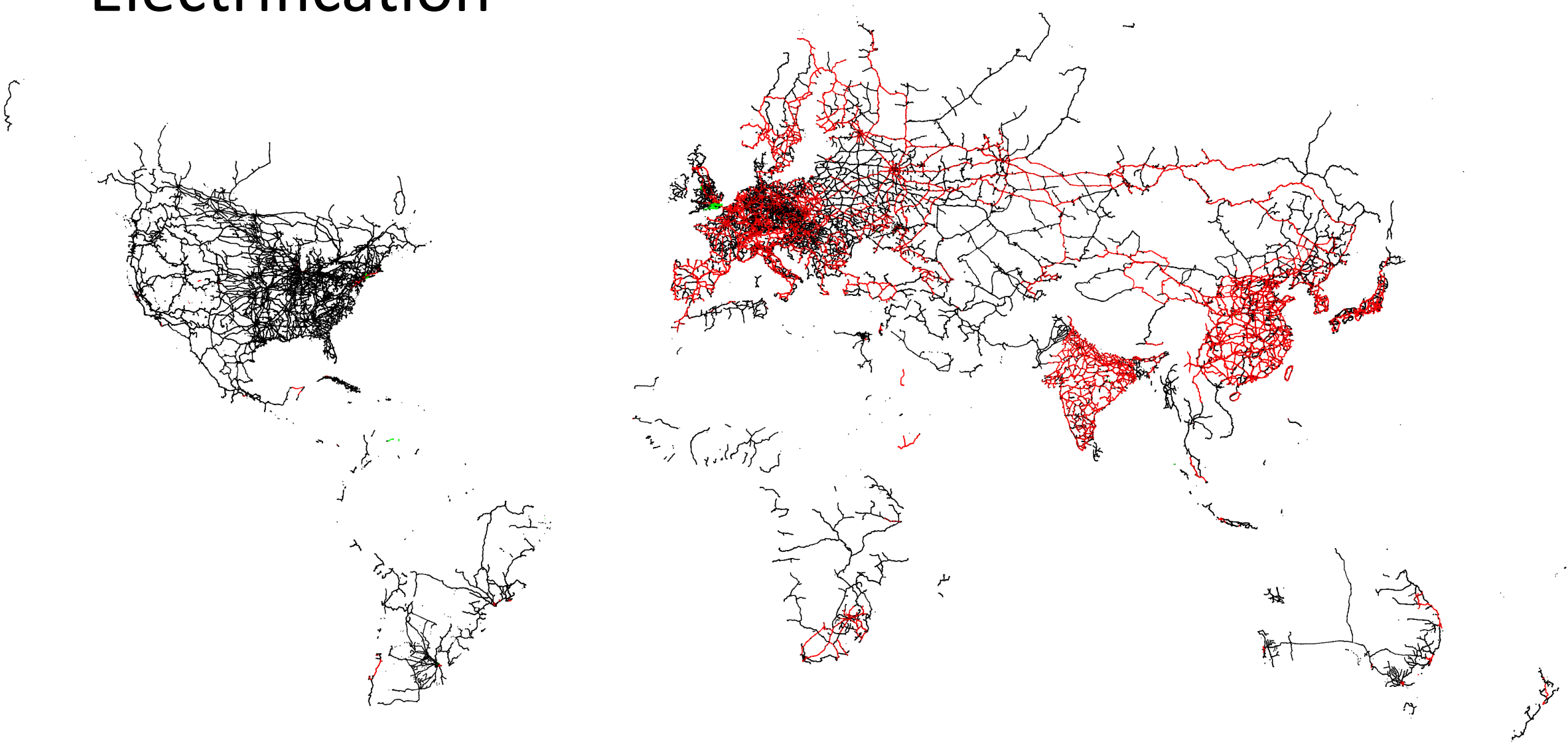
Electrification



Electrification



Electrification



Work in progress



Rail Electrification

‘Once upon a time on a hot day in May 2020 amidst a pandemic lockdown, a rail engineer tweeted....’

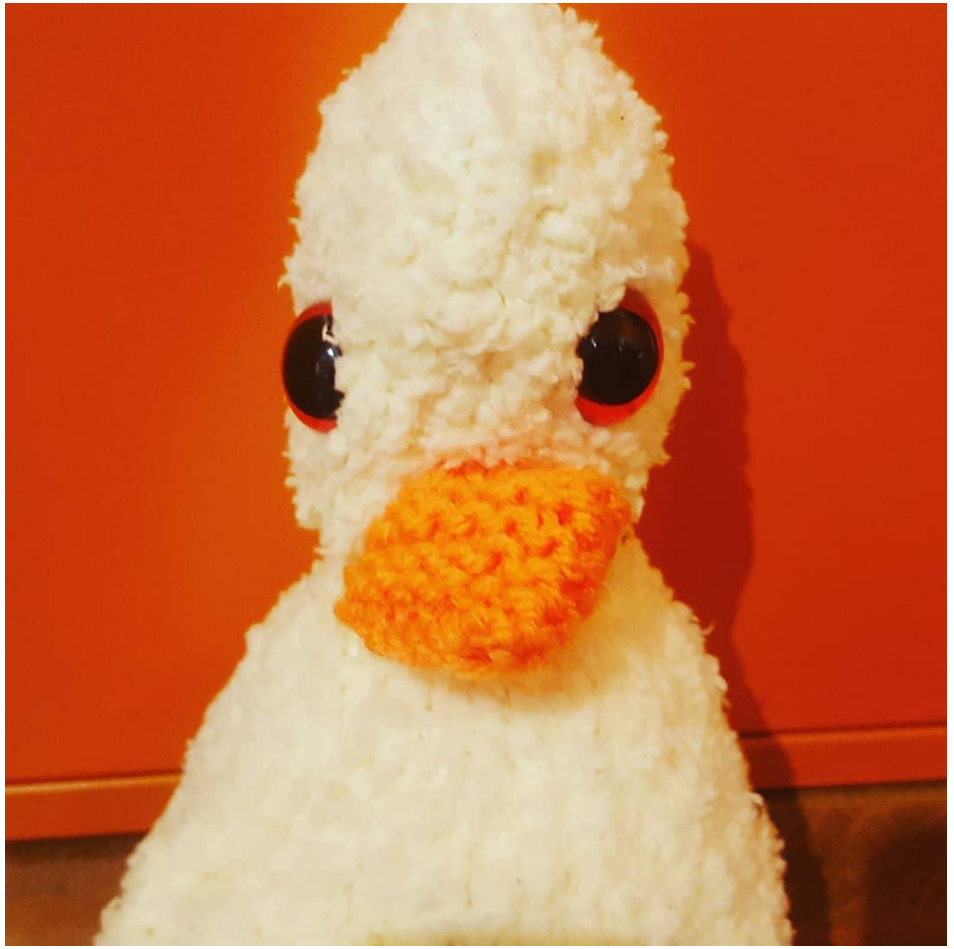


Garry Keenor (He/Him)
@25kV

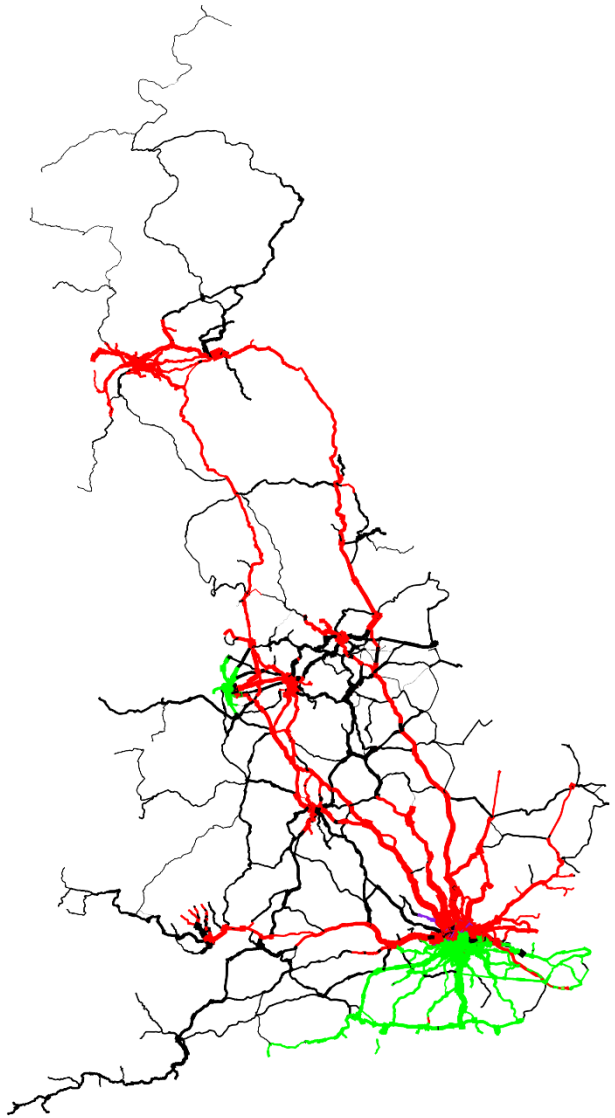
If anyone out there has experience of building an instance of @openstreetmap, could you get in touch? I've had a dangerous idea, but I don't have all the necessary technical skills to implement

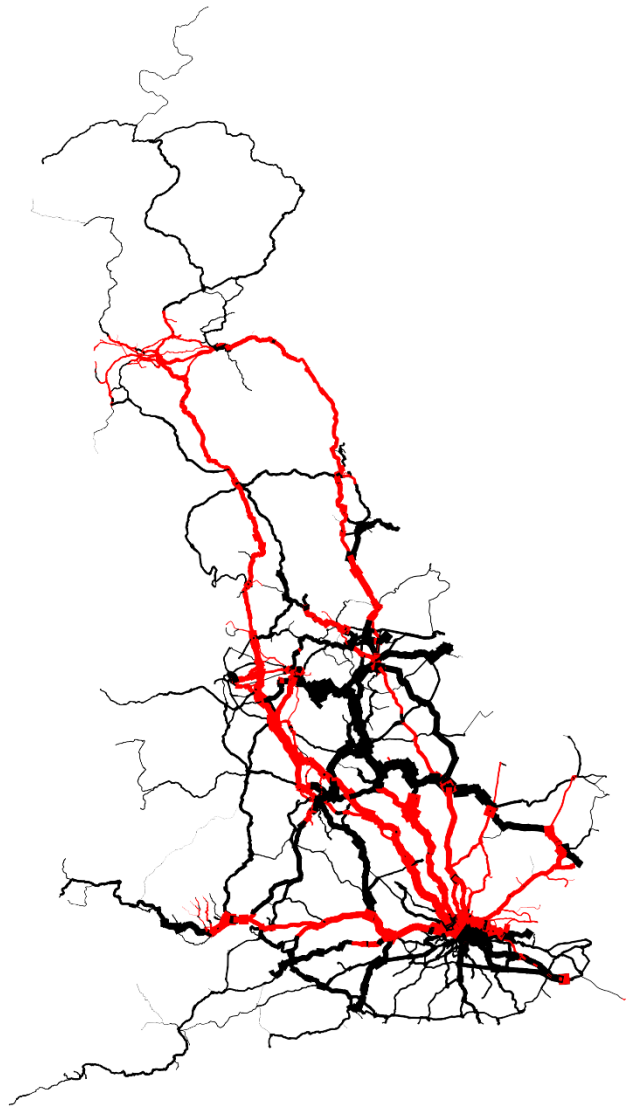
10:42 am · 25 May 2020 · Twitter for Android

1 Retweet **12** Likes

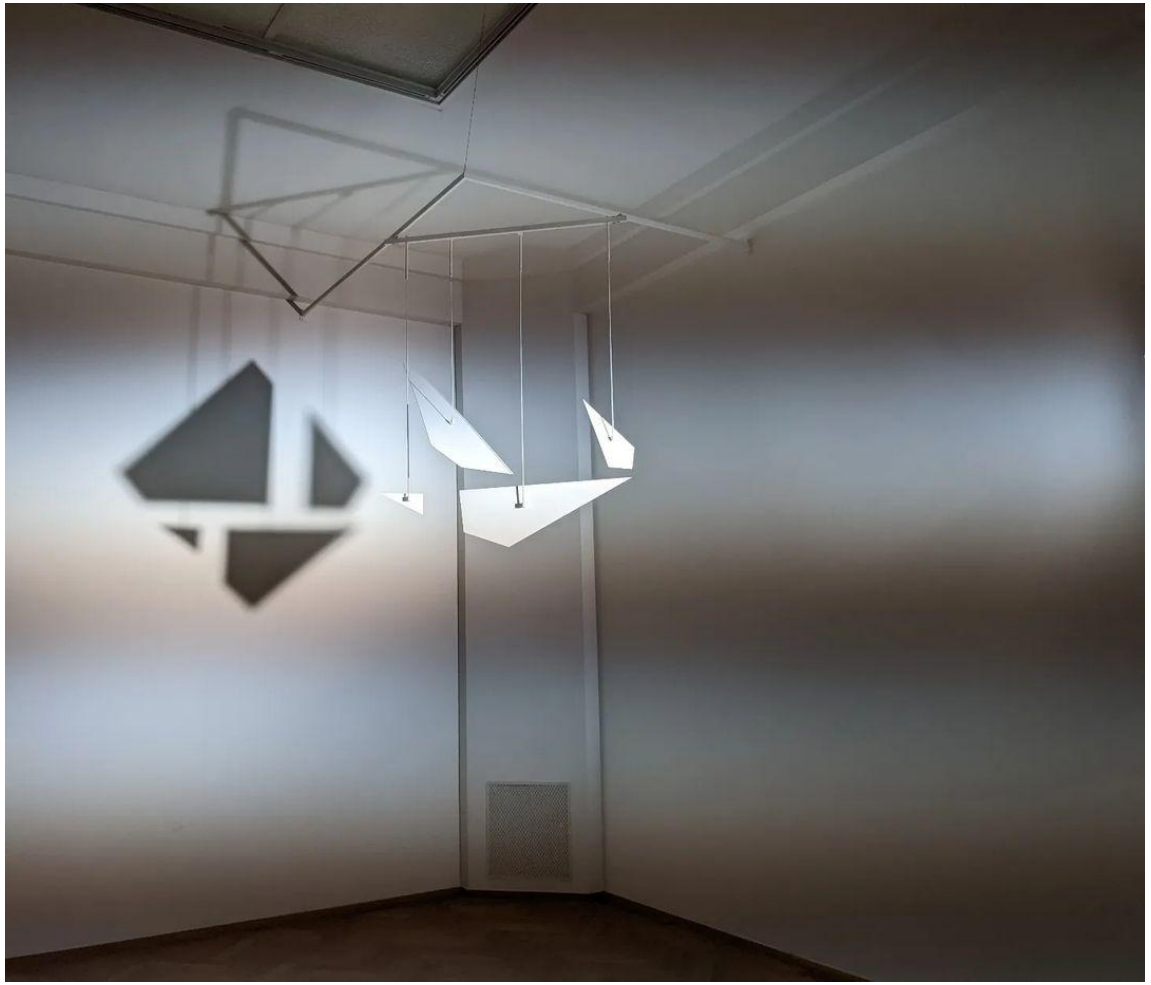


Rail Electrification





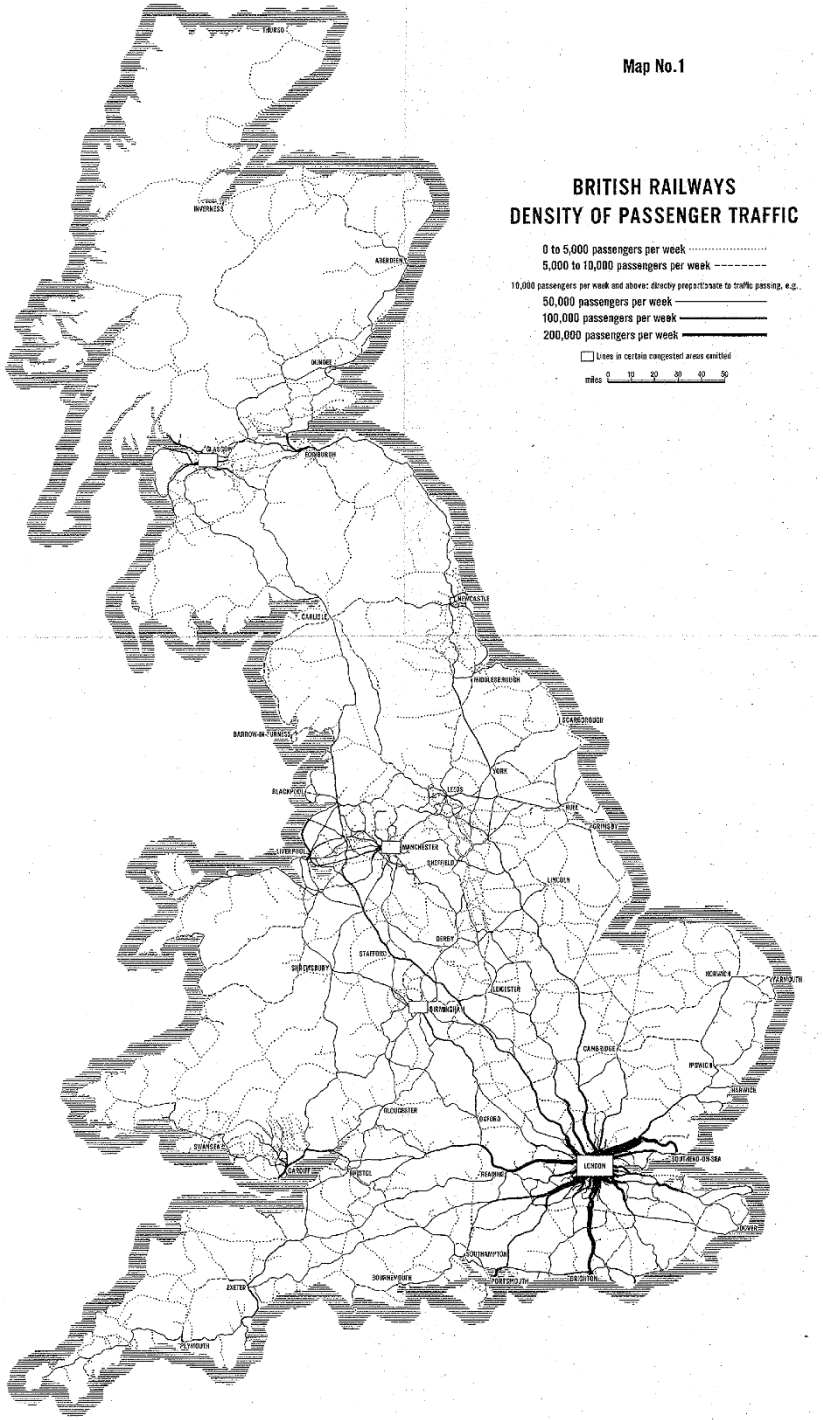
Where?



The Railway

The Reshaping of British Railways

‘The Beeching Report’ 1963



Animation goes here

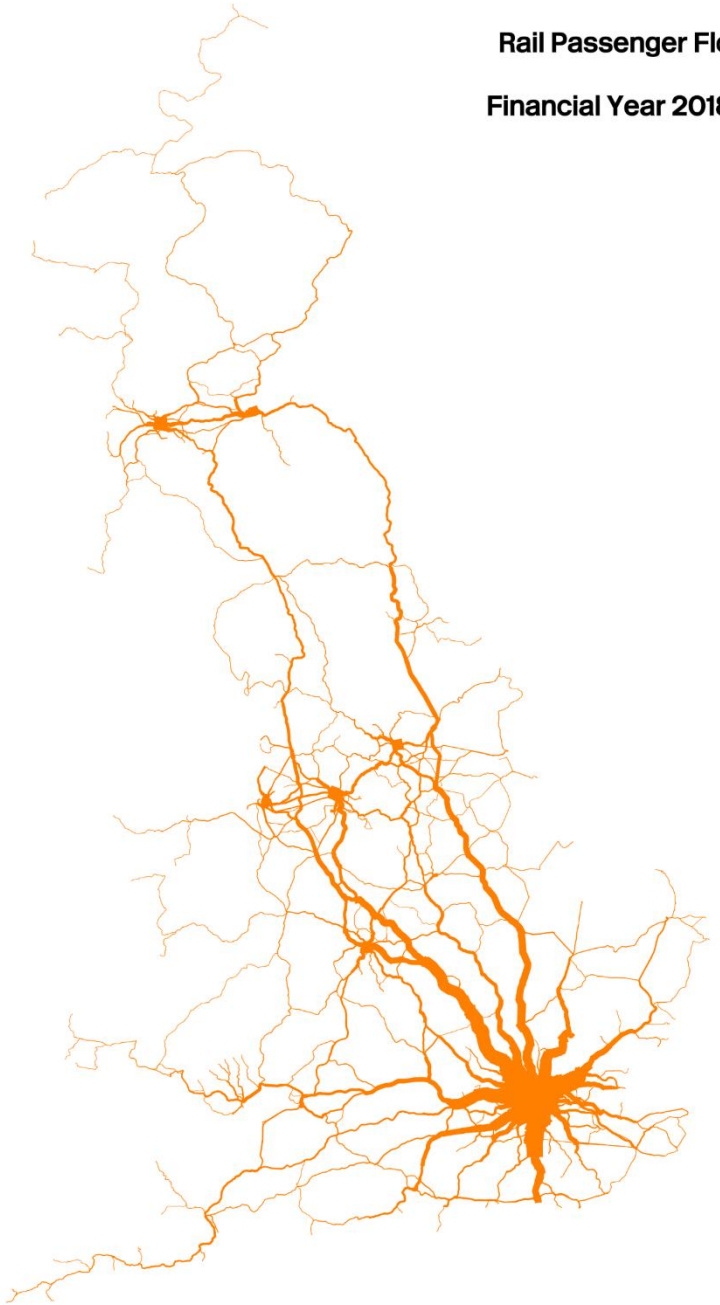
Seats

Carriages

Services

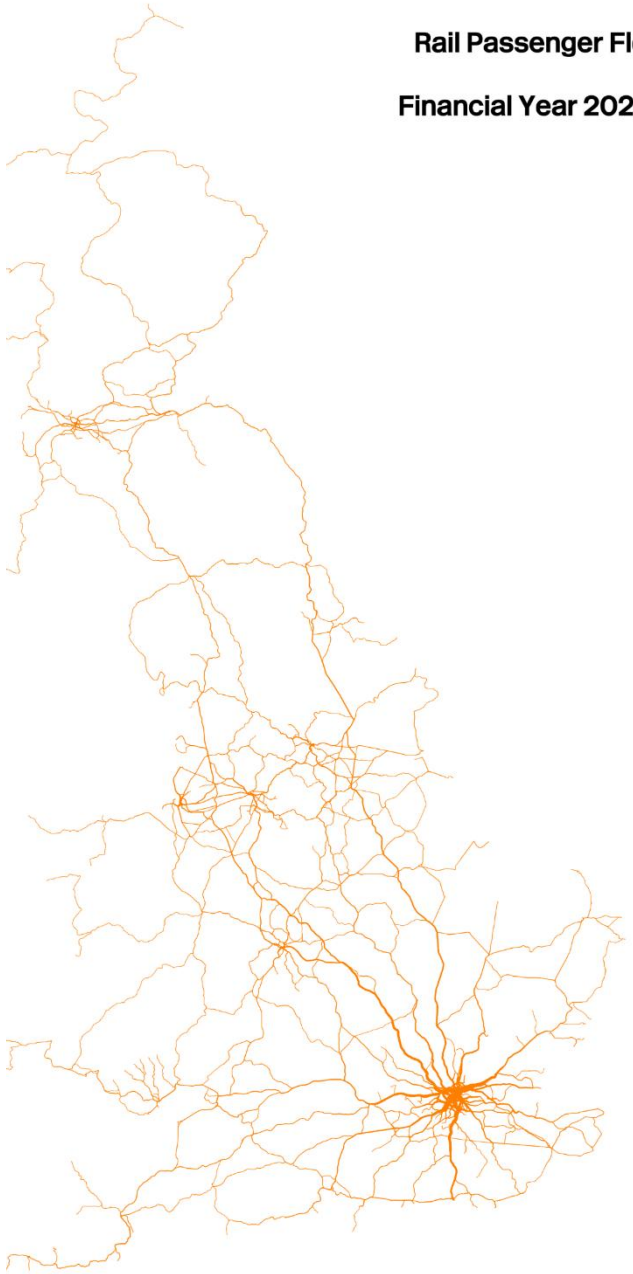
Rail Passenger Flow

Financial Year 2018-19



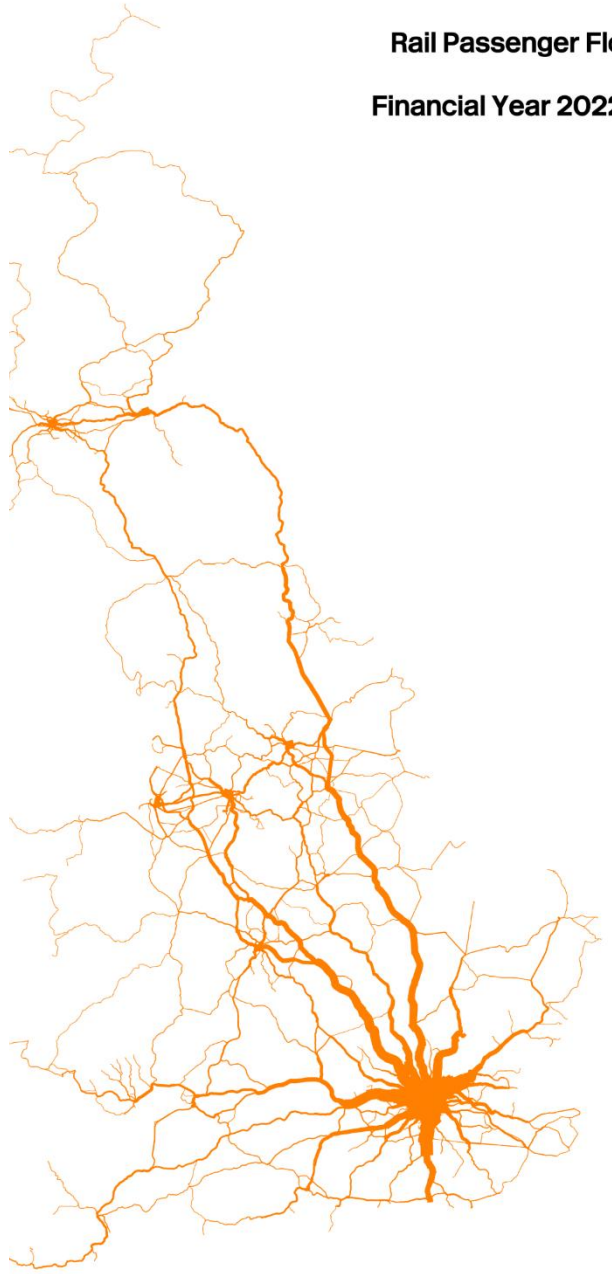
Rail Passenger Flow

Financial Year 2020-21



Rail Passenger Flow

Financial Year 2022-23



Equality
or
Equity?



hic sunt dragones

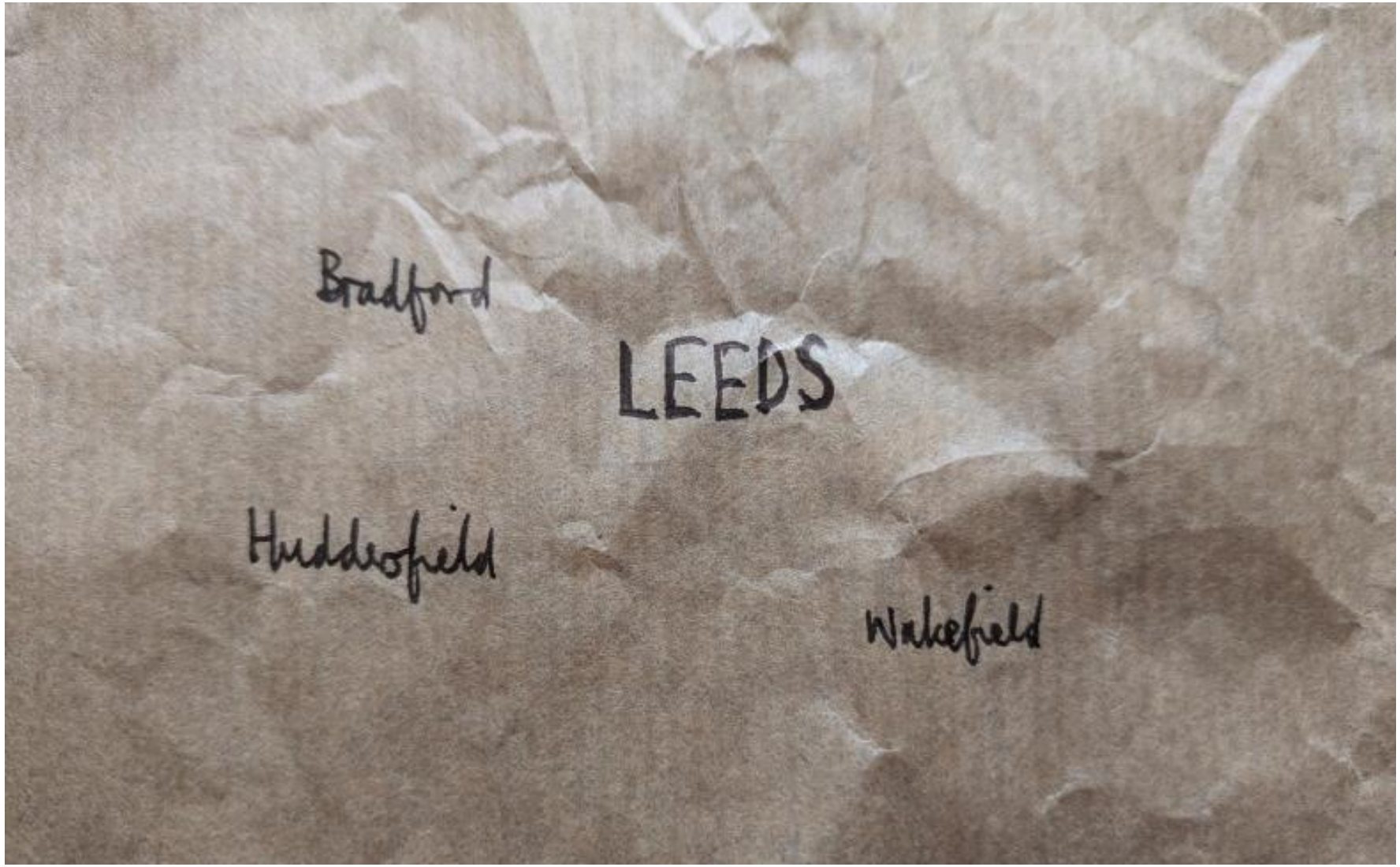


Transport Funding

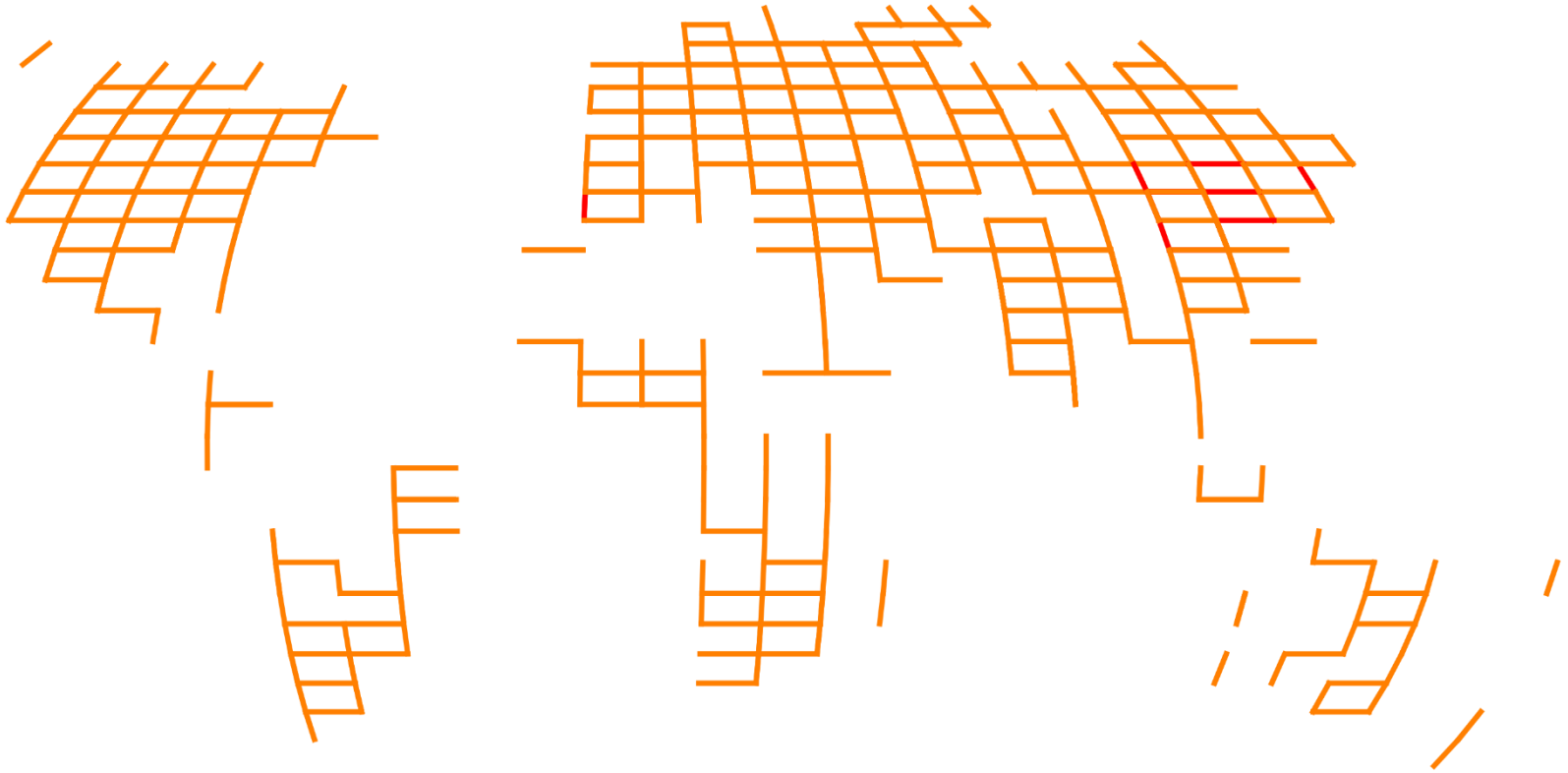
Region	public transport	railway	total
London	1,047	218	1,313
North West	440	84	729
West Midlands	477	36	706
South East	327	23	628
East	359	21	599
North East	264	34	541
Yorkshire and The Humber	223	35	495
South West	178	34	429
East Midlands	175	32	368
Total England	432	66	693

GBP per head 2023/24 from Commons Library research briefings

Leeds Metro



Global Railway



Questions and Answers



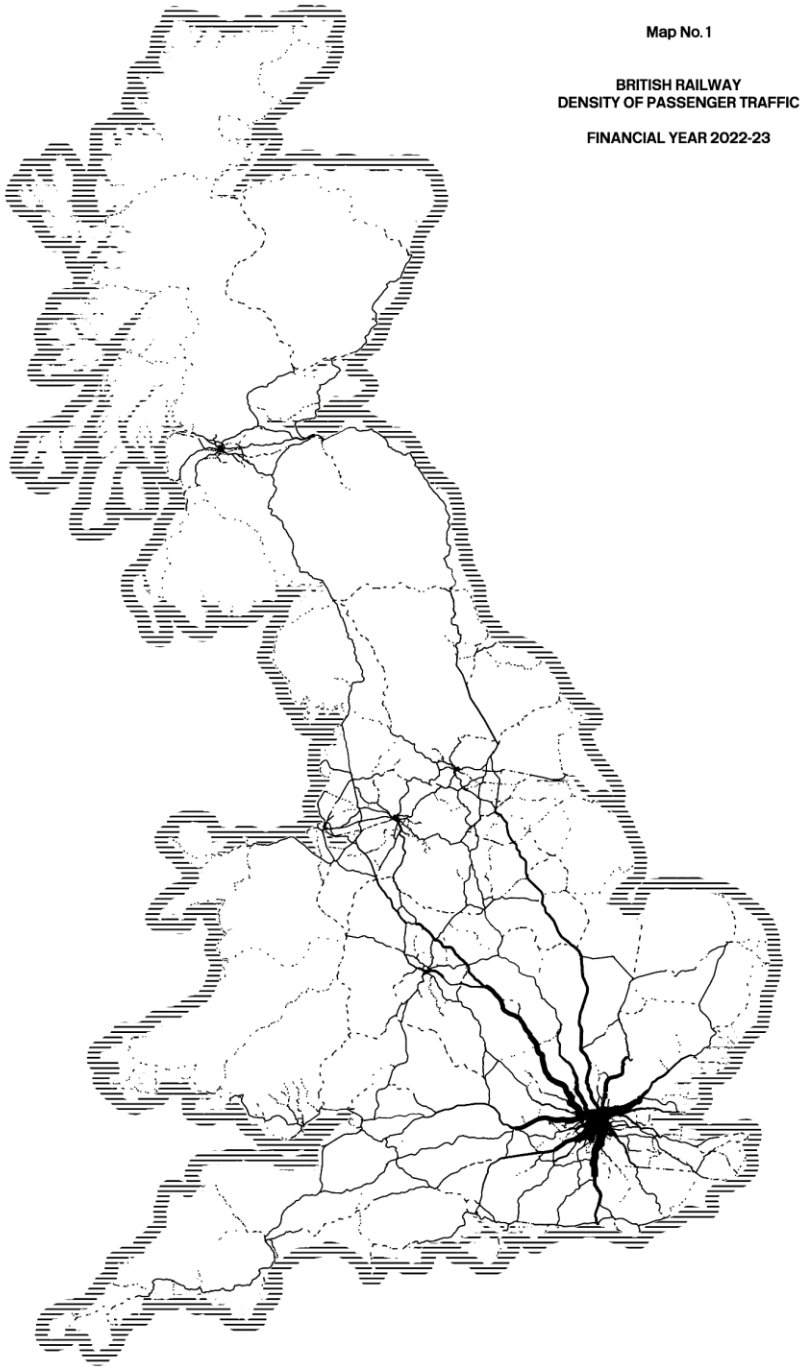
Parting Words

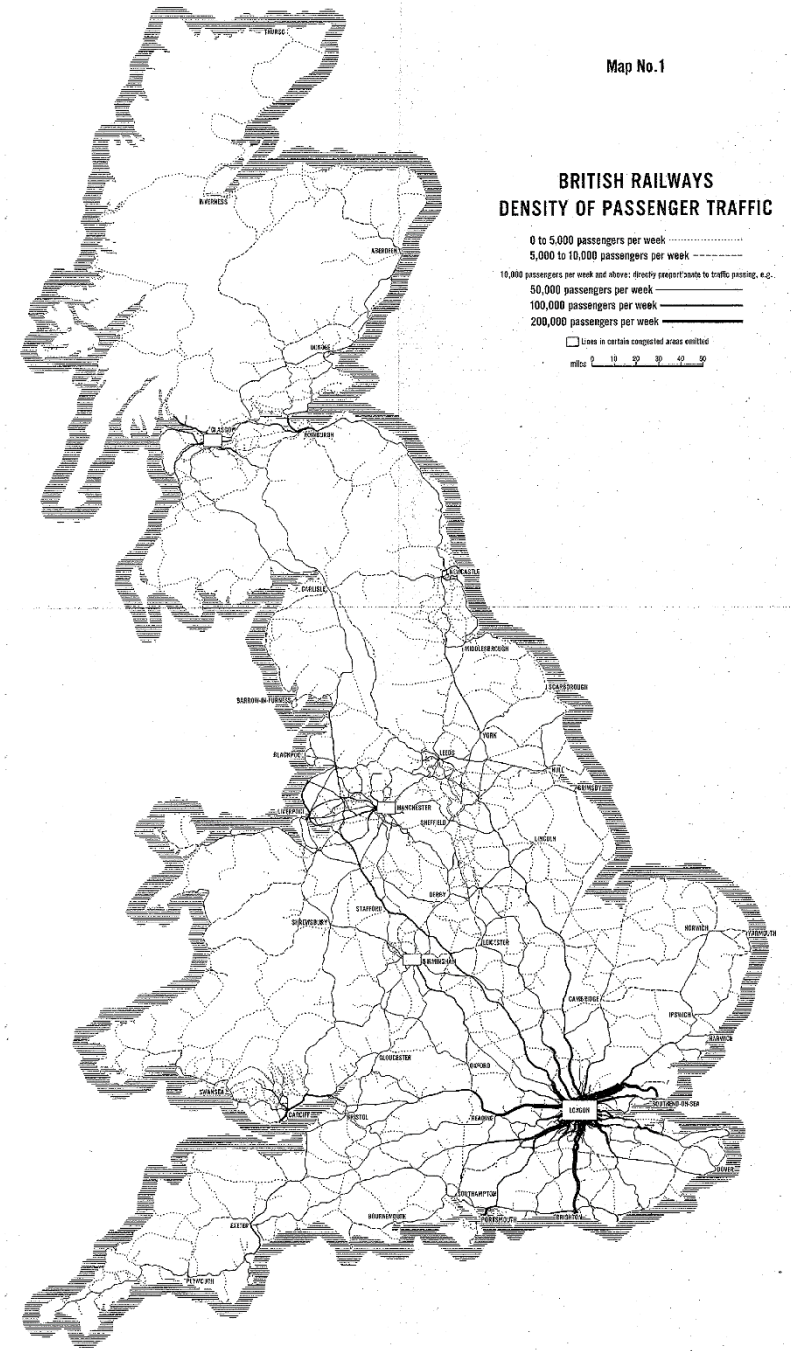


Art



The Railway


Map No.1
BRITISH RAILWAY
DENSITY OF PASSENGER TRAFFIC
FINANCIAL YEAR 2022-23


Map No.1
BRITISH RAILWAYS
DENSITY OF PASSENGER TRAFFIC
0 to 5,000 passengers per week
5,000 to 10,000 passengers per week
10,000 passengers per week and above: directly proportionate to traffic passing, e.g.
50,000 passengers per week
100,000 passengers per week
200,000 passengers per week
Lines in certain congested areas omitted
miles 0 10 20 30 40 50

The How

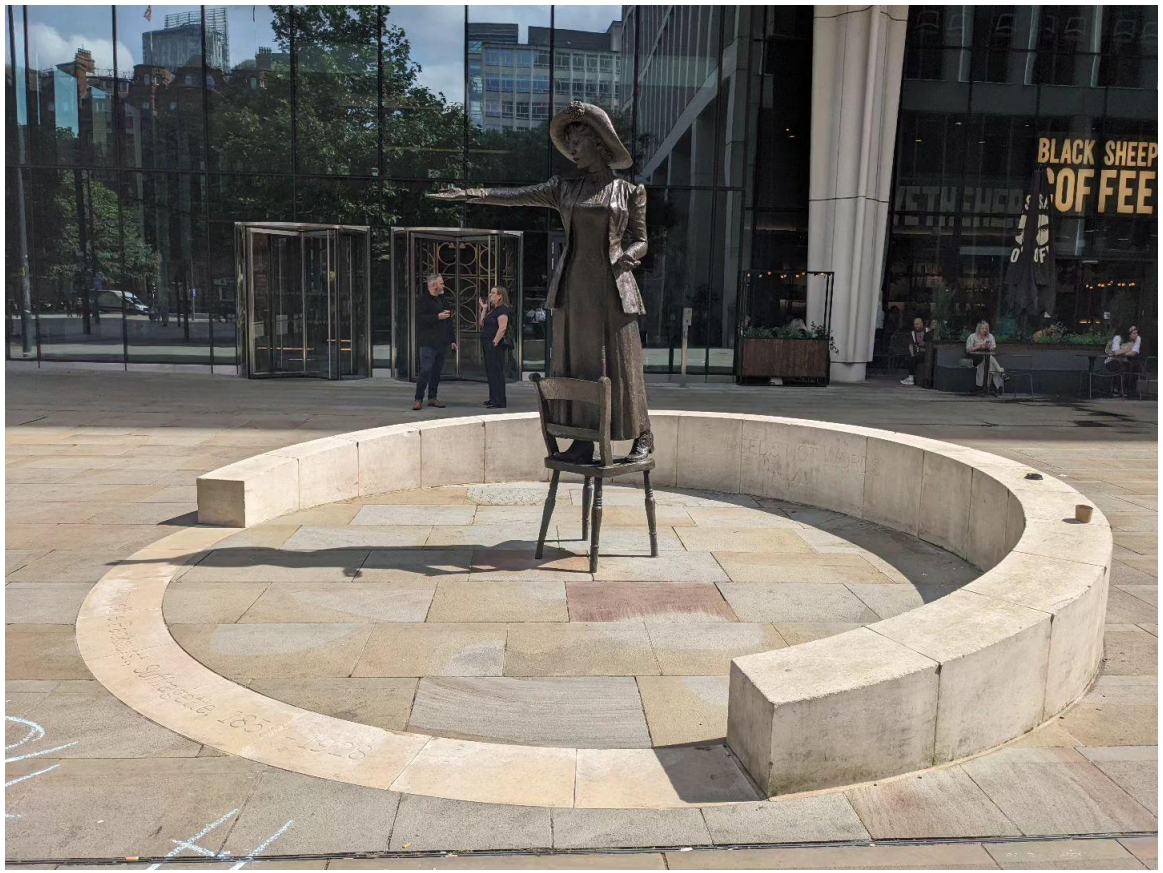


Open Data (Current attribution)

All data used on the basis that it under open or permissive license.

1. The base map of mainland Britain is derived from the WorldPop base maps under CC 4.0 by deed retrieved 2026-08-08.
2. The centre-line track-model is hosted by OpenRailData under the Open Government License by Network Rail, retrieved 2026-06-14.
3. The Origin Destination Matrix data, for example ODM 2022-23, were published by the Office of Road and Rail on the Rail Development Group Rail Data Marketplace, under the Open Government License. Retrieved 2024-02-18.
4. The Station Attributes for All-Mainline Stations published by the Office of Road and Rail under the Open Government License. Retrieved 2026-09-08.
5. The Network Rail CORPUS dataset is an open data feed which is released under a OGL. Retrieved 2023-11-29 as a local copy.
6. The National Public Transport Access Network NaPTAN under OGL and is updated each time the scripts are run.
7. While this implementation now uses NaPTAN and CORPUS to validate and identify six closed stations, the Isle of Wight ferry-link continues to use OpenStreetMap data, licensed under CC-BY-SA 2.0 through the OverPassAPI Turbo service, and is updated each time the scripts are run.

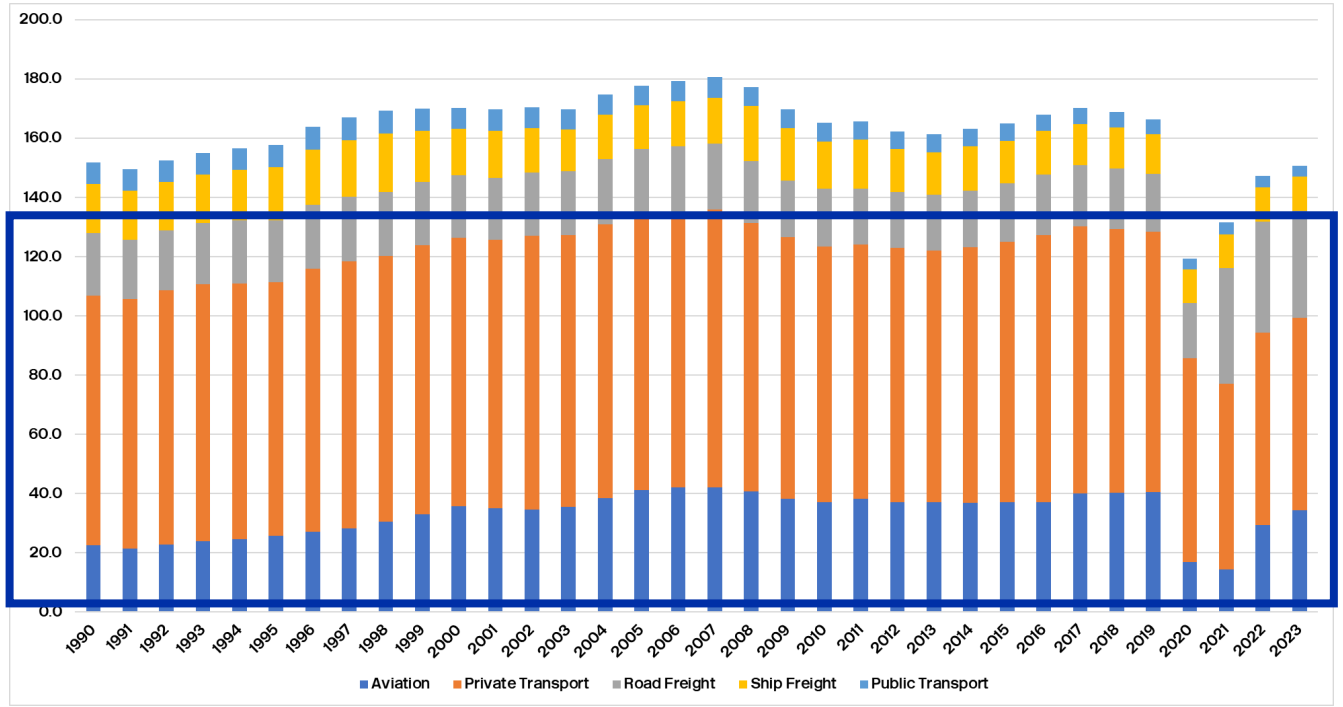
Emissions



Incremental Change

Significant investment in **rail** will make a difference

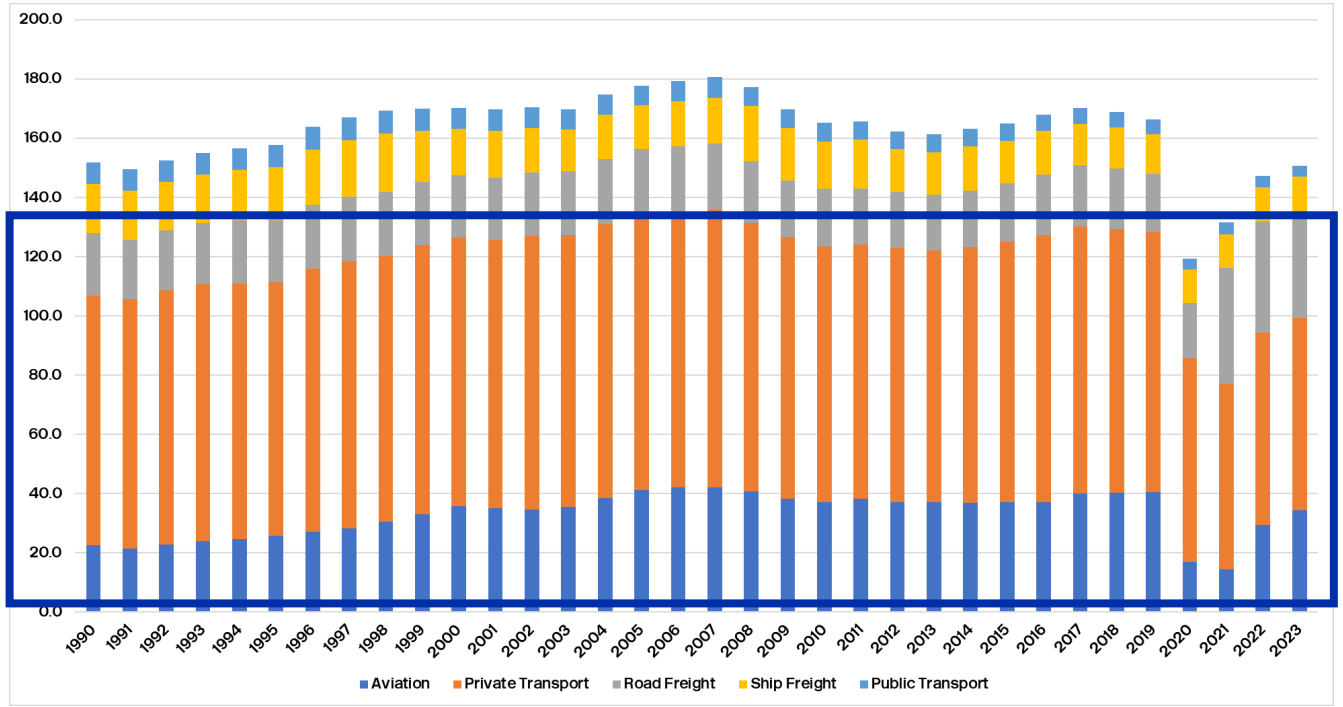
Is it enough?



Incremental Change

Significant investment in **public transport** makes a difference

Is it enough?



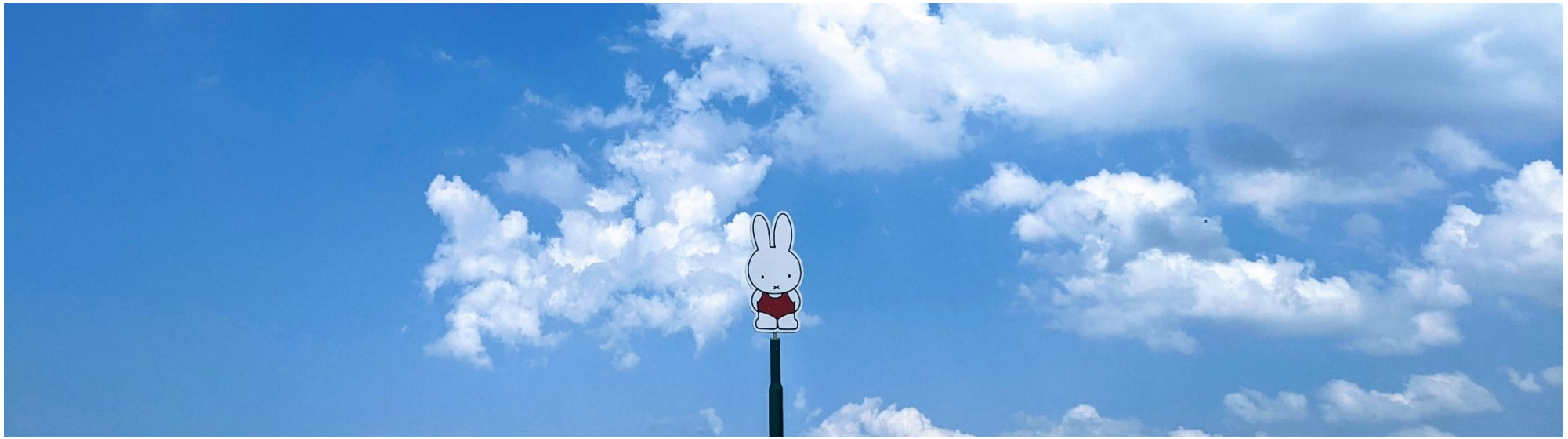
Is it enough?





Build it and they will come!

Thank You



Will Deakin
@wnd@fosstodon.org
@anisotropi4

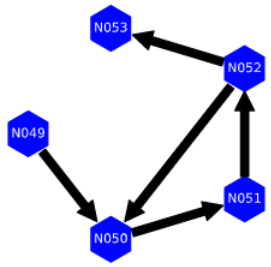
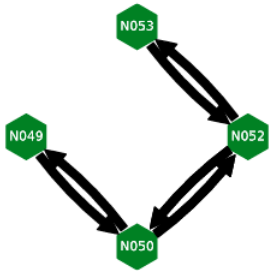
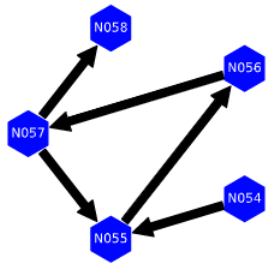
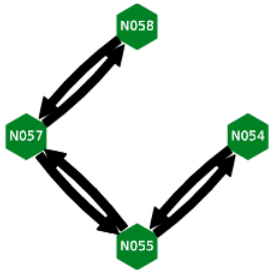
Postscript

‘It is better to ask some of the questions that to know all of the answers’

- James Thurber

My thanks go to my ever and long suffering family, all friends, colleagues and contributors to all the projects I have wilfully used for their help, support and advice

Technology

ID	Simply-connected network	Simplified network
W015		
W016		

Tools

- github.com
- gist.github.com
- bl.ocks.org
- d3js.org
- python.org
- gdal.org
- leaflet.js
- ./jq
- nodejs.org
- Tesseract-OCR
- MapBox Tippecanoe
- a5
- arangodb.com
- postgresql.org
- tabula.technology
- tesseract-OCR
- solr.apache.org
- qgis.org
- gdal.org
- python Pandas
- python GeoPandas
- python osmnx
- python polars
- h3

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everyone
home safe
every day