

Lecture 8: OpenStreetMap and OSMnx

Instructor: Ane Rahbek Vierø

Mar 20, 2023



? Exam Project Questions ?

Today you will learn about OpenStreetMap

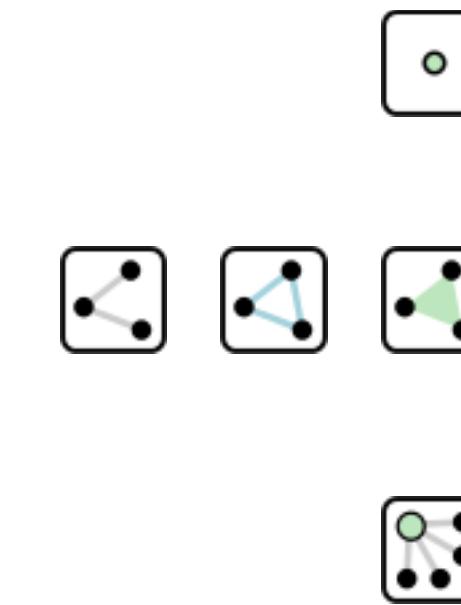
What is OSM?



GDS with OSMnx



Accessing & Handling OSM Data



```
<node id="25496583"  
lat="51.5173639"  
lon="-0.140043" version="1"  
changeset="203496"  
user="80n" uid="1238"  
visible="true"  
timestamp="2007-01-28T11:40  
:26Z">  
  <tag k="highway"  
v="traffic_signals" />  
</node>
```

OpenStreetMap (OSM) is like wikipedia for maps

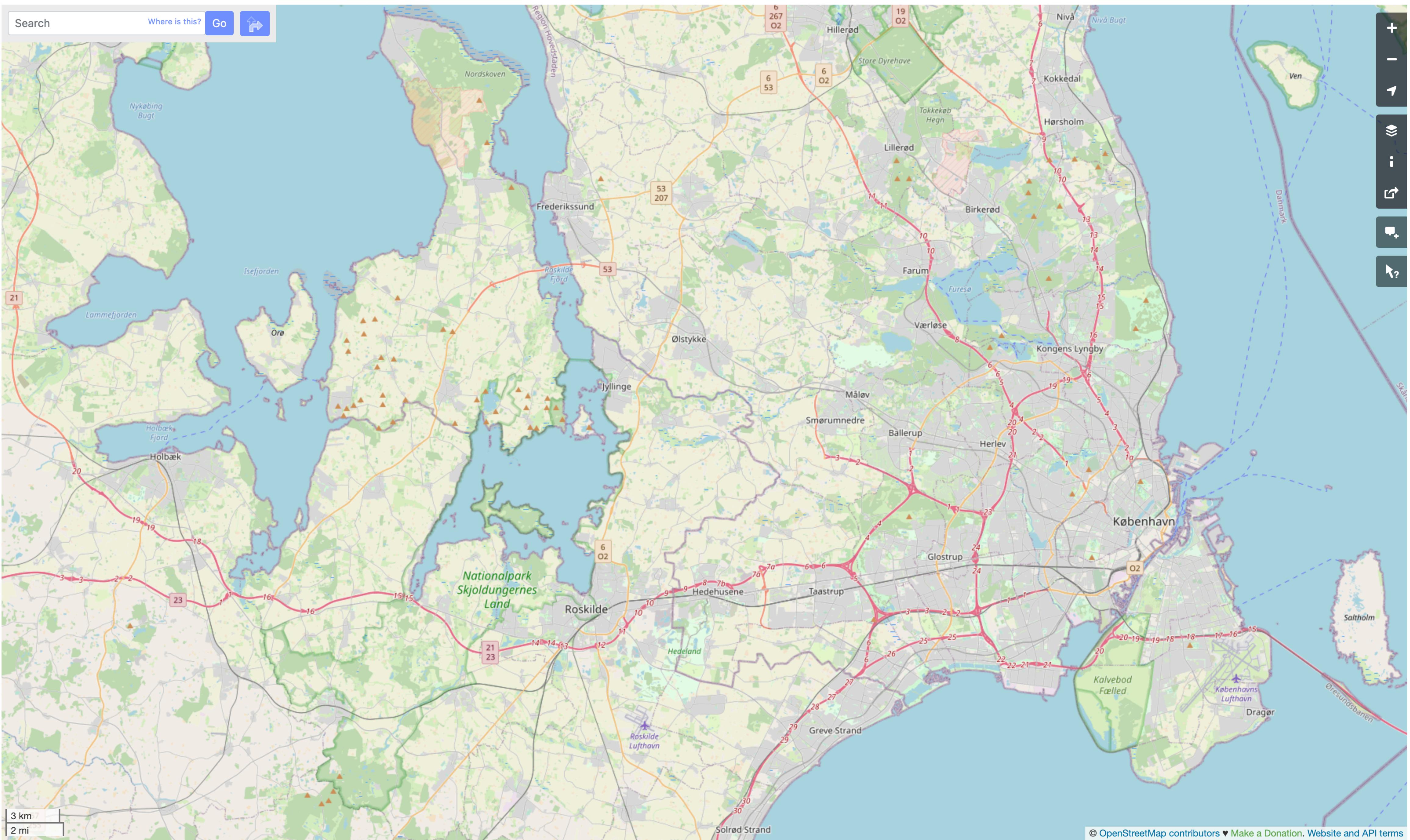
Established 2004 by Steve Coast

Volunteered geographical information (VGI)

The basis for most routing apps and many geo services (Amazon, Mapbox, Tesla, ...)



Contributors are not just local mappers, but huge organizations (NGOs, and commercial ones like Microsoft, Facebook, Apple)



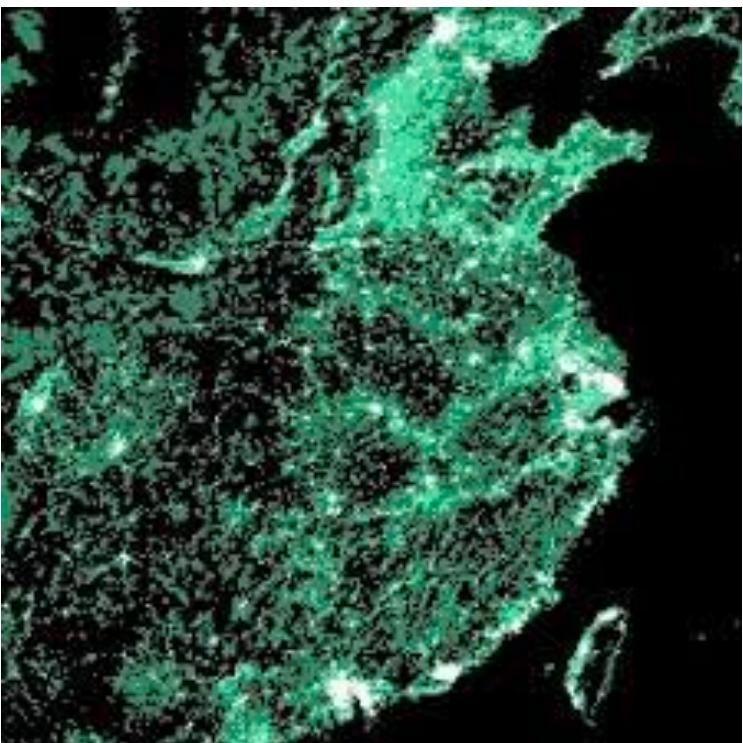
Today most public data are open

OPEN DATA DK



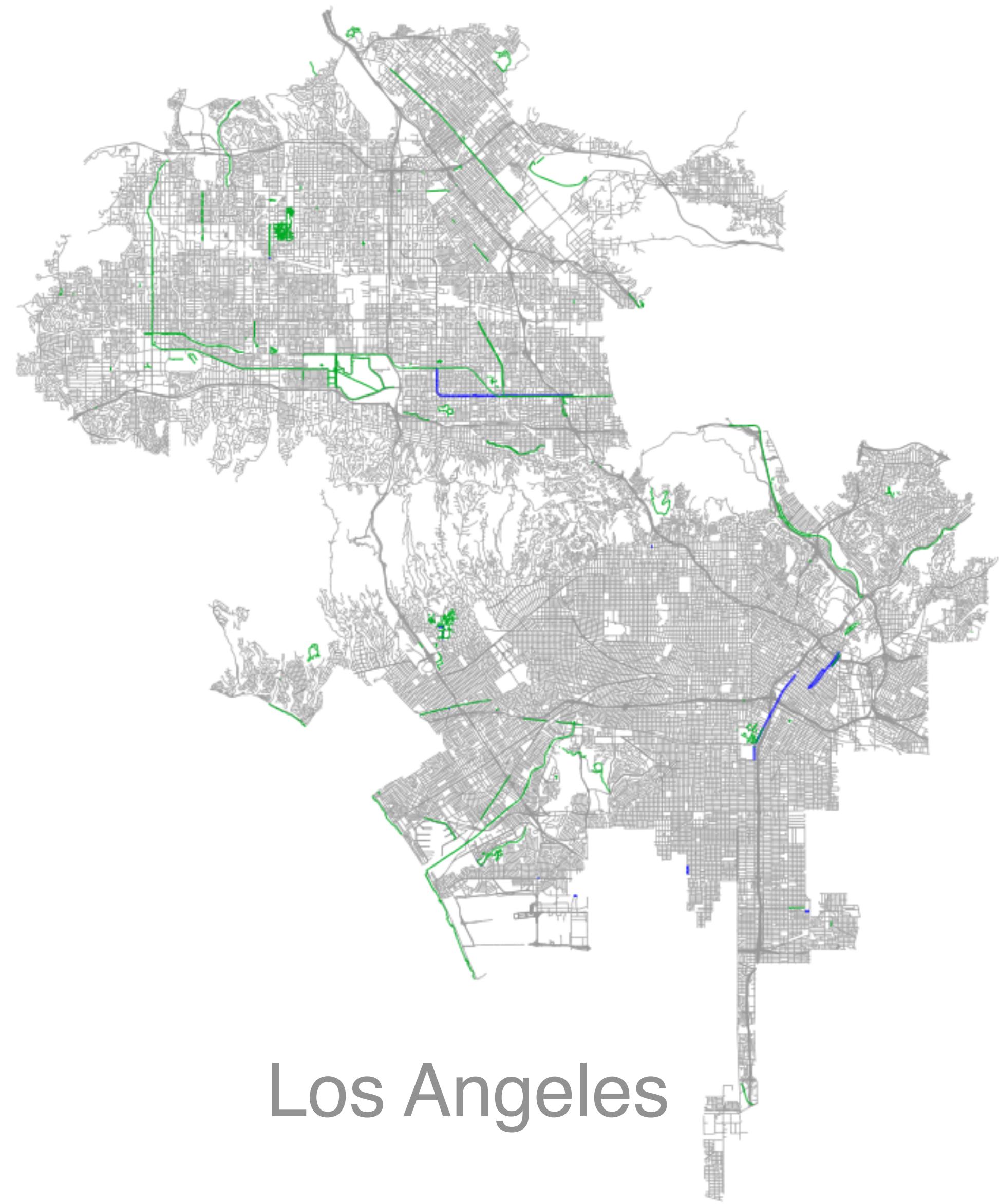
DATAFORDELER

Global Human Settlement

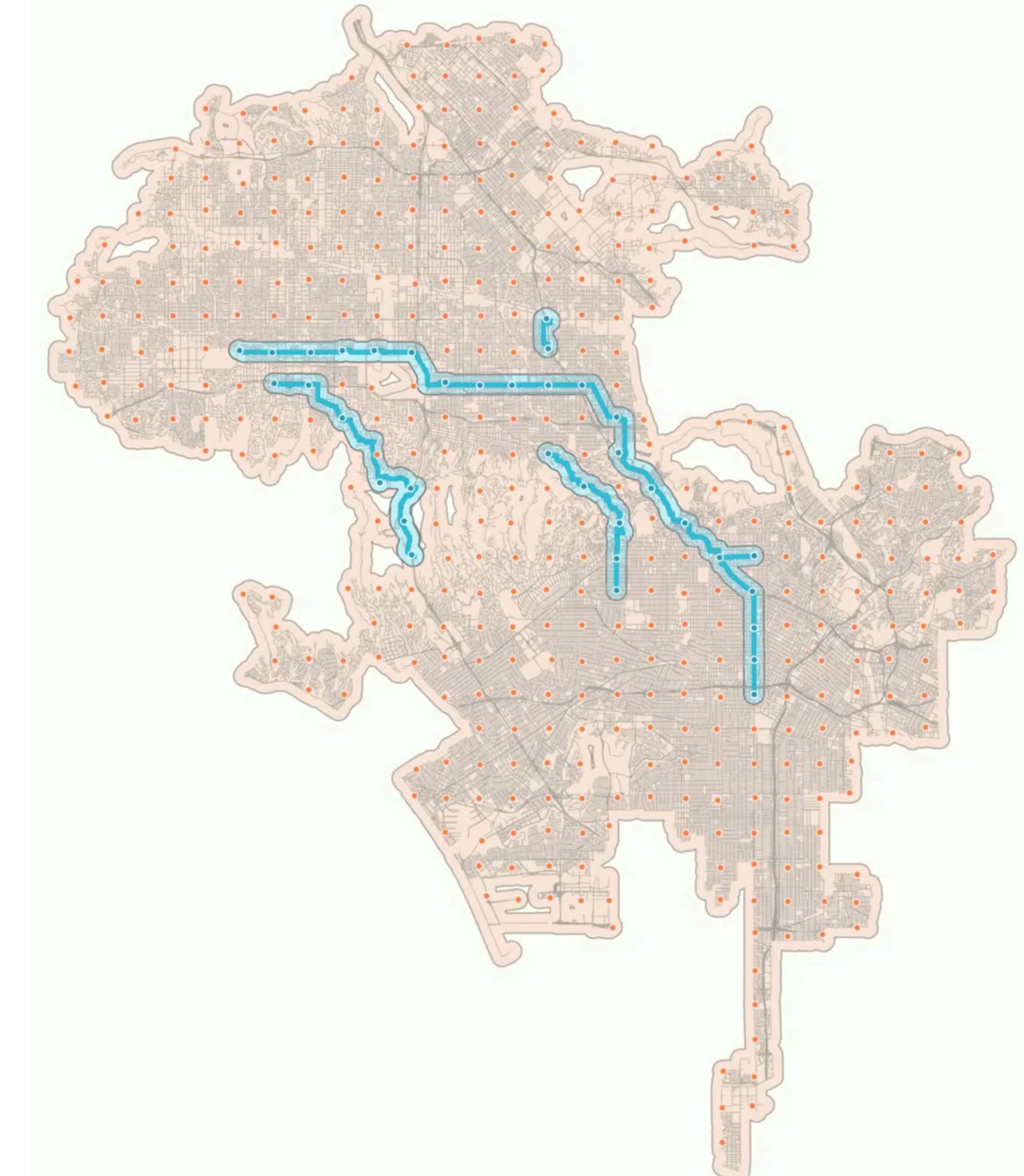


OSM Application Examples

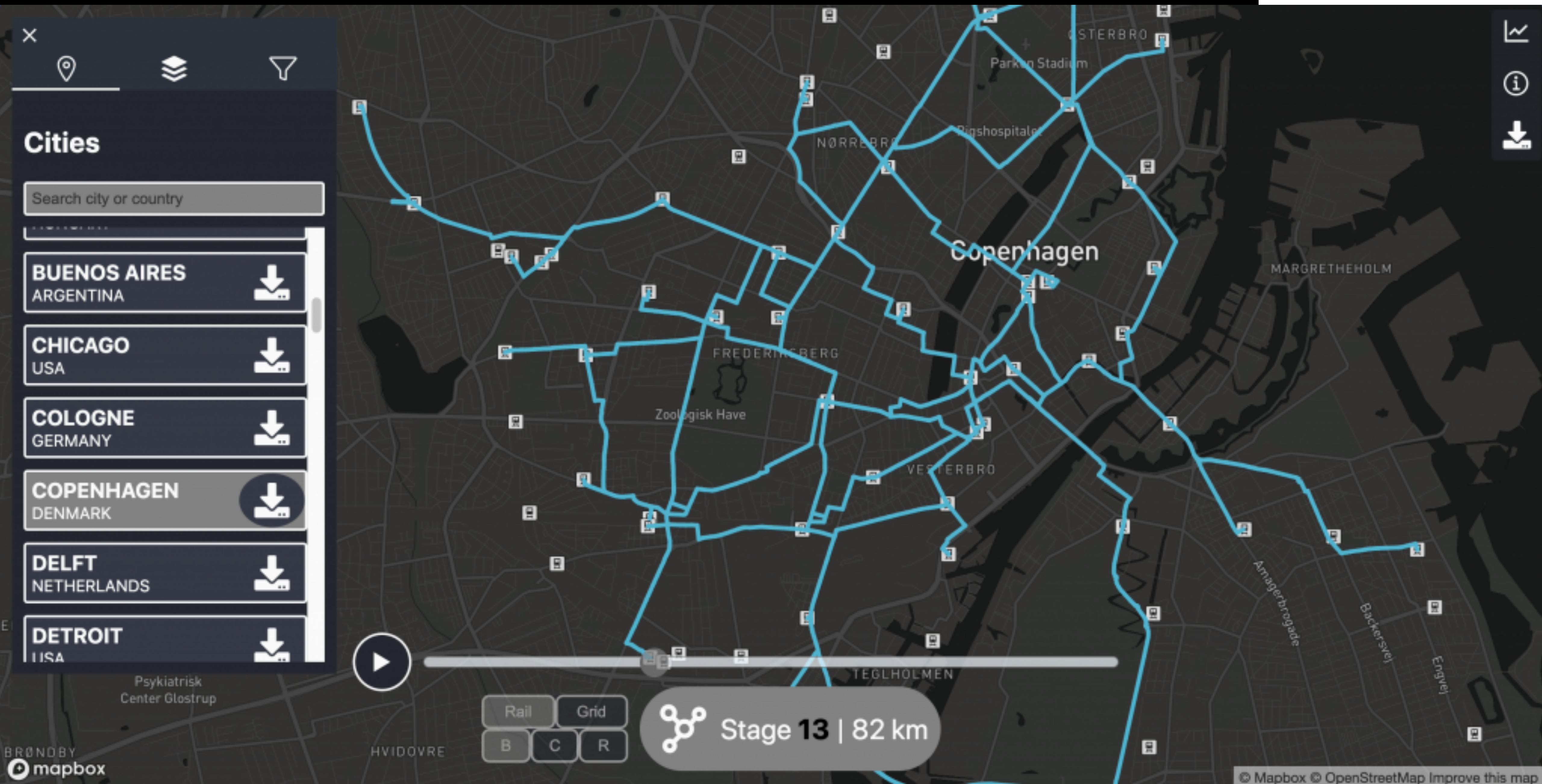
Research: Growing bicycle networks from scratch



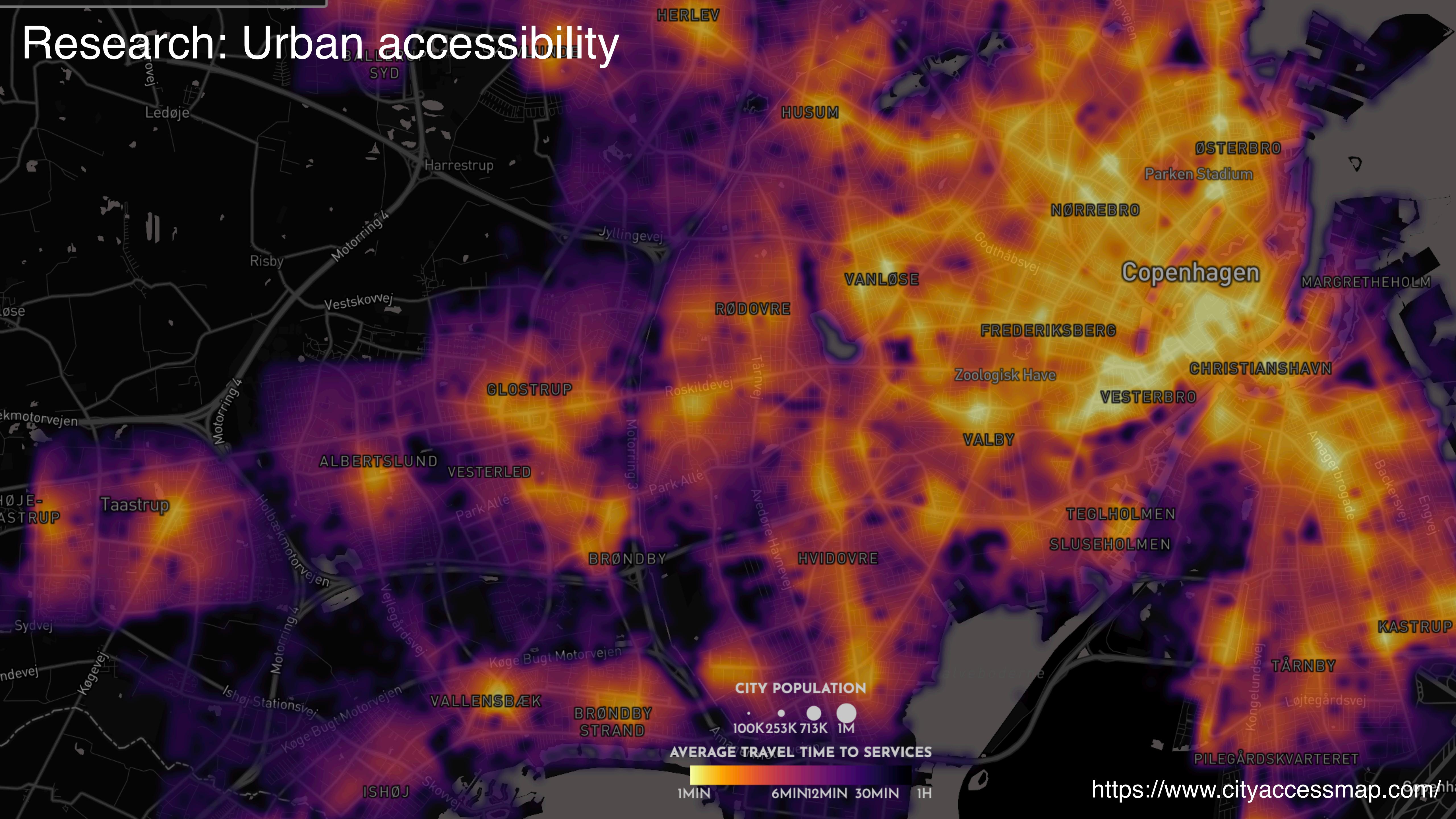
Los Angeles



Research: Growing bicycle networks from scratch



Research: Urban accessibility



<https://www.cityaccessmap.com/>

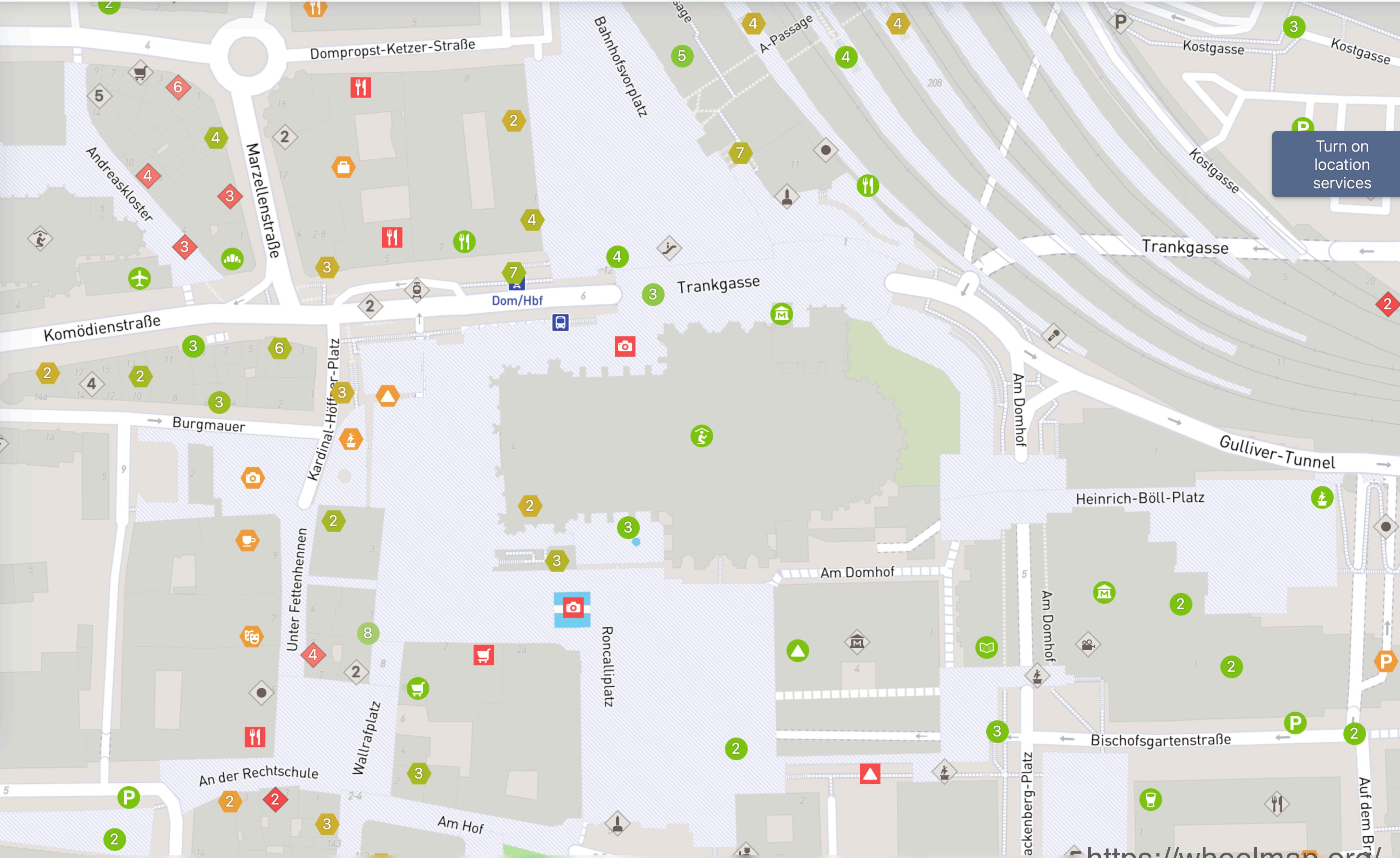
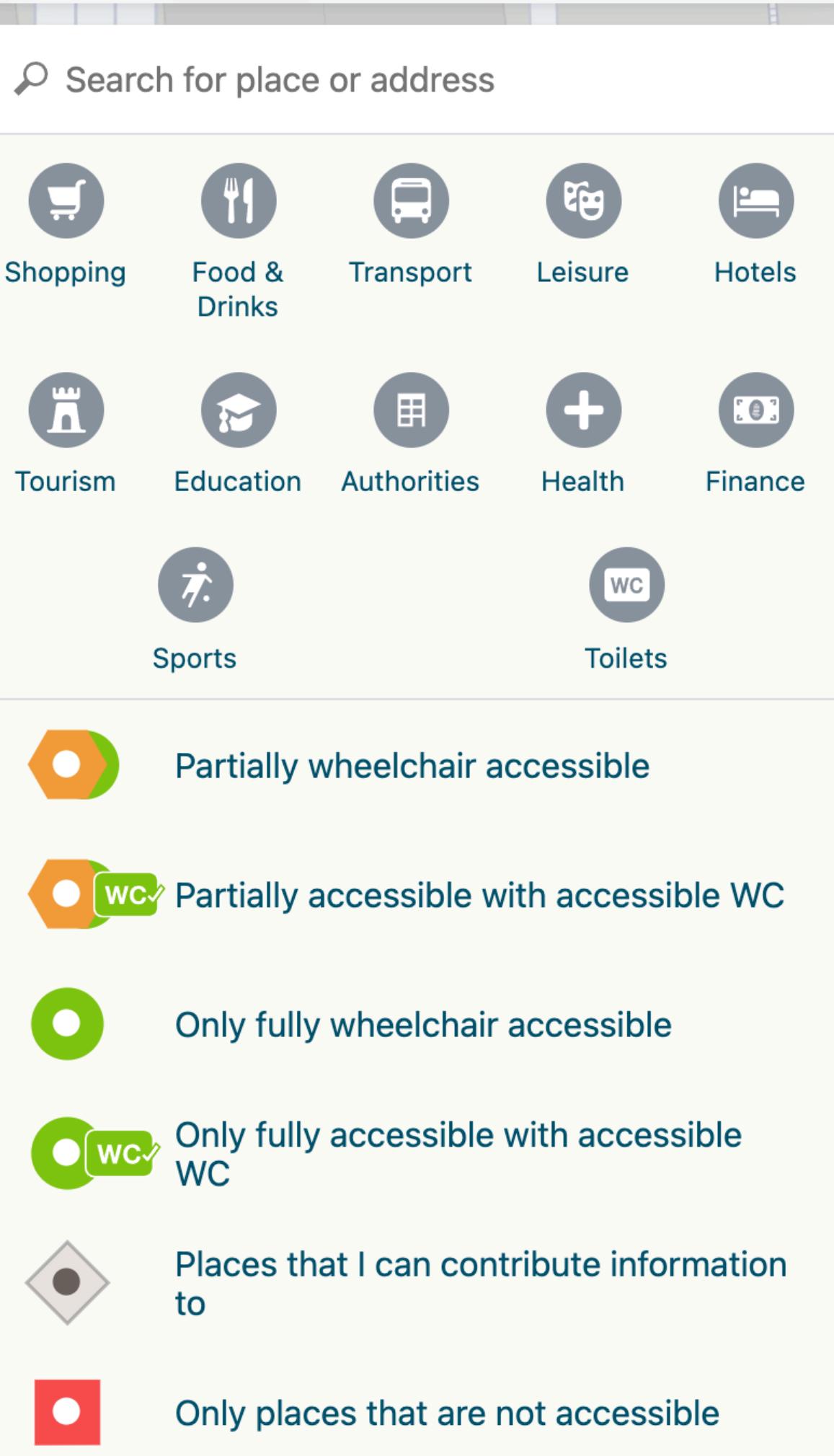
Non-profits: A/B Street



Activism: WheelMap

wheelmap.org Find wheelchair accessible places.

Get involved News Press Contact Legal FAQ Events Add a place



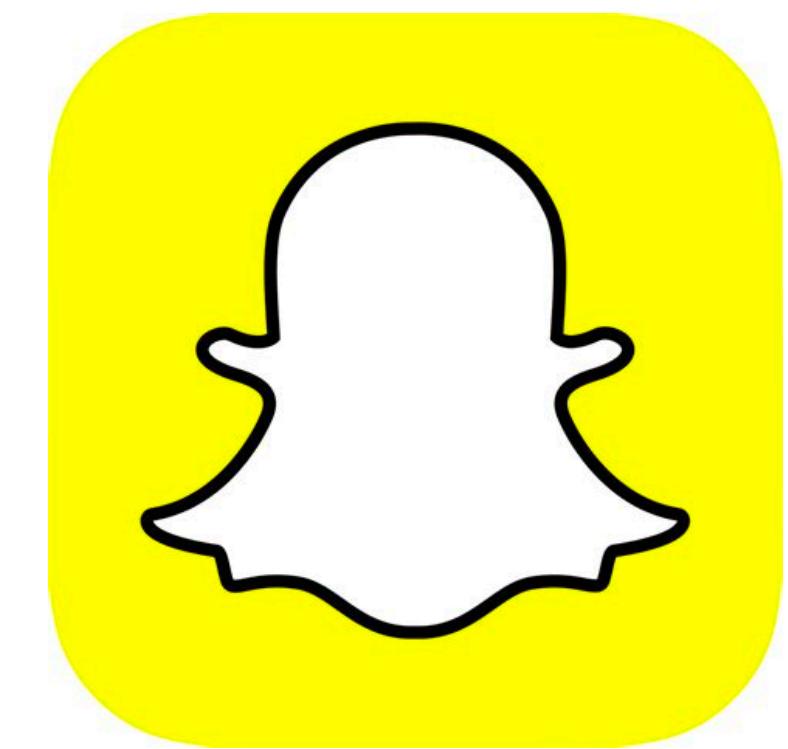
Routing



OSM are not just used for hobby projects!



UNITED NATIONS



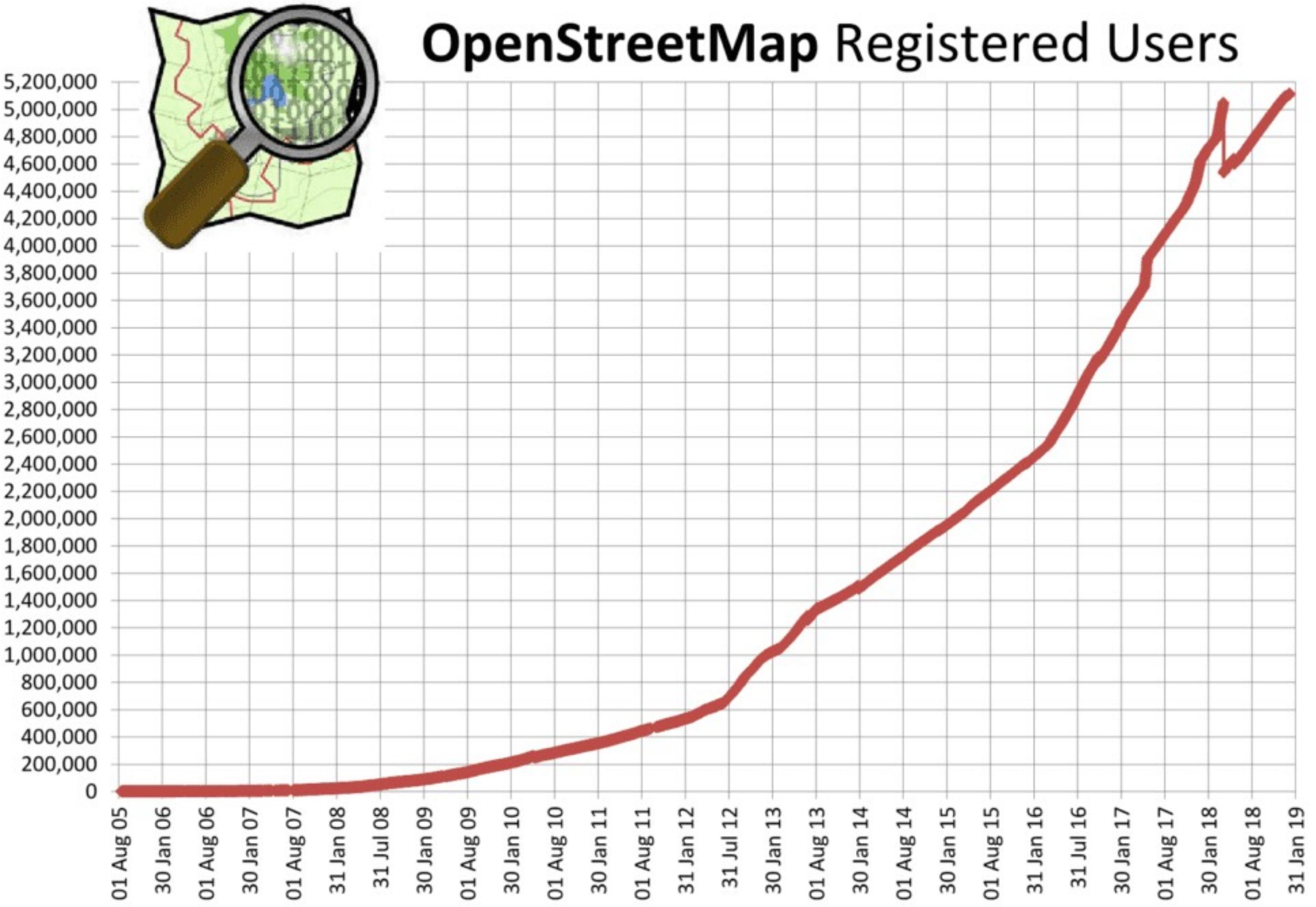
<https://welcome.openstreetmap.org/about-osm-community/consumers/>

<https://www.bloomberg.com/news/articles/2021-02-19/openstreetmap-charts-a-controversial-new-direction>

OSM History and Quality

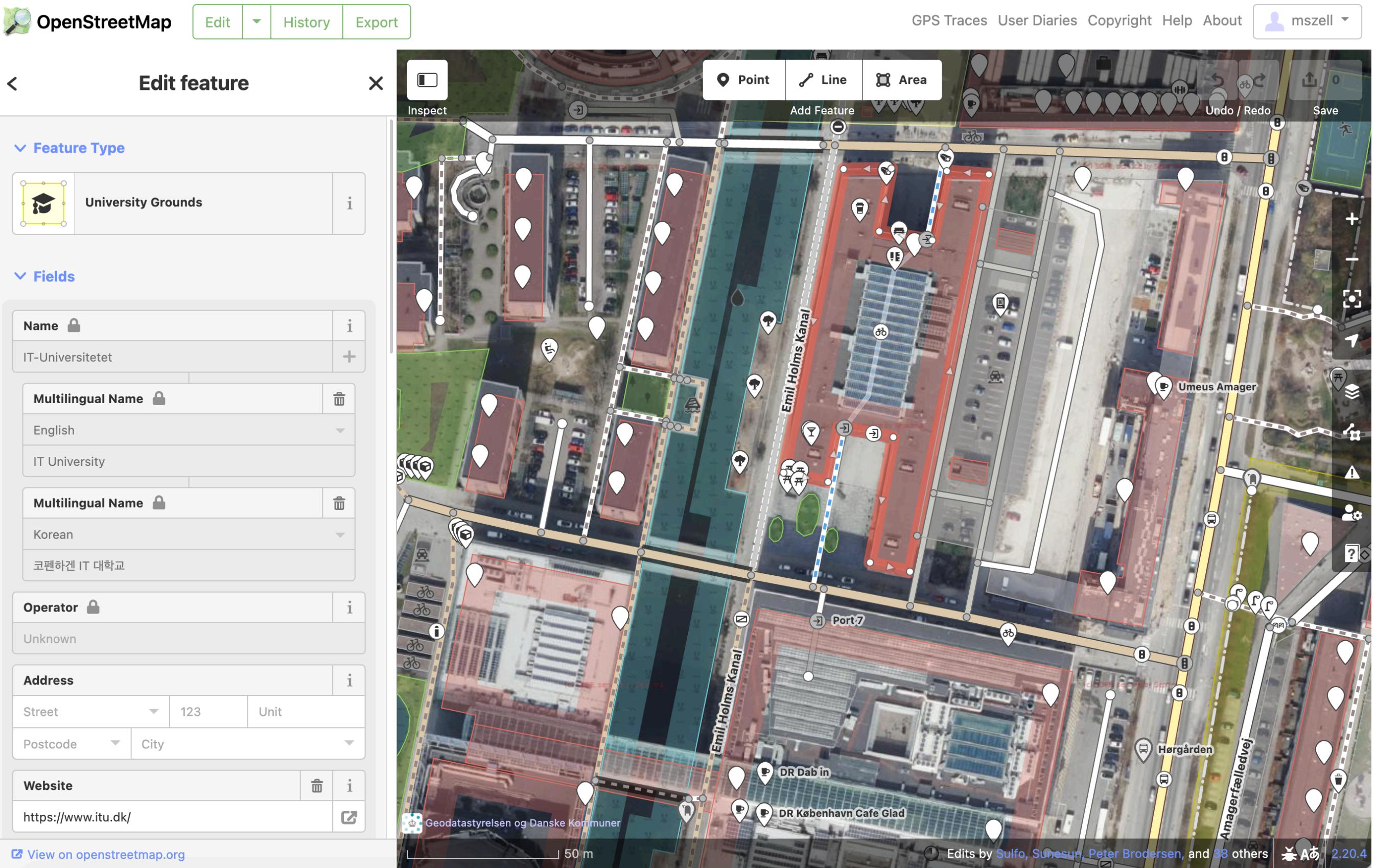
OSM is huge

8+ Mio contributors

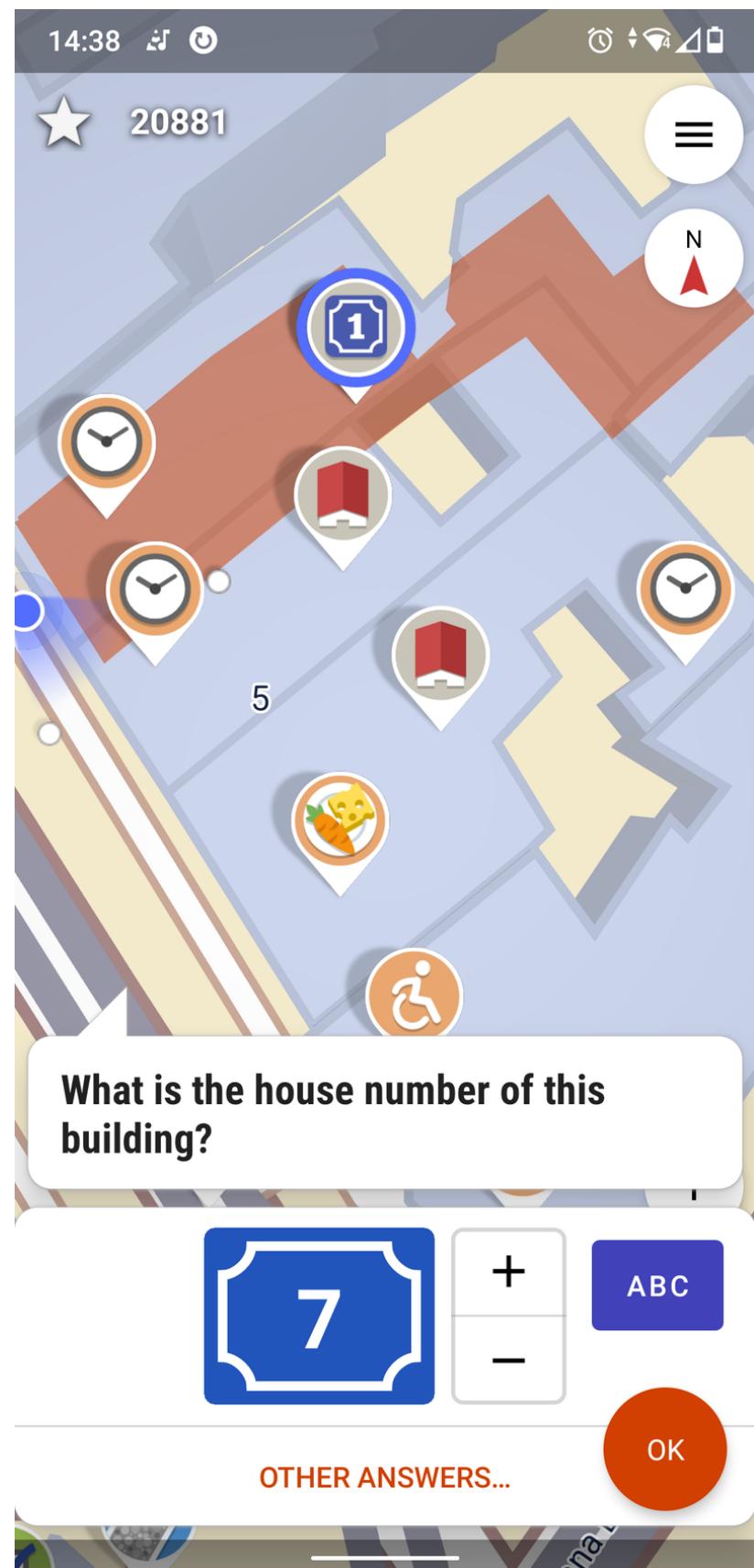


How to contribute as local mapper?

Directly in the browser

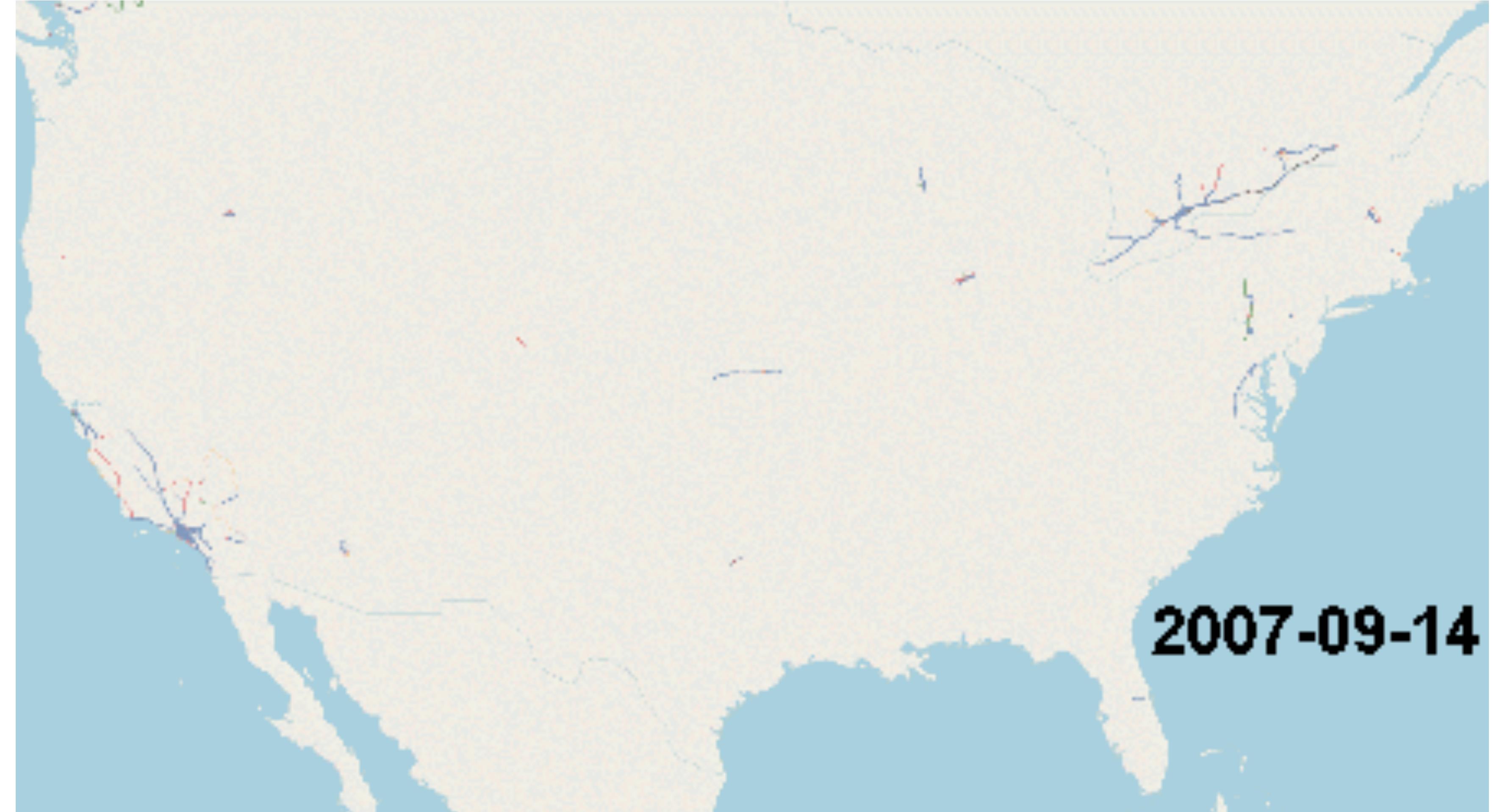


StreetComplete
(gamified mobile app)

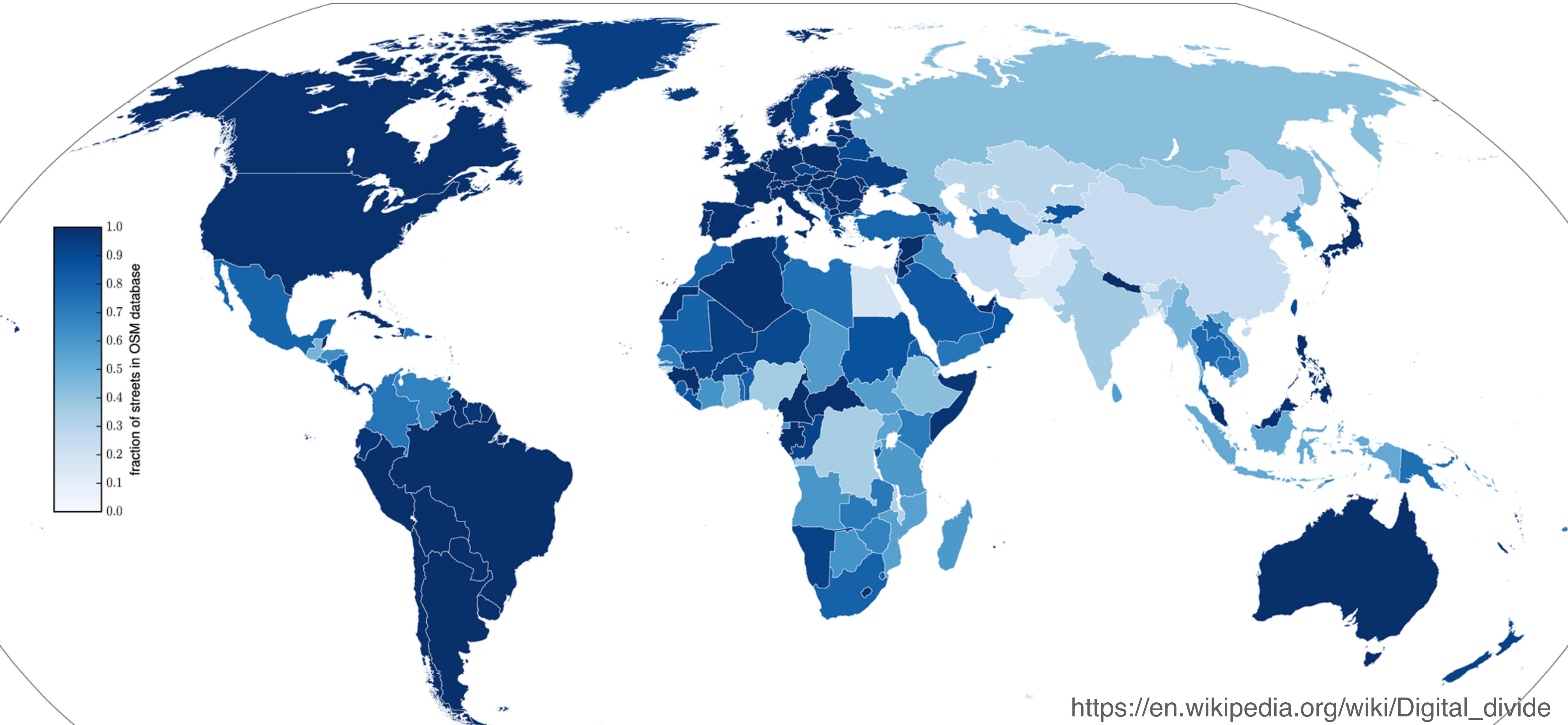


Batch imports from official sources are an important foundation

TIGER (Topologically Integrated Geographic Encoding and Referencing)



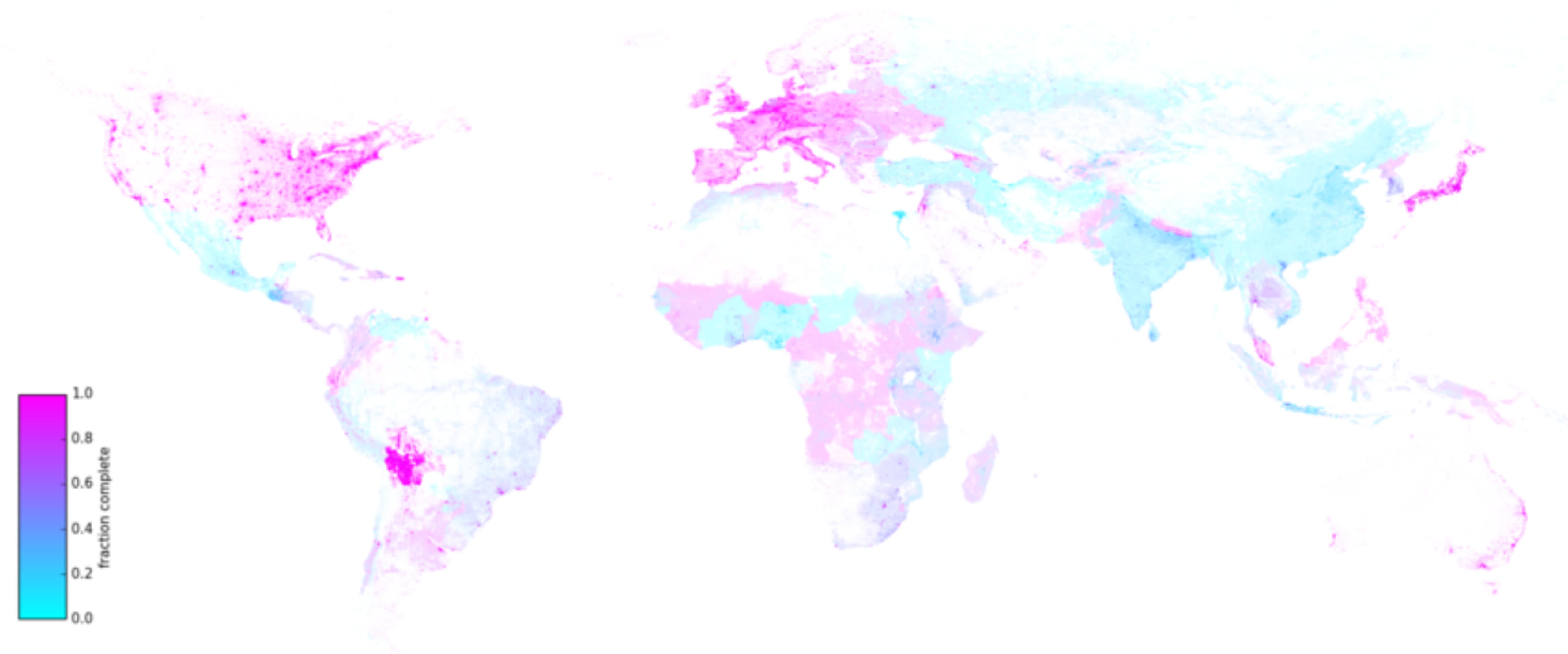
OSM is relatively complete



https://en.wikipedia.org/wiki/Digital_divide

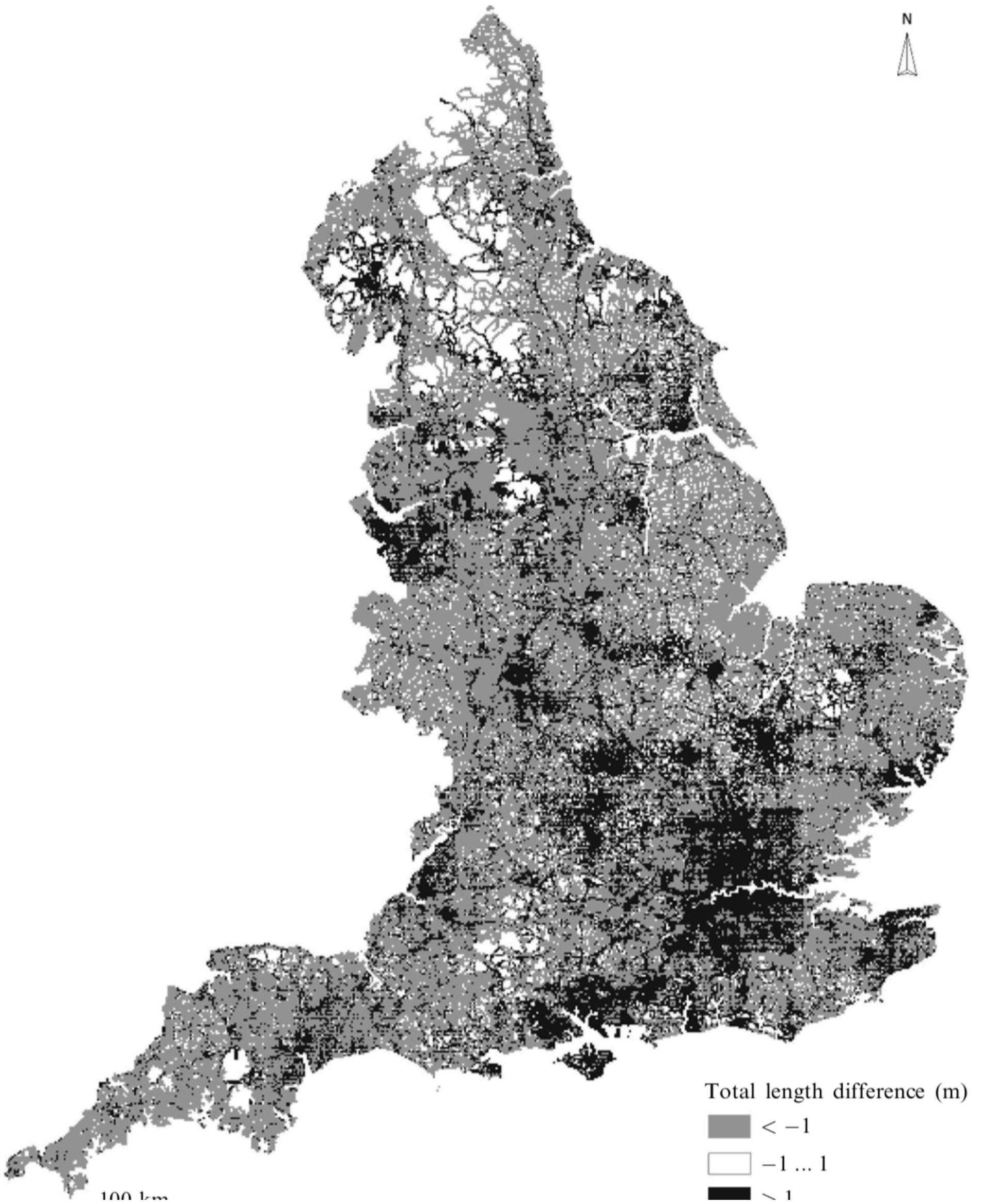
Barrington-Leigh and Millard-Ball, PLOS ONE (2017)

OSM is relatively complete



https://en.wikipedia.org/wiki/Digital_divide
Barrington-Leigh and Millard-Ball, PLOS ONE (2017)

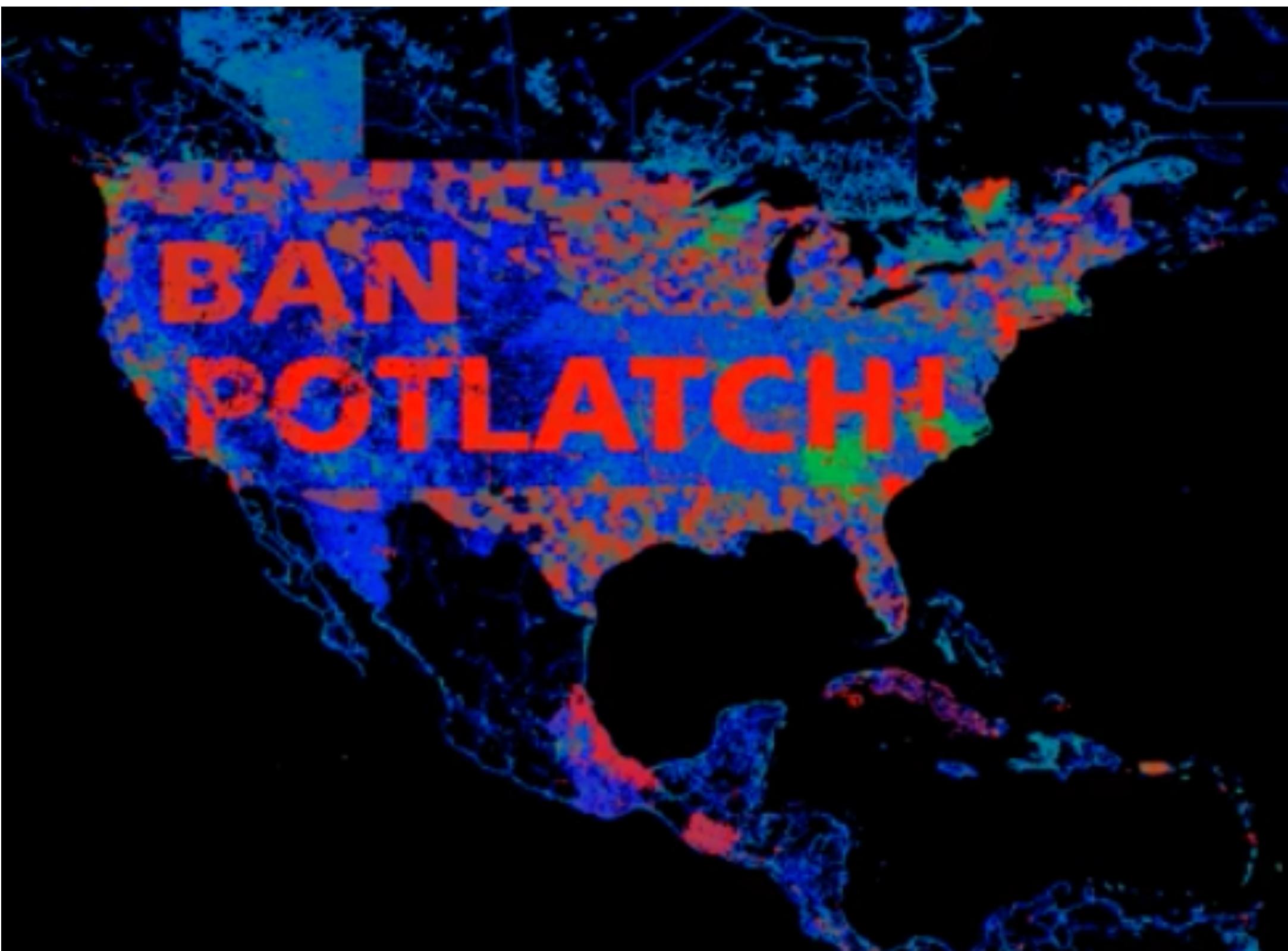
OSM is well covered where wealthy people live



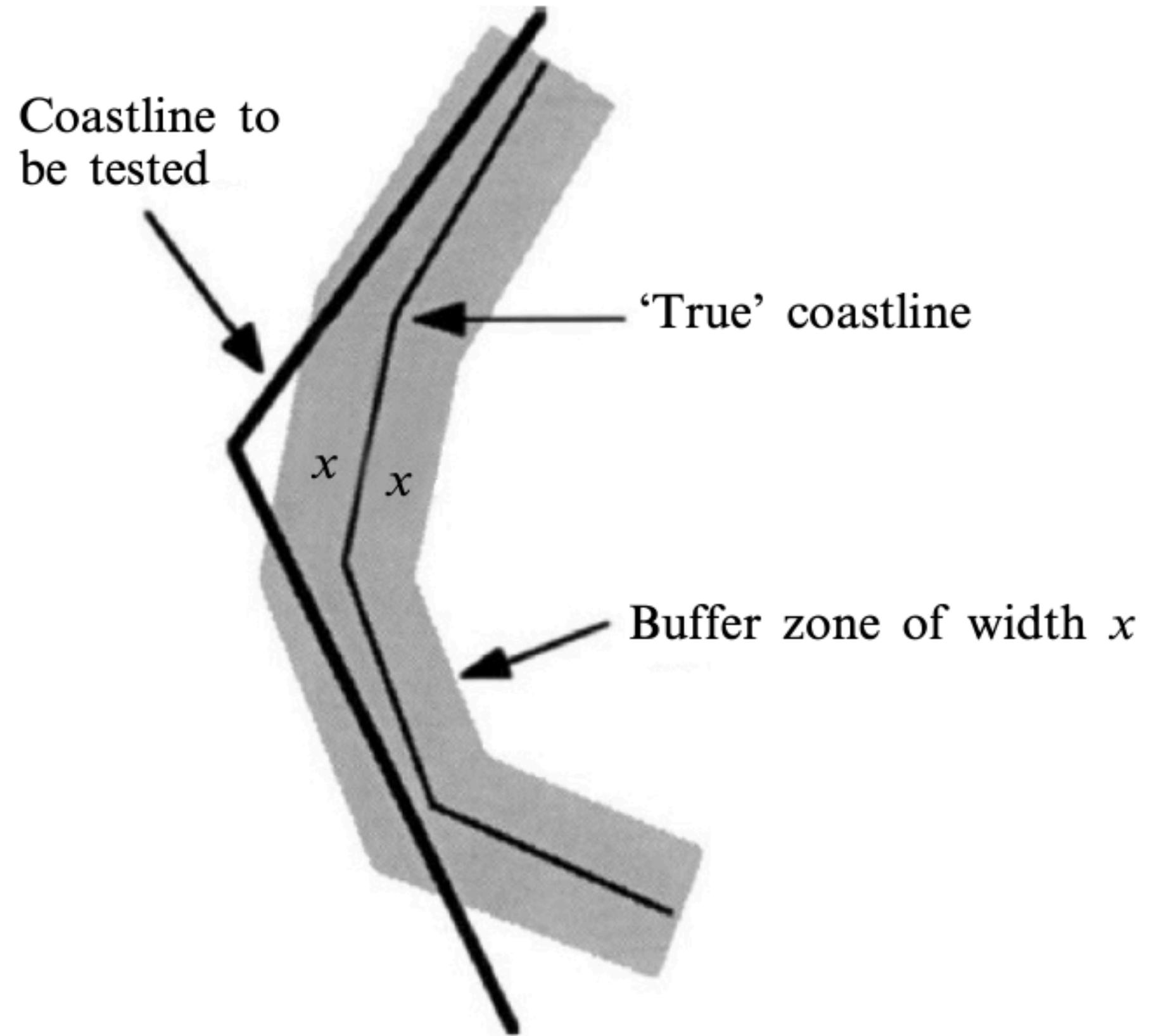
| ID 2007 percentile | All roads (%) | Named roads (%) |
|--------------------|---------------|-----------------|
| 1–10 (poor) | 46.09 | 22.52 |
| 91–100 (wealthy) | 76.59 | 30.21 |
| Overall | 57.00 | 16.87 |

OSM is relatively accurate

Temporary vandalism is possible

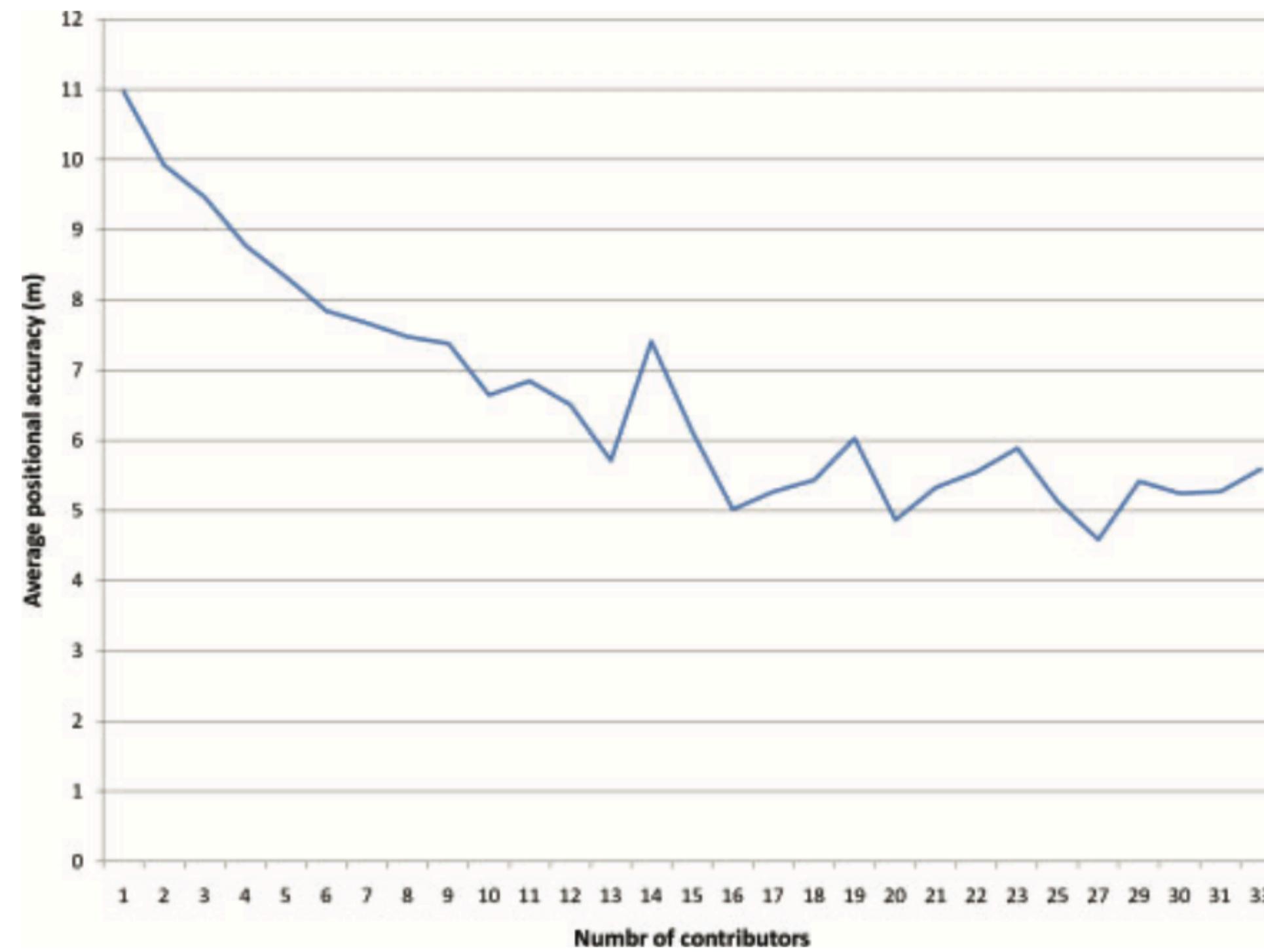


Buffer-zone method between OSM and ground truth

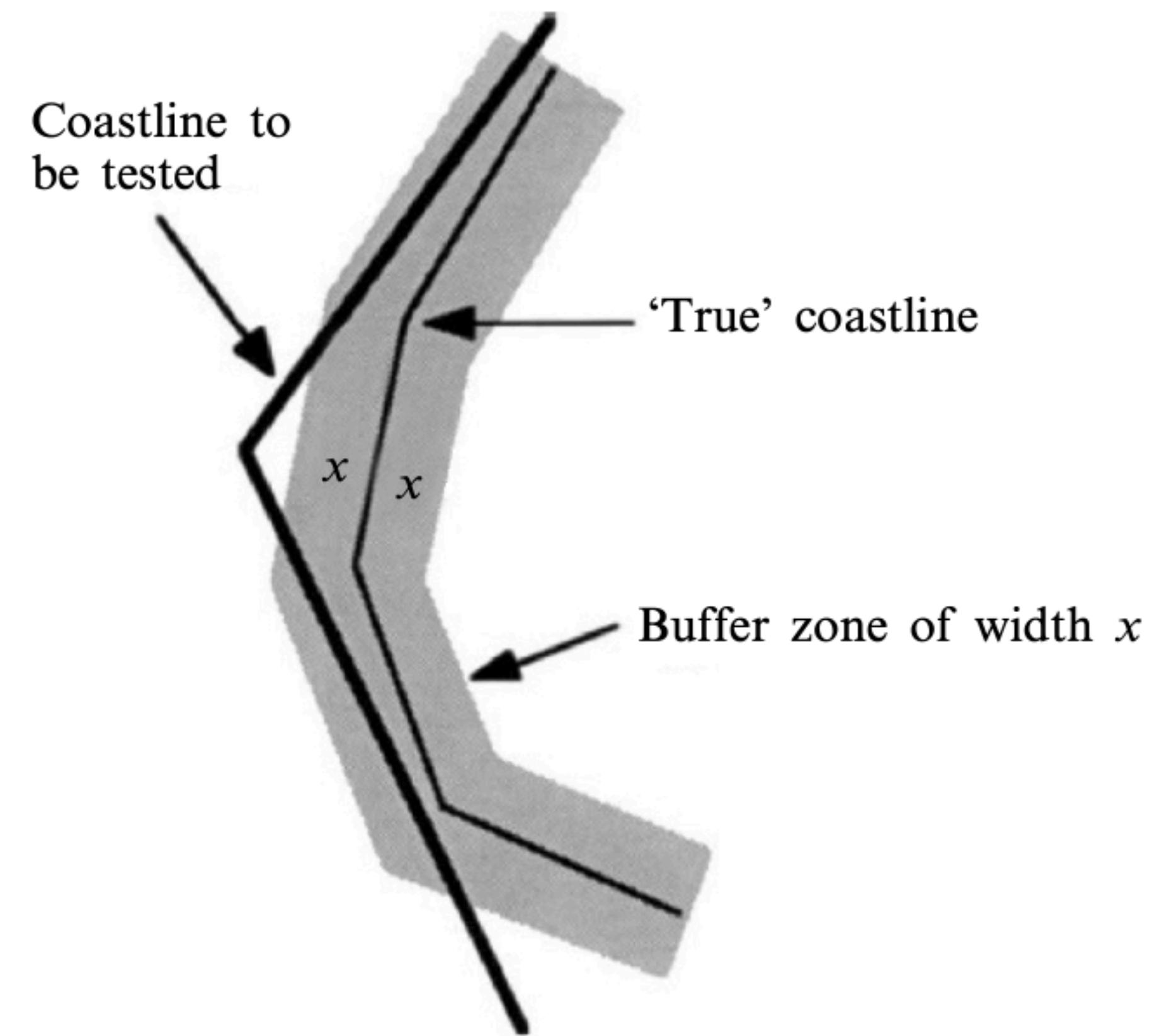


OSM is relatively accurate

The more contributors,
the better the accuracy



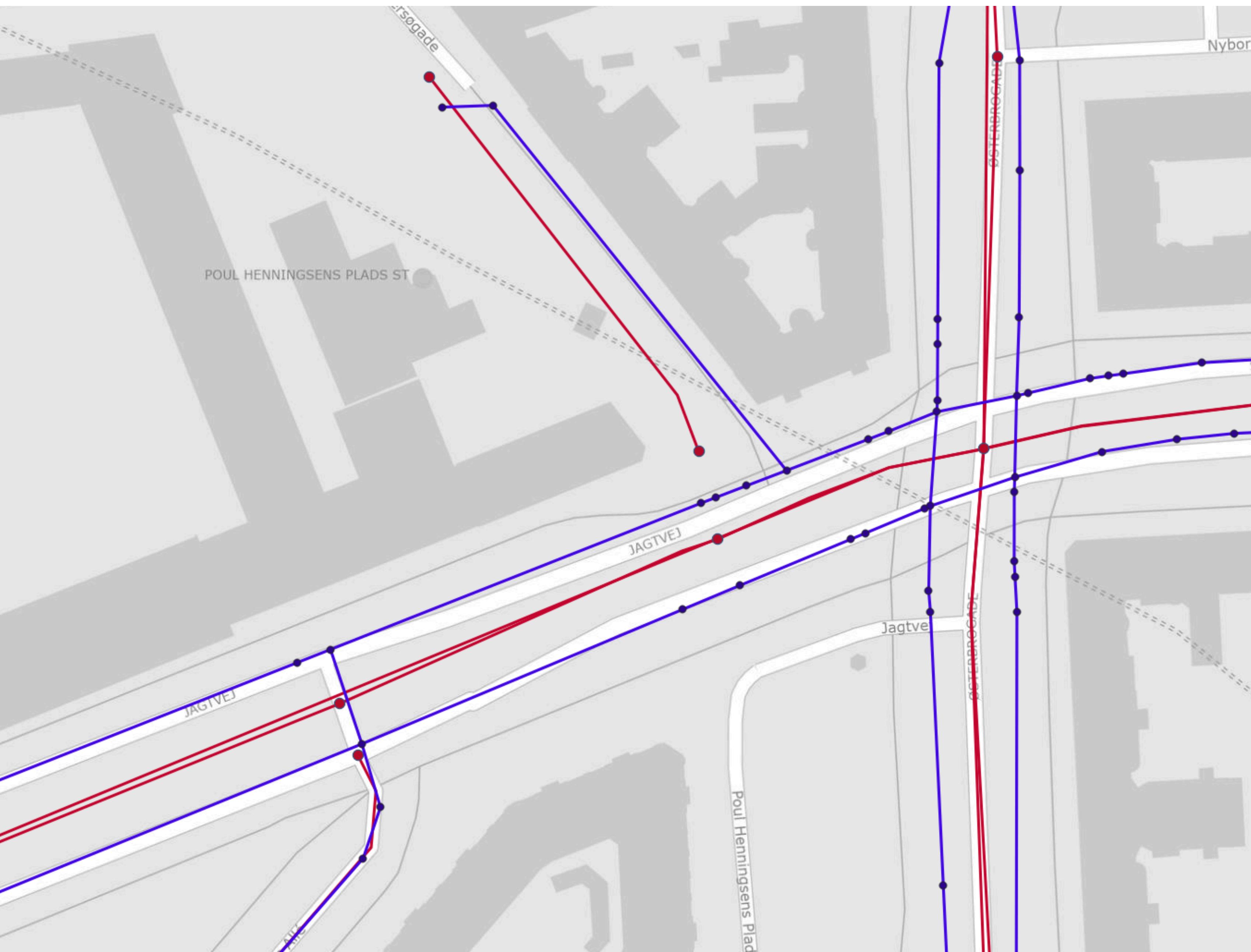
Buffer-zone method between
OSM and ground truth



*Linus' law: Given enough eyeballs,
all bugs are shallow*

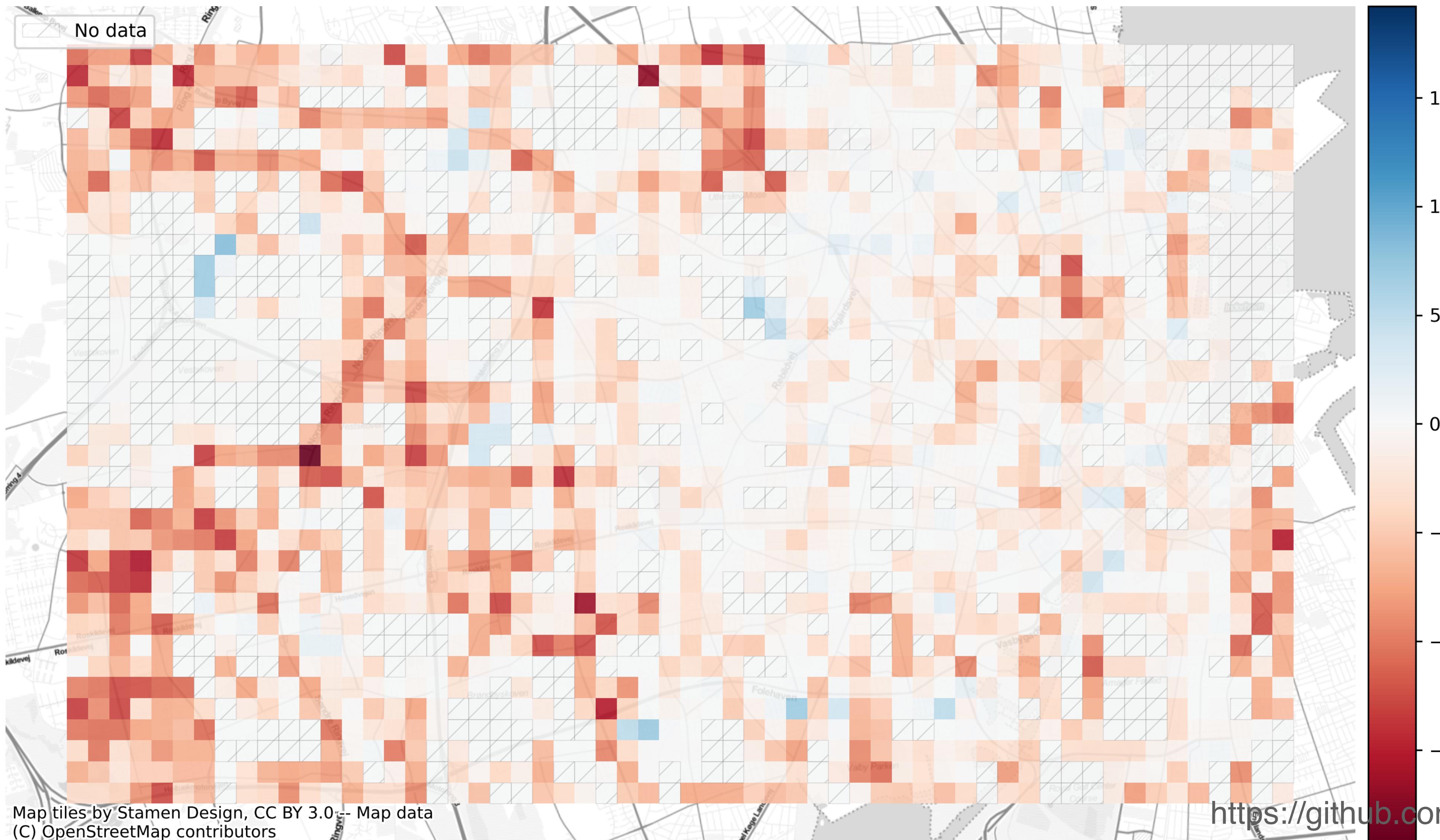
Haklay et al. *The cartographic journal* 47.4 (2010)

OSM often has much better quality than official data

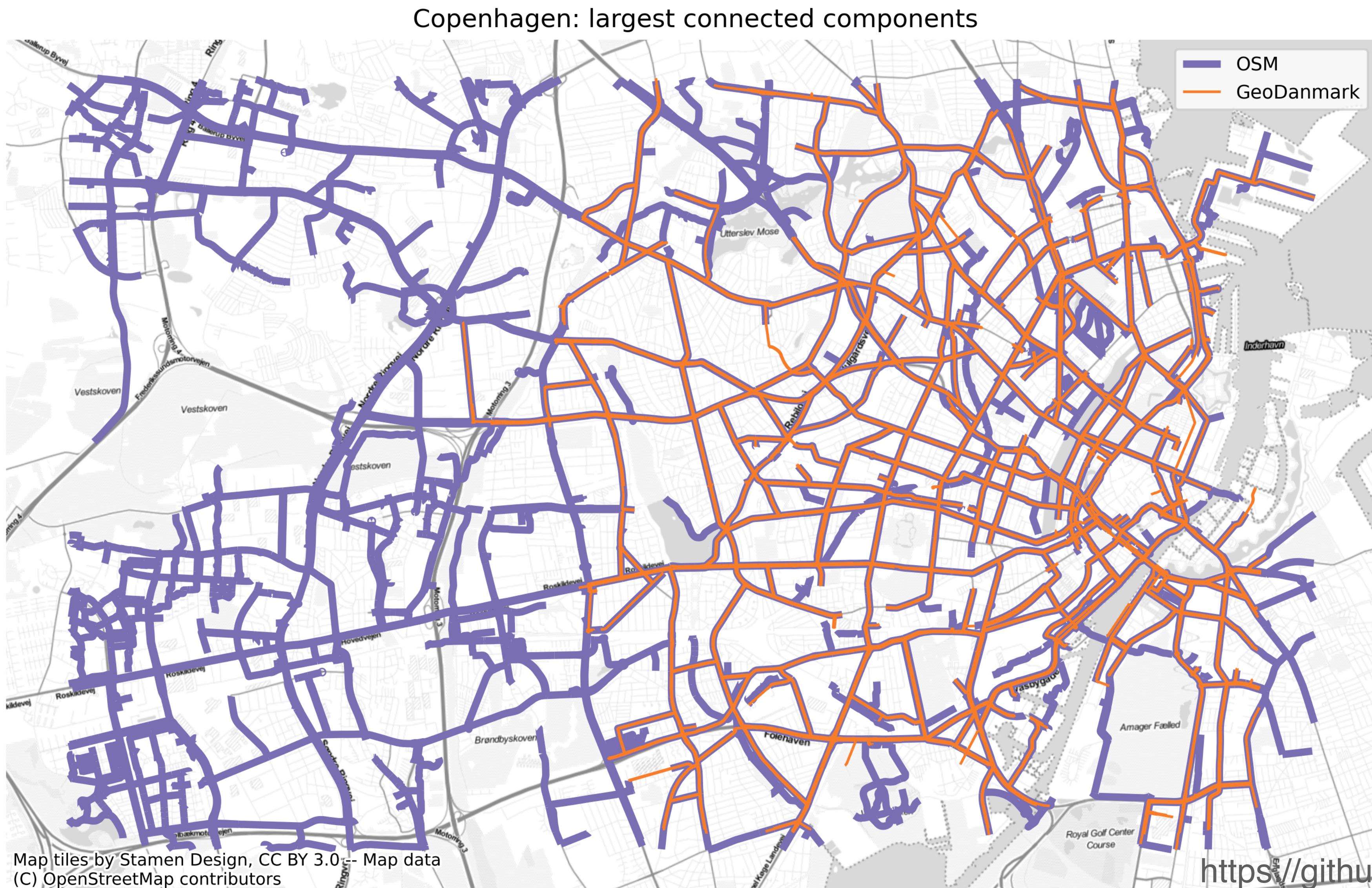


BikeDNA Bicycle Infrastructure Data & Network Assessment

Copenhagen: GeoDanmark edge density differences to OSM (m/km²)

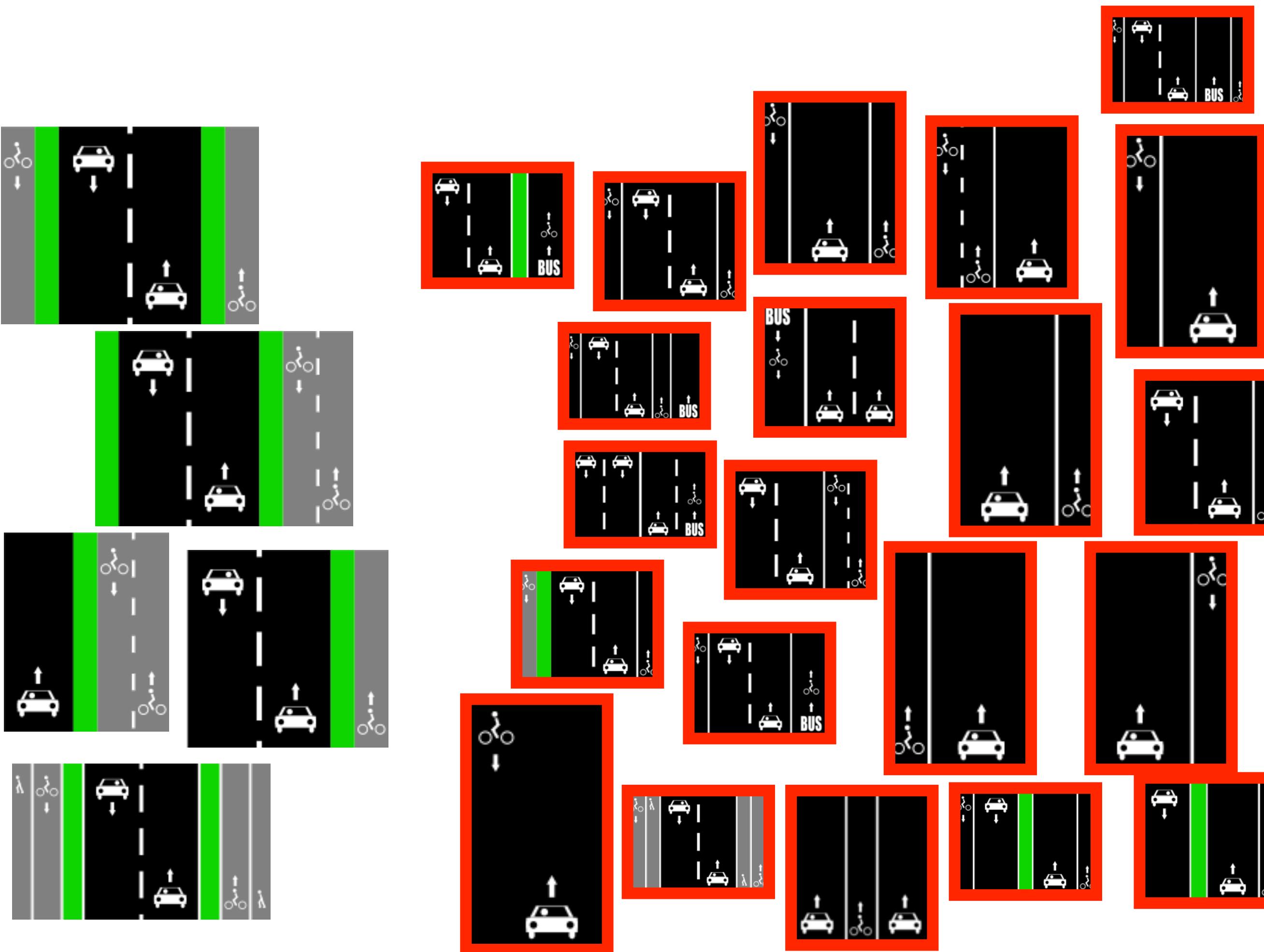


BikeDNA Bicycle Infrastructure Data & Network Assessment



OSM is ever evolving and can be very messy

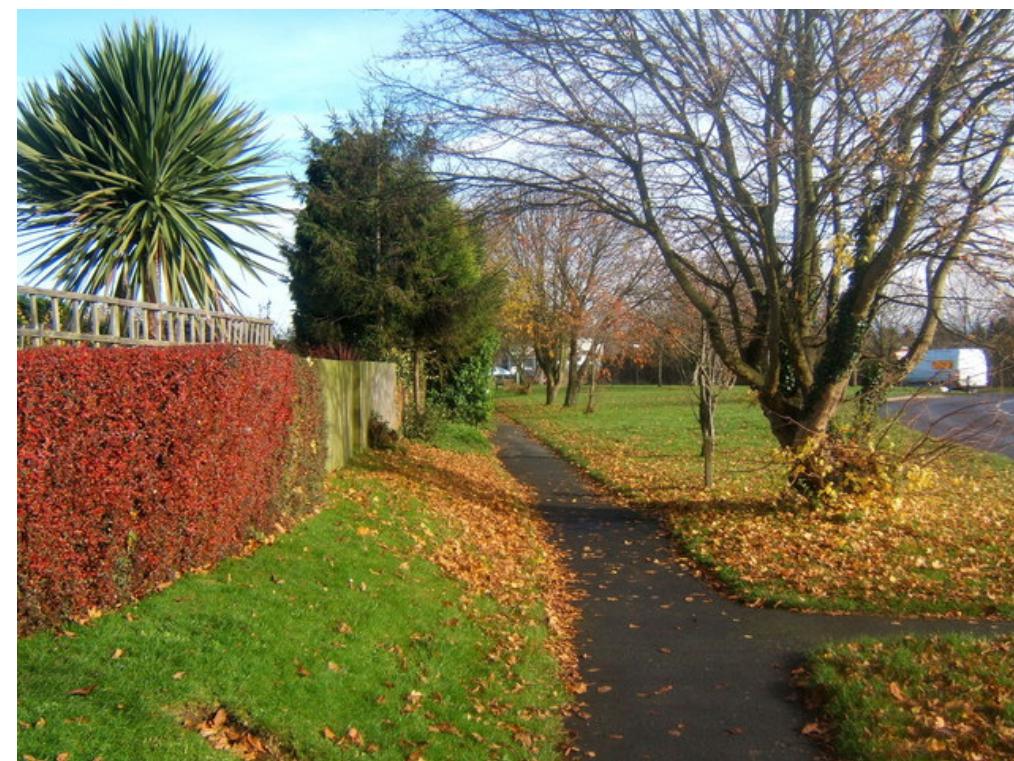
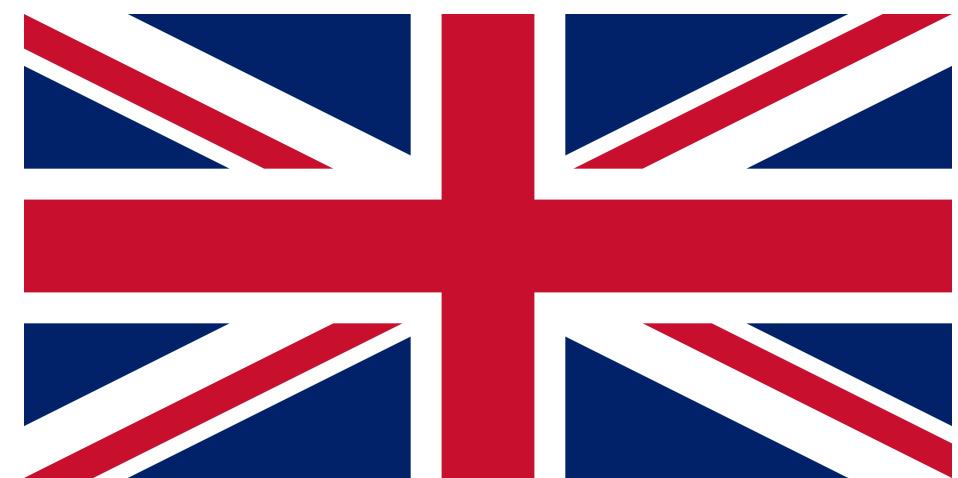
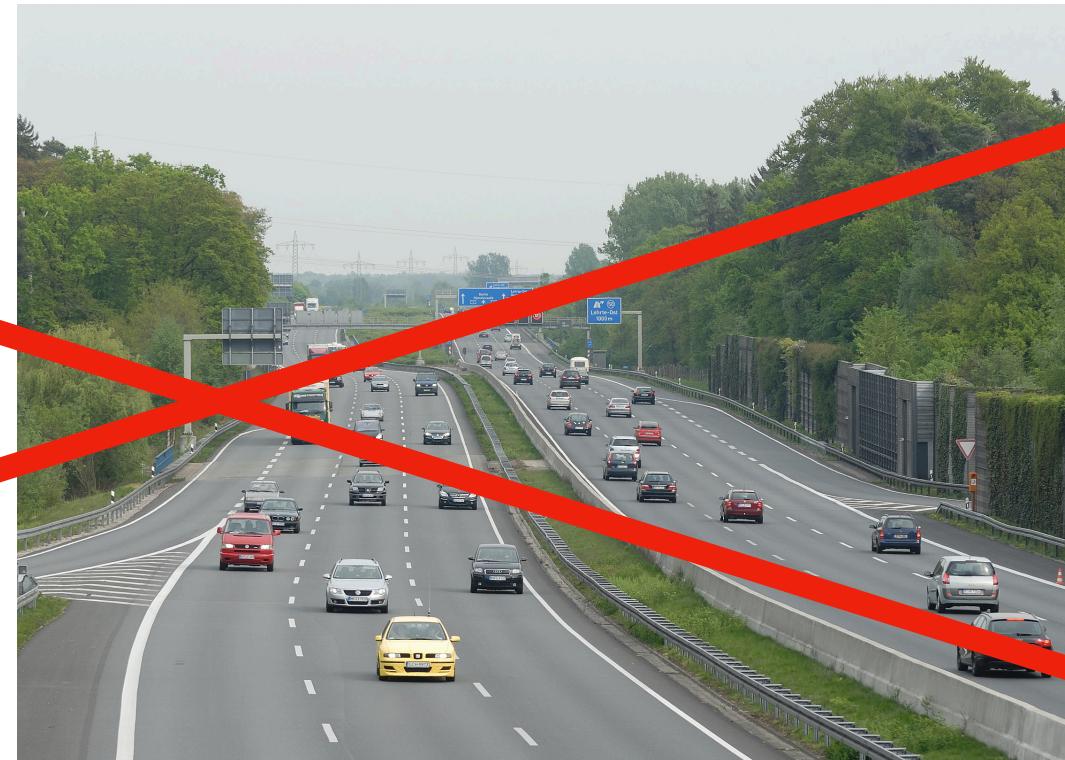
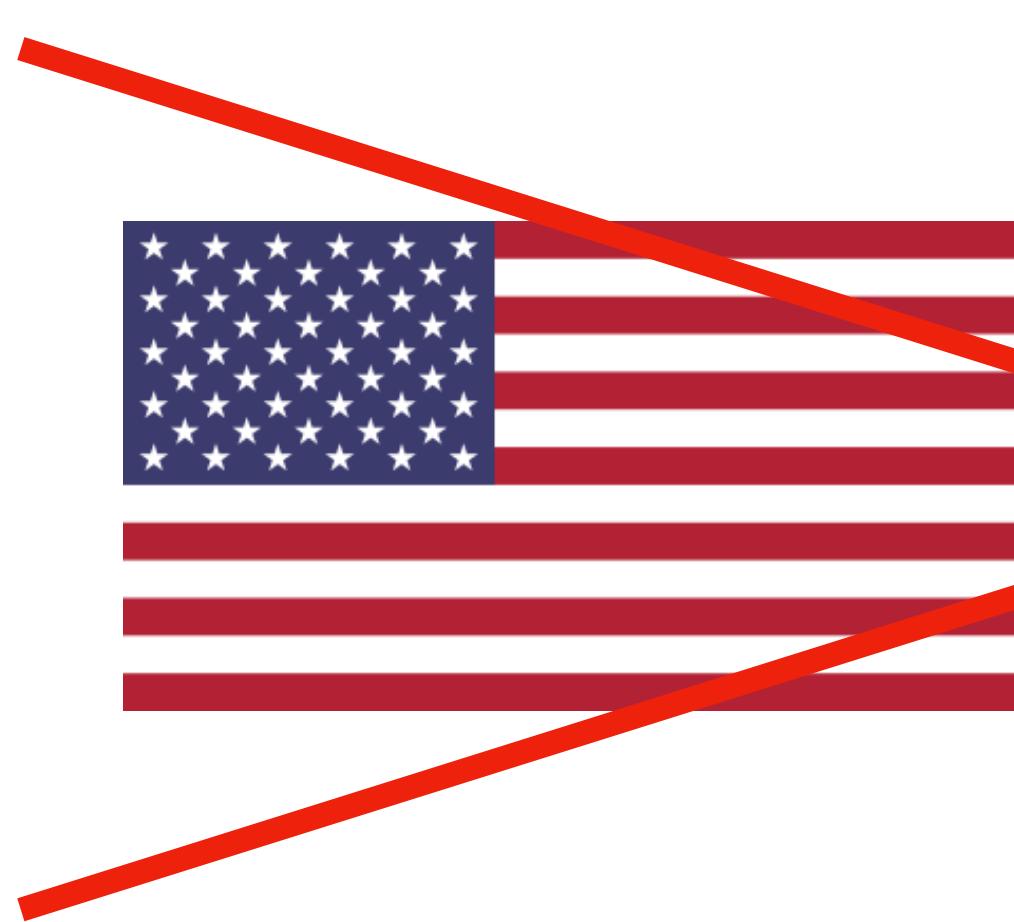
Dozens of ways to encode bicycle infrastructure!



OSM is a good preview of ‘real’ data



"highway" = any road/way/path for any non-rail transport



Why OSM and not just Google Maps?

OSM

Free,
also for commercial applications

Google Maps

Not free,
licensing and fees at whim of management

Why OSM and not just Google maps?

OSM

Free,
also for commercial applications

Ecosystem of open tools, research

Google maps

Not free,
licensing and fees at whim of management

Proprietary

Why OSM and not just Google maps?

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Ecosystem of open tools, research

Less polished rendering and UX

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Why OSM and not just Google maps?

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Less polished rendering and UX

Underlies most map-based software

Google maps

Not free,
licensing and fees at whim of management

Proprietary

More polished rendering and UX

Integration with Google products

Why OSM and not just Google maps?

OSM

Free,
also for commercial applications

Ecosystem of open tools, research

Less polished rendering and UX

Underlies most map-based software

Maps cycle paths, footpaths,..

Google maps

Not free,
licensing and fees at whim of management

Proprietary

More polished rendering and UX

Integration with Google products

Car-centric (but improving!)

Accessing & Handling OSM Data

OSM has a topological data structure

The logical structure between elements is important (routing,...)

OSM data consists generally of graphs: nodes+links

more on this next week!

OSM has a topological data structure

The logical structure between elements is important (routing,...)

OSM data consists generally of graphs: nodes+links

3 elements / primitives:

- | | | |
|--|-----------------|-----------------------|
| | Node | id, lat, lon |
| | Way | ordered list of nodes |
| | Relation | multiple elements |

OSM has a topological data structure

The logical structure between elements is important (routing,...)

OSM data consists generally of graphs: nodes+links

3 elements / primitives:

| | | |
|----------|----------|--|
| | Node | id, lat, lon |
| | Way | ordered list of nodes |
| | Relation | multiple elements |
| | Tag | key=value, describing an element's feature |

Point

Line

Area

Edit feature

Feature Type



Parking Ticket Vending Machine



A machine selling tickets for parking

[View documentation](#)

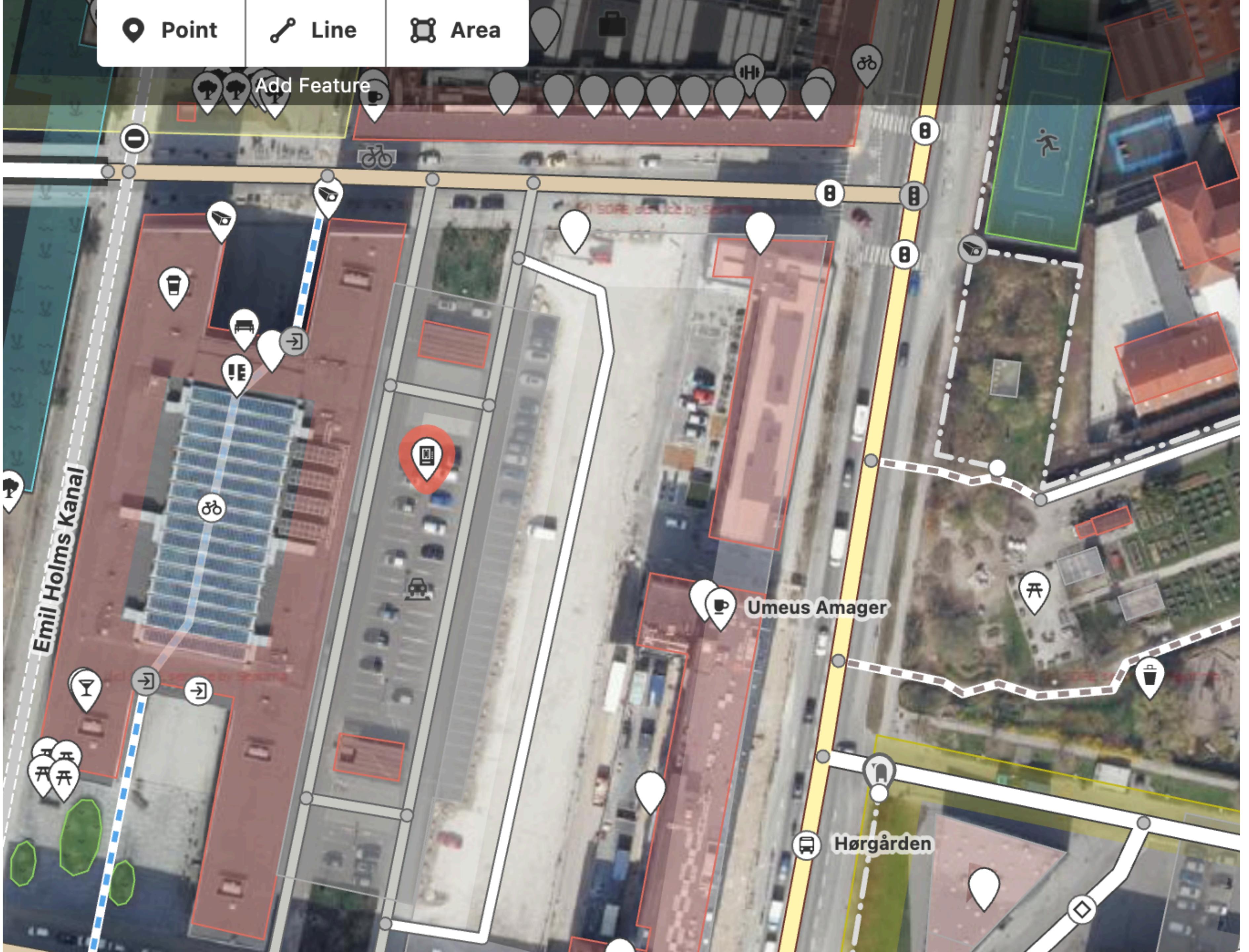
> Fields

Tags (3)



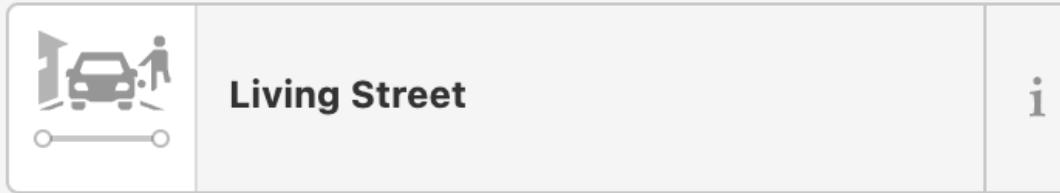
| | | | |
|------------|-----------------|--|--|
| amenity | vending_machine | | |
| check_date | 2021-02-18 | | |
| vending | parking_tickets | | |
| + | | | |

Relations (0)



Edit feature

Feature Type



Road with very low speed limits and other pedestrian friendly traffic rules.



View documentation

> Fields

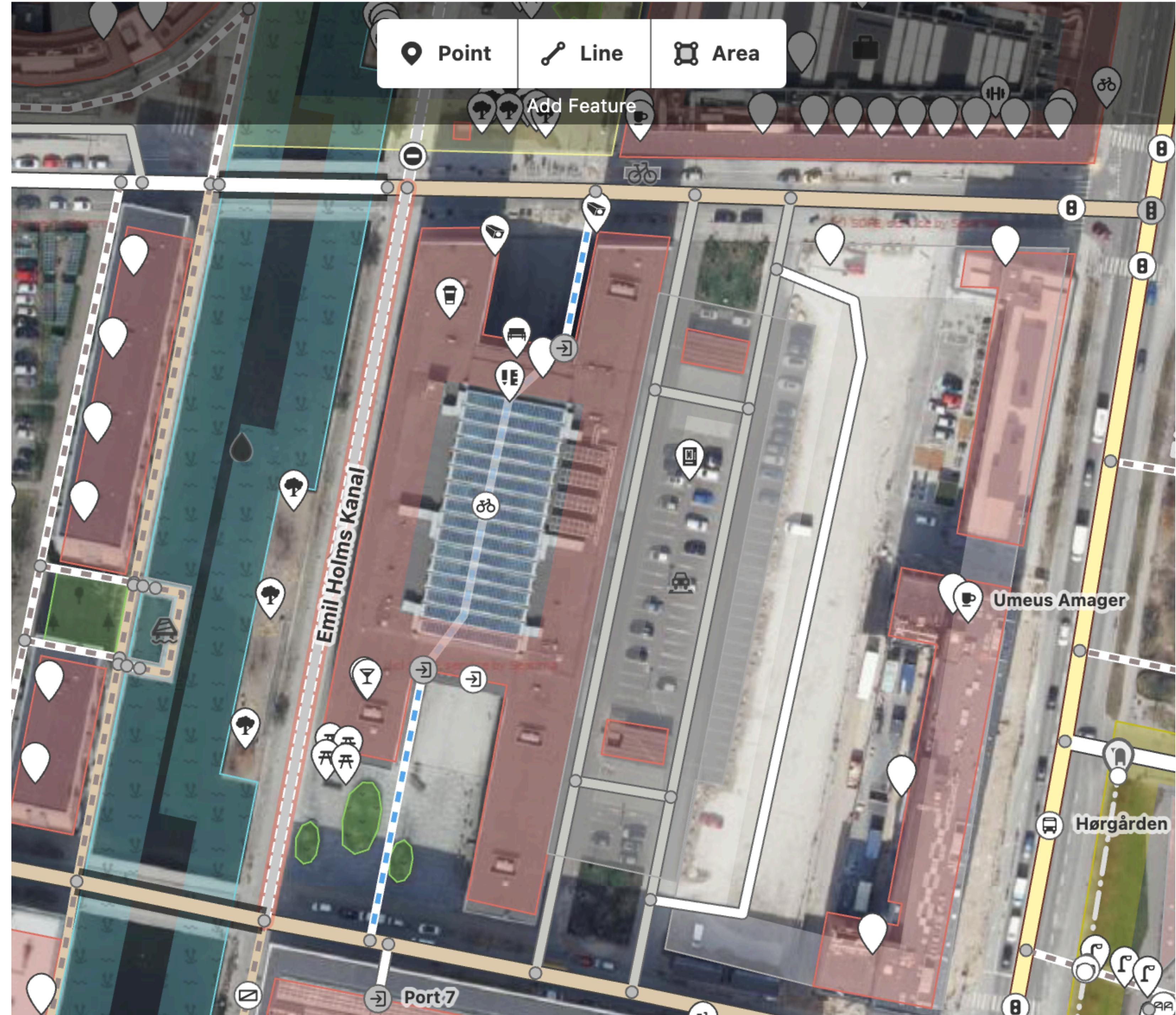
Tags (6)

| bicycle | yes | | | |
|-----------|------------------|--|--|--|
| highway | living_street | | | |
| lit | yes | | | |
| maxweight | 3.5 | | | |
| name | Emil Holms Kanal | | | |
| surface | paving_stones | | | |

+

Relations (0)

+



Edit feature X

Feature Type

| | | |
|---|--------------------|---|
|  | University Grounds | i |
|---|--------------------|---|

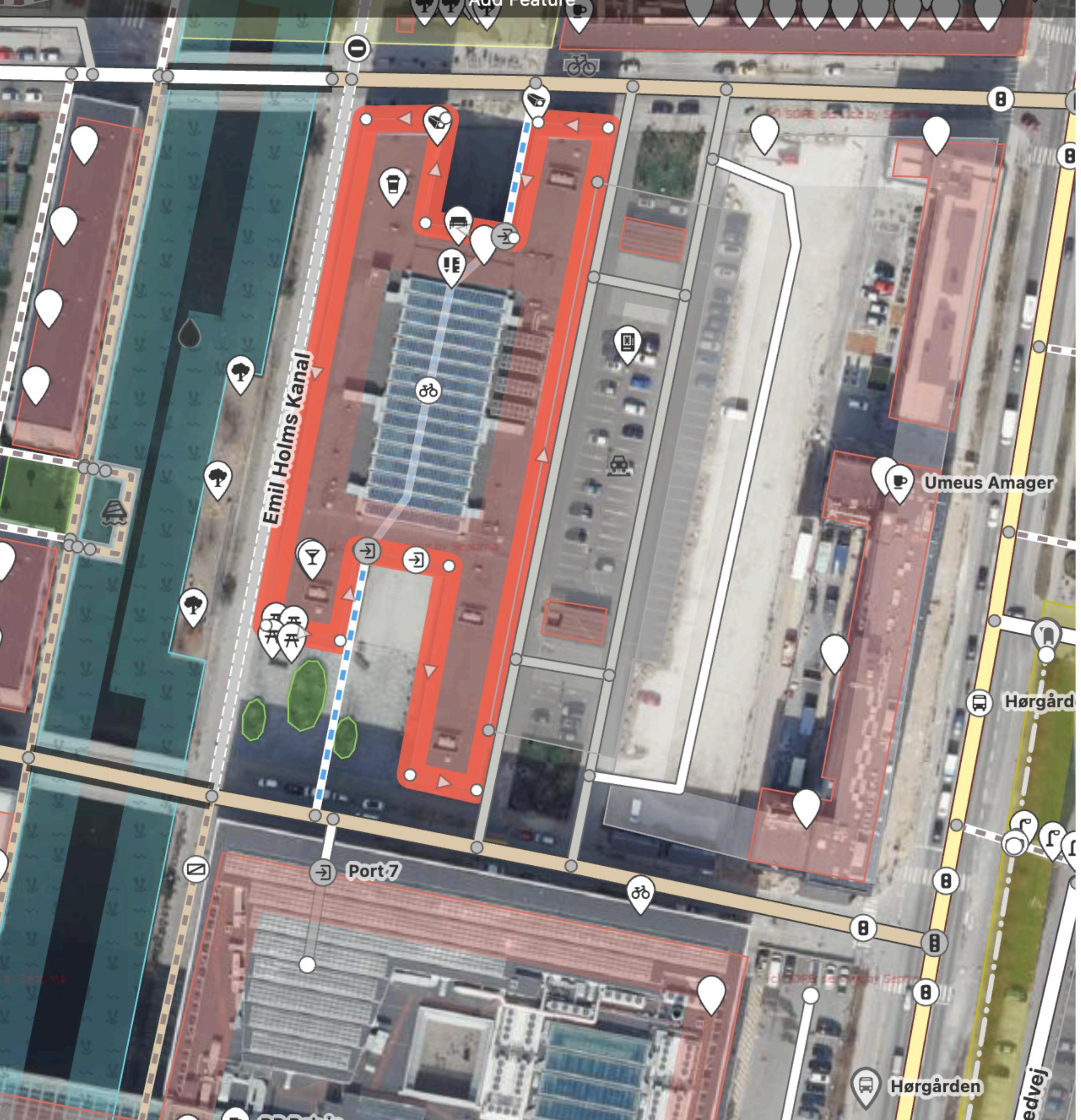
An educational institution designed for instruction, examination, or both, of students in many branches of advanced learning.

[View documentation](#)

Fields

Tags (16)

| amenity | university |  |  | |
|--------------------|---|---|---|--|
| architect | Henning Larsen |  |  | |
| architect:wikidata | Q1377332 |  |  | |
| building | university |  |  | |
| name | IT-Universitetet |  |  | |
| name:en | IT University |  |  | |
| name:ko | 코펜하겐 IT 대학교 |  |  | |
| official_name | IT-Universitetet i ... |  |  | |
| official_name:en | IT University of C... |  |  | |
| phone | +45 72185000 |  |  | |
| short_name | ITU |  |  | |
| toilets:wheelchair | yes |  |  | |
| website | https://www.itu.dk/ |  |  | |
| wheelchair | yes |  | | |
| wikidata | Q124882 | | | |
| wikipedia | da:IT-Universitet... | | | |





OSM stores data in XML format

```
<node id="25496583" lat="51.5173639" lon="-0.140043" version="1"
changeset="203496" user="80n" uid="1238" visible="true"
timestamp="2007-01-28T11:40:26Z">
    <tag k="highway" v="traffic_signals"/>
</node>
```

```
<way id="5090250" visible="true" timestamp="2009-01-19T19:07:25Z"
version="8" changeset="816806" user="Blumpsy" uid="64226">
    <nd ref="822403"/>
    <nd ref="21533912"/>
    <nd ref="821601"/>
    ...
    <nd ref="823771"/>
    <tag k="highway" v="residential"/>
    <tag k="name" v="Clipstone Street"/>
    <tag k="oneway" v="yes"/>
</way>
```

OSM stores data in XML format

```
<relation id="56688" user="kmvar" uid="56190" visible="true" version="28"
changeset="6947637" timestamp="2011-01-12T14:23:49Z">
  <member type="node" ref="294942404" role="" />
  ...
  <member type="node" ref="364933006" role="" />
  <member type="way" ref="4579143" role="" />
  ...
  <member type="node" ref="249673494" role="" />
  <>tag k="name" v="Küstenbus Linie 123"/>
  <>tag k="network" v="VVW"/>
  <>tag k="operator" v="Regionalverkehr Küste"/>
  <>tag k="ref" v="123"/>
  <>tag k="route" v="bus"/>
  <>tag k="type" v="route"/>
</relation>
```

PBF format is highly compressed OSM data

Protocolbuffer Binary Format: **.osm.pbf**

Planet.osm 1553 GB

Planet.osm.pbf 62 GB

There are many different ways of accessing OSM Data

Export screen from browser

Download via Overpass API/turbo

Download extracted region from distributors

Download via software (like JSOM)

Download via Python (OSMnx, pyrosm)

Export screen from browser

The screenshot shows the OpenStreetMap website interface with a red circle highlighting the 'Export' button in the top navigation bar.

OpenStreetMap | Edit | History | **Export** | GPS Traces | User Diaries | Copyright | Help | About | mszell

Search | Where is this? | Go |

Export

Manually select a different area

55.66070
12.58756
12.59531
55.65825

Manually select a different area

Licence

OpenStreetMap data is licensed under the [Open Data Commons Open Database License \(ODbL\)](#).

Export

If the above export fails, please consider using one of the sources listed below:

Overpass API
Download this bounding box from a mirror of the OpenStreetMap database

Planet OSM
Regularly-updated copies of the complete OpenStreetMap database

Geofabrik Downloads
Regularly-updated extracts of continents, countries, and selected cities

Other Sources
Additional sources listed on the OpenStreetMap wiki

30 m | |

https://www.openstreetmap.org/export#map=18/55.65948/12.59143

The main map view shows a detailed area of Copenhagen, Denmark, including streets like Rued Langgaards Vej, Universitetskanalen, Emil Holms Kanal, Kaj Munks Vej, and Amagerfælledvej. It also shows several buildings, parks, and landmarks such as Mikado House, Gorillas Amager, Cafe Analog, Alexandra Institutet, IT Universitetet, Umeus Amager, Hørgården, Aktivitetshuset, and DR Databank. A green polygon highlights a specific area for export.

GPS Traces | User Diaries | Copyright | Help | About | mszell

© OpenStreetMap contributors | Make a Donation | Website and API terms | openstreetmap.org

Download via Overpass API

The **Overpass API** is a read-only API that serves up parts of the OSM map data.

It acts as a database over the web: the client sends a query to the API and gets back the data set that corresponds to the query.

https://wiki.openstreetmap.org/wiki/Overpass_API

https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL

https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_API_by_Example

Download via Overpass API

The **Overpass API** is a read-only API that serves up parts of the OSM map data.

It acts as a database over the web: the client sends a query to the API and gets back the data set that corresponds to the query.

It uses **Overpass Query Language** (Overpass QL). You can select and filter node, way, relation, with certain tags, and perform recursion queries.

Uses regex, is quite human-unreadable
Syntax is limited

https://wiki.openstreetmap.org/wiki/Overpass_API

https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL

https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_API_by_Example

Download via Overpass API

```
node(50.745,7.17,50.75,7.18)[highway=bus_stop];  
out;
```

```
[ "key" ]          /* filter objects tagged with this key and any value */  
[ !"key" ]         /* filter objects not tagged with this key and any value */  
[ "key"="value" ]   /* filter objects tagged with this key and this value */  
[ "key"!="value" ]  /* filter objects tagged with this key but not this value, or not tagged with this key */  
[ "key"~"value" ]   /* filter objects tagged with this key and a value matching a regular expression */  
[ "key"!~"value" ]  /* filter objects tagged with this key but a value not matching a regular expression */  
[ ~"key"~"value" ]  /* filter objects tagged with a key and a value matching regular expressions */  
[ ~"key"~"value",i] /* filter objects tagged with a key and a case-insensitive value matching regular expressions */
```

https://wiki.openstreetmap.org/wiki/Overpass_API

https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL

https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_API_by_Example

Download via Overpass API

```
/*
This query looks for nodes, ways and relations
with the given key/value combination.
Choose your region and hit the Run button above!
*/
[out:json][timeout:25];
// gather results
(
    // query part for: "amenity=post_box"
    node["amenity"="post_box"]({{bbox}});
    way["amenity"="post_box"]({{bbox}});
    relation["amenity"="post_box"]({{bbox}});
);
// print results
out body;
>;
out skel qt;
```

The screenshot shows the Overpass Turbo web application. At the top, there are buttons for Run, Share, Export, Wizard, Save, Load, Settings, Help, and a link to overpass turbo. The main area contains an Overpass query editor with the following code:

```
/*
This is an example Overpass query.
Try it out by pressing the Run button above!
You can find more examples with the Load tool.
*/
node
[amenity=bicycle_parking]
({{bbox}});
out;
```

Below the query editor is a map of a specific geographic area. The map displays streets, buildings, and water bodies. Labels on the map include 'Universitetskanalen', 'Emil Hølms Kanal', 'Cafe Analog', 'Alexandra Institutet', 'Umeus Amager', and 'Høgårdens Aktivitetscenter'. There are also several numbered locations (e.g., 10A, 10B, 11, 12, 13, 14, 15) and street names like 'Rued Langgaards Vej' and 'Kaj Munks Vej'. A legend on the right side of the map provides symbols for different types of features.

<https://overpass-turbo.eu/>

https://wiki.openstreetmap.org/wiki/Overpass_API

https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL

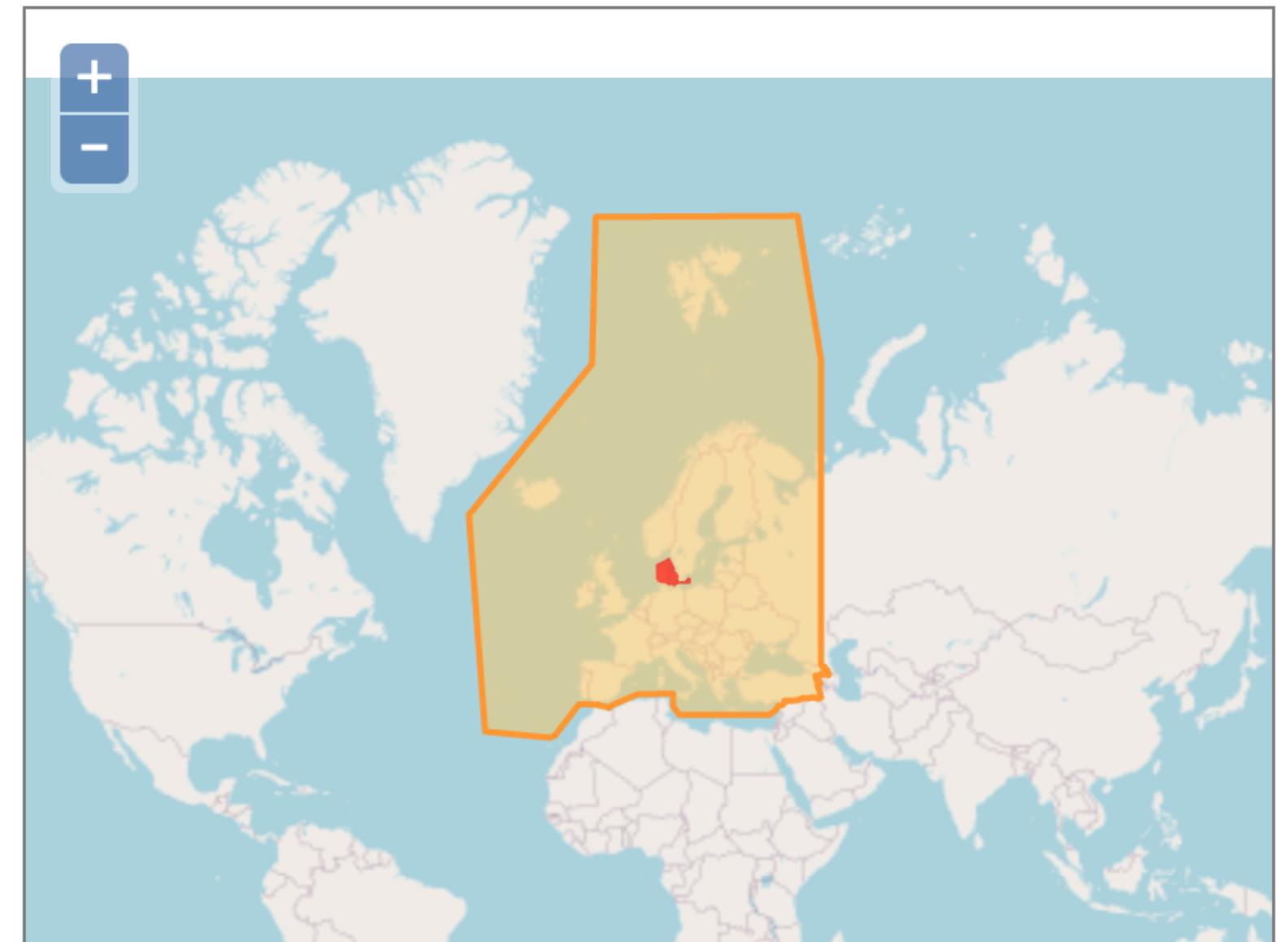
https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_API_by_Example

Download extracted region from distributor

Sub Regions

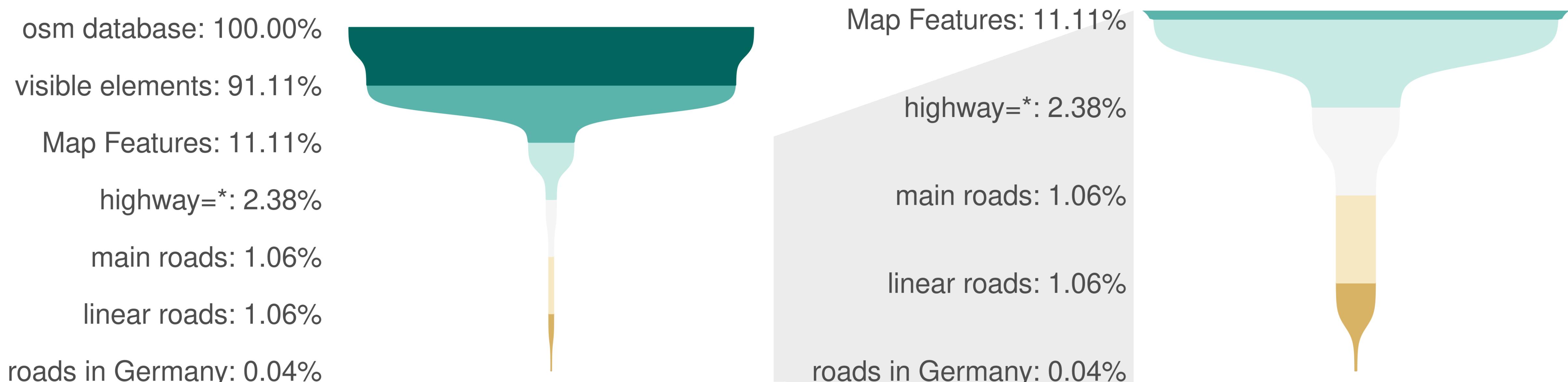
Click on the region name to see the overview page for that region, or select one of the file extension links for quick access.

| Sub Region | Quick Links | | |
|------------------------------------|----------------------|------------|------------|
| | .osm.pbf | .shp.zip | .osm.bz2 |
| Albania | [.osm.pbf] (42.7 MB) | [.shp.zip] | [.osm.bz2] |
| Andorra | [.osm.pbf] (1.8 MB) | [.shp.zip] | [.osm.bz2] |
| Austria | [.osm.pbf] (644 MB) | [.shp.zip] | [.osm.bz2] |
| Azores | [.osm.pbf] (12.4 MB) | [.shp.zip] | [.osm.bz2] |
| Belarus | [.osm.pbf] (244 MB) | [.shp.zip] | [.osm.bz2] |
| Belgium | [.osm.pbf] (462 MB) | [.shp.zip] | [.osm.bz2] |
| Bosnia-Herzegovina | [.osm.pbf] (107 MB) | [.shp.zip] | [.osm.bz2] |
| Bulgaria | [.osm.pbf] (111 MB) | [.shp.zip] | [.osm.bz2] |
| Croatia | [.osm.pbf] (135 MB) | [.shp.zip] | [.osm.bz2] |
| Cyprus | [.osm.pbf] (20.0 MB) | [.shp.zip] | [.osm.bz2] |
| Czech Republic | [.osm.pbf] (758 MB) | [.shp.zip] | [.osm.bz2] |
| Denmark | [.osm.pbf] (394 MB) | [.shp.zip] | [.osm.bz2] |
| Estonia | [.osm.pbf] (94 MB) | [.shp.zip] | [.osm.bz2] |
| Faroe Islands | [.osm.pbf] (4.6 MB) | [.shp.zip] | [.osm.bz2] |



It is usually better to build your OSM data bottom up

- 1. Visibility:** Ignore deleted elements and elements without tags unless you really need them
- 2. Keys:** Start with the so-called “Map Features”
- 3. Values:** Prefer allowlists over blocklists over *
- 4. Geometry:** Choose reasonable geometry types that match the real-world objects you have in mind
- 5. Area-of-interest:** Avoid too simple and too complex bounding geometries



Fast command line tools can filter and wrangle OSM data

Osmium

<https://osmcode.org/osmium-tool/>

Osmfilter

<https://wiki.openstreetmap.org/wiki/Osmfilter>

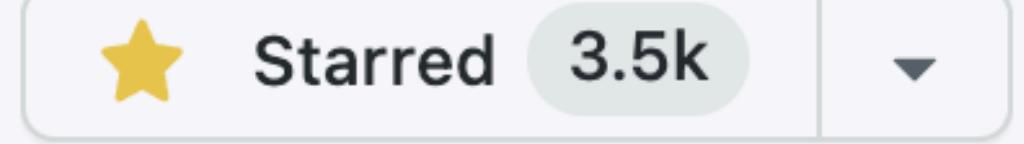
Osmconvert

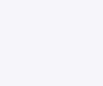
<https://wiki.openstreetmap.org/wiki/Osmconvert>

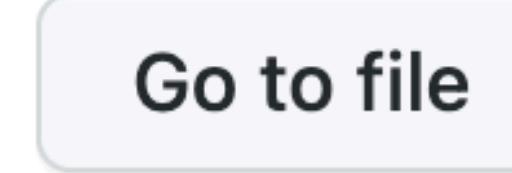
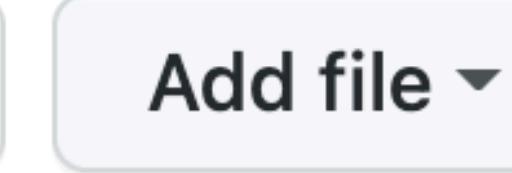
Osmosis

<https://wiki.openstreetmap.org/wiki/Osmosis>

How to use OSM for research: OSMnx

 [gboeing / osmnx](https://github.com/gboeing/osmnx) Public  Watch 115  Fork 668  Starred 3.5k

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 [gboeing](#) pin black ver...   3 days ago  2,446

 [.github](#) drop python 3.7 support... 9 days ago

 [docs](#) version bump 4 months ago

About

OSMnx: Python for street networks. Retrieve, model, analyze, and visualize street networks and other spatial data from OpenStreetMap.

<https://github.com/gboeing/osmnx>

<https://osmnx.readthedocs.io/en/stable/>

How to use OSM for research

OSMnx (= OSM+NetworkX)

Small area or <100,000 elements

Use for downloading data + network analysis

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Easy to use, GeoPandas

Relies on Overpass API

Custom filters limited

Slow (use igraph to make faster)

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Small area or <100,000 elements

Download and network analysis

Easy to use, GeoPandas

Relies on Overpass API

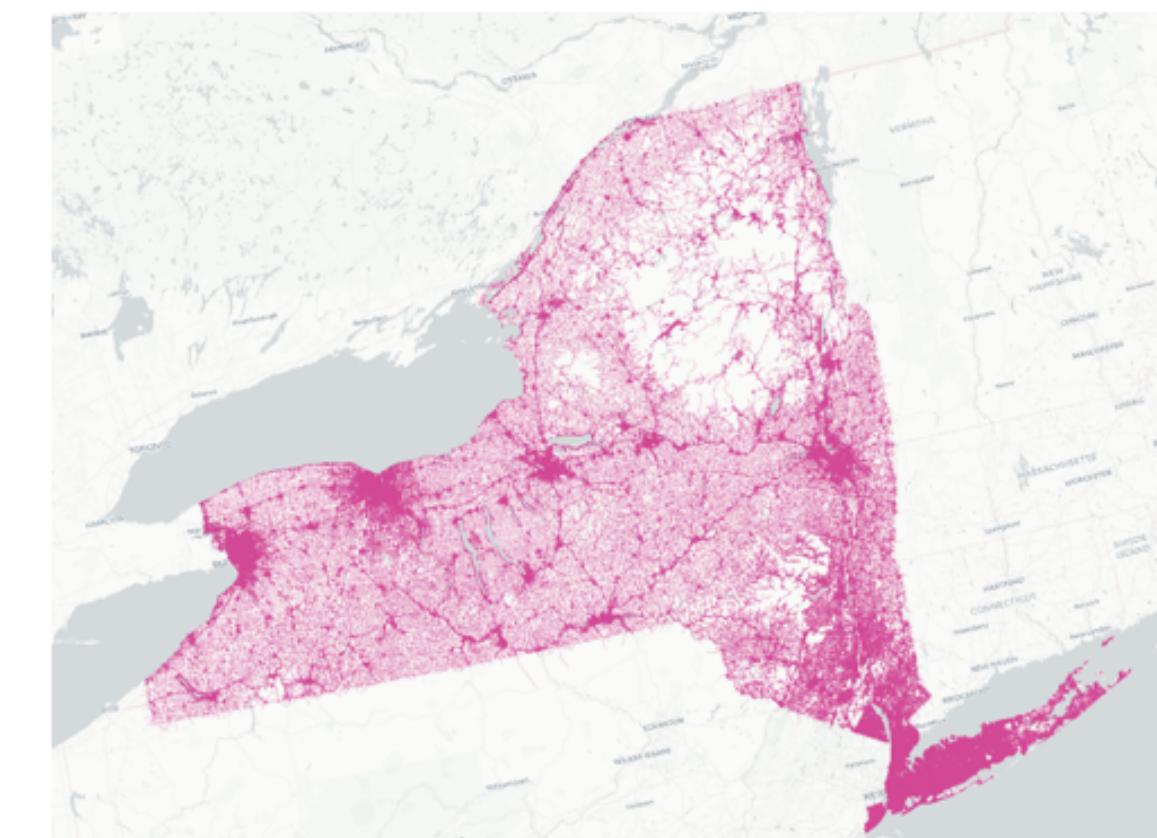
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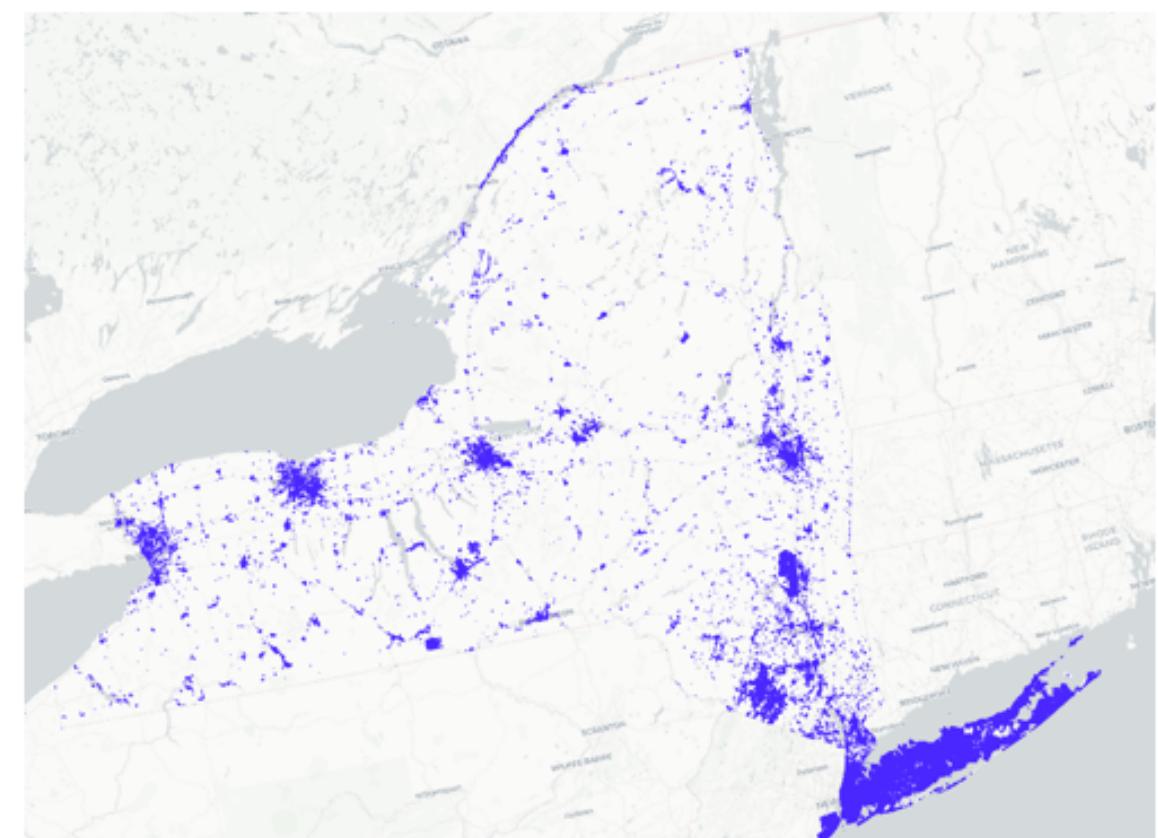
pyrosm

Large area or >100,000 elements

Downloads and parses pbf



N.Y. roads (N = 165,000)

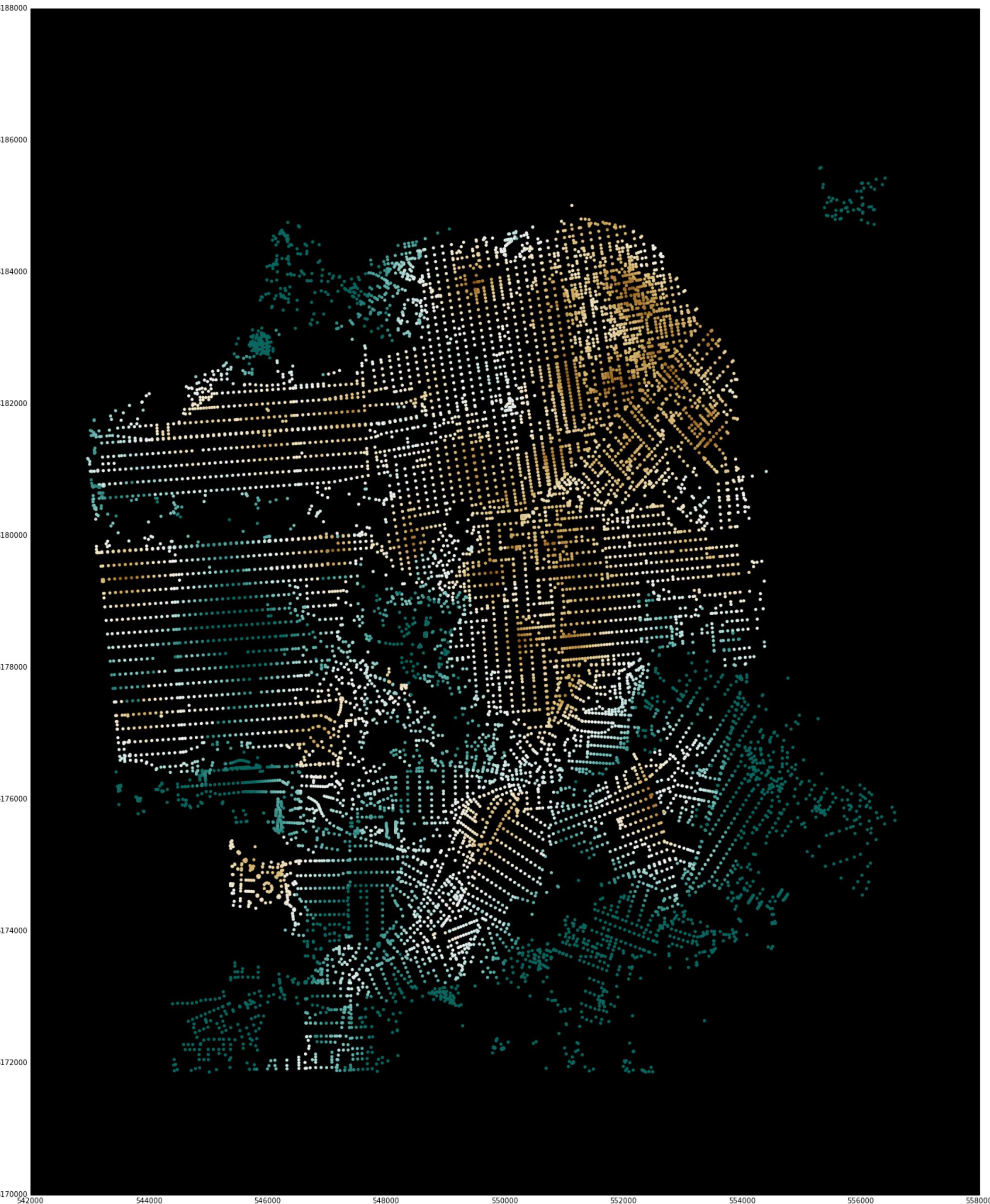


N.Y. buildings (N = 2,200,000)

How to use OSM for research

pandana

Fast calculation
of accessibility



<https://udst.github.io/pandana/>
<https://urbansim.com/udst/>

Useful OSM-related tools

Nominatim

Geocoding

[https://
nominatim.openstreetmap.org/](https://nominatim.openstreetmap.org/)

Mapbox

Online map provider

<https://www.mapbox.com/>

Graphhopper

Routing

<https://www.graphhopper.com/>

Extract.bbbike

Custom extract

<https://extract.bbbike.org/>

prettymaps

Pretty maps

[https://github.com/marceloprates/
prettymaps](https://github.com/marceloprates/prettymaps)

Jupyter

Sources and further materials for today's class



<https://udsleeds.github.io/openinfra/articles/openinfra.html>

<https://github.com/gboeing/osmnx-examples>

<https://pyrosm.readthedocs.io/en/latest/index.html>

Next week: Spatial networks

