

## Lecture 8: OpenStreetMap and OSMnx

Instructor: Michael Szell

Mar 24, 2022



# Today you will learn about OpenStreetMap

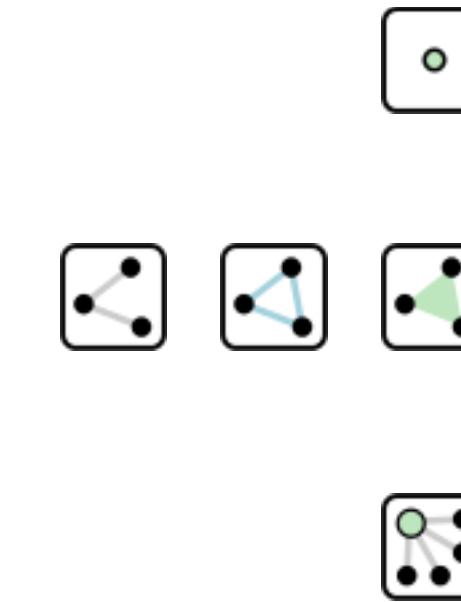
## What is OSM?



## 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)

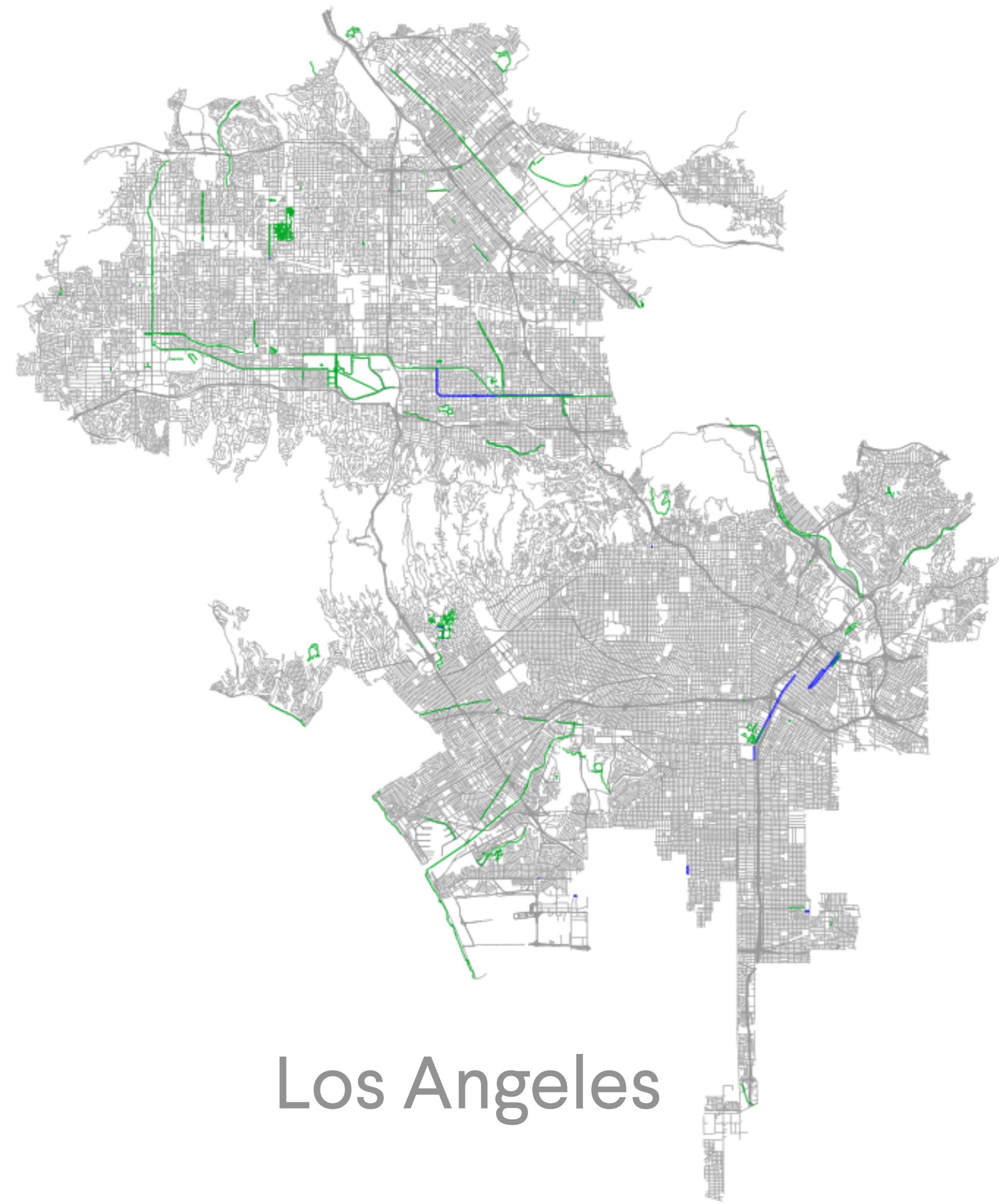
The basis for most routing apps and many geo services (Amazon, Mapbox, Tesla, ...)



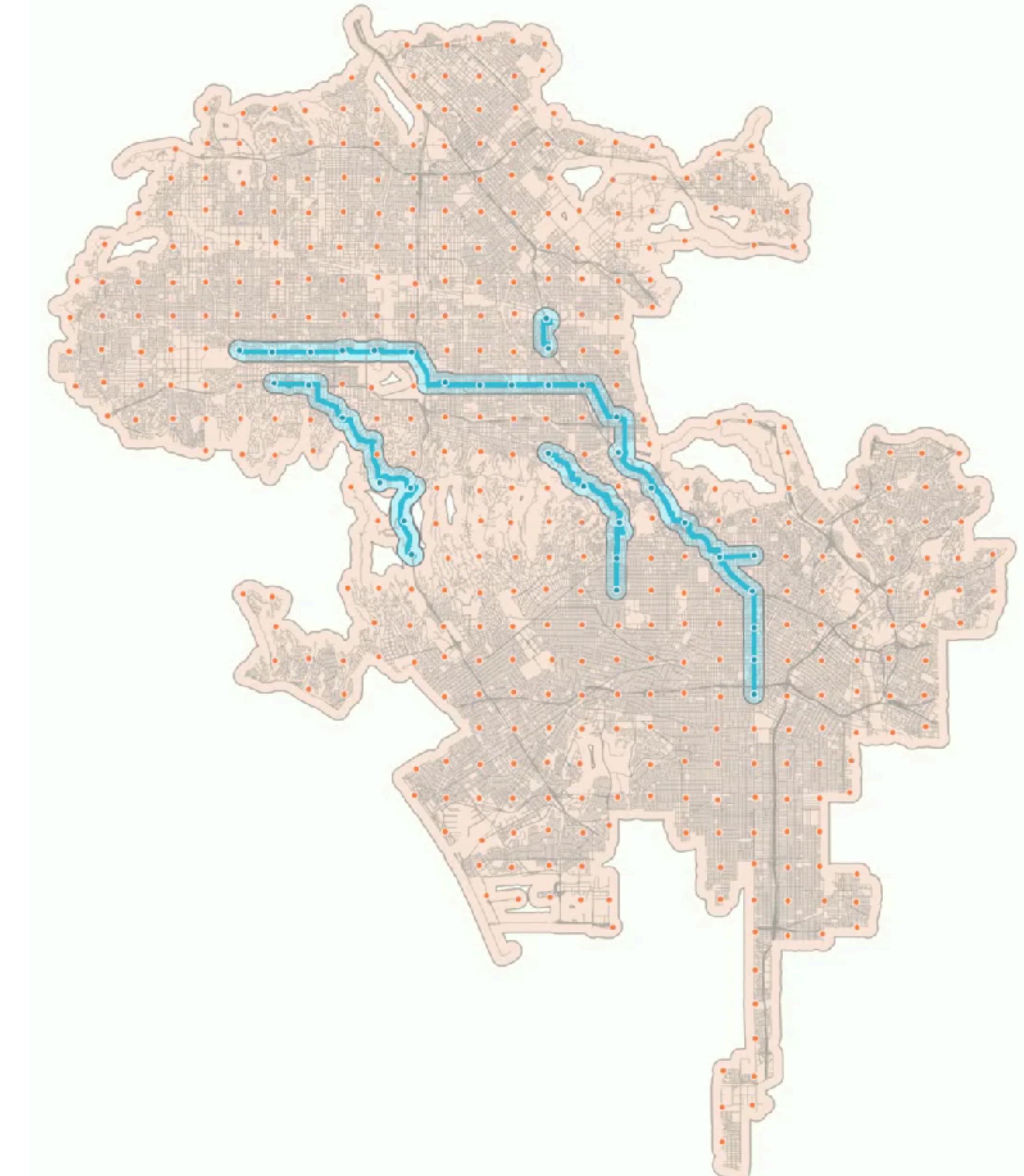
Contributors are not just local mappers, but huge organizations (NGOs, and commercial ones like Microsoft, Facebook, Apple)

# OSM Application Examples

# Data Science: Growing bicycle networks from scratch



Los Angeles



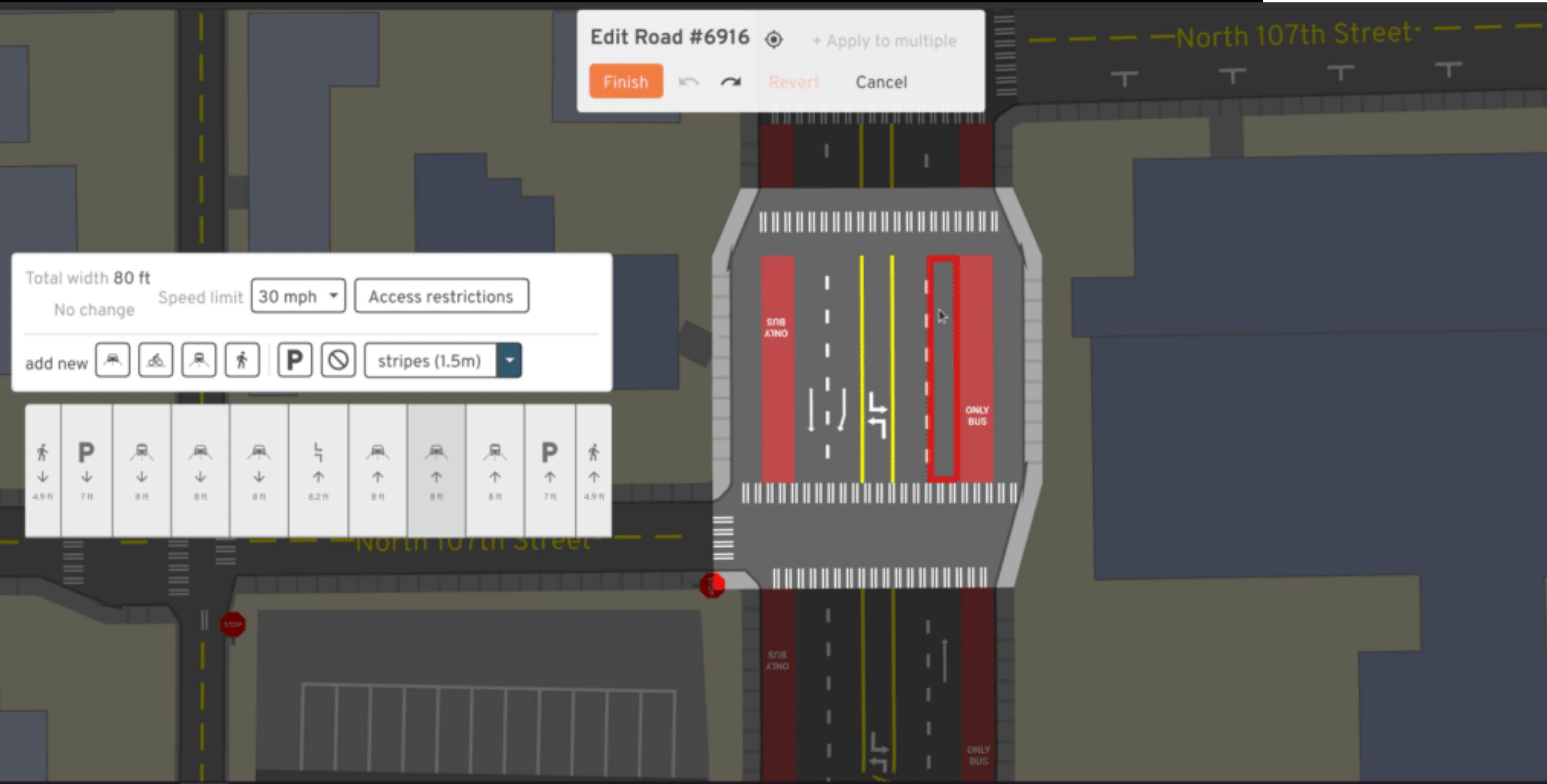
# Data Science: Growing bicycle networks from scratch



# Social good: A/B Street



# Social good: A/B Street



# Social good: WheelMap

wheelmap.org Find wheelchair accessible places.

Get involved News Press Contact Legal FAQ Events Add a place

Search for place or address

Shopping Food & Drinks Transport Leisure Hotels

Tourism Education Authorities Health Finance

Sports Toilets

Partially wheelchair accessible

Partially accessible with accessible WC

Only fully wheelchair accessible

Only fully accessible with accessible WC

Places that I can contribute information to

Only places that are not accessible

Turn on location services

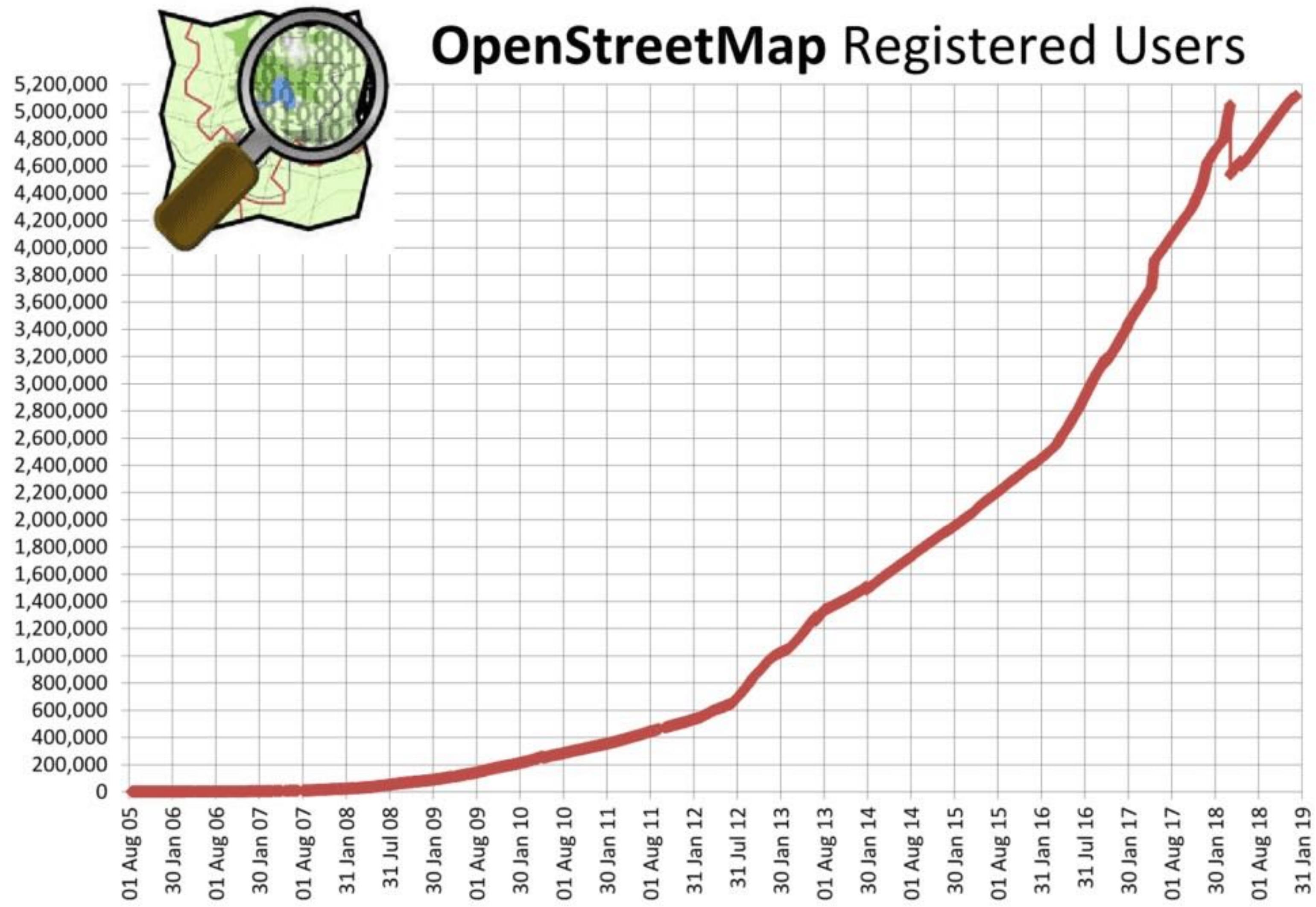
<https://wheelmap.org/>

# **OSM History and Quality**

# OSM is huge

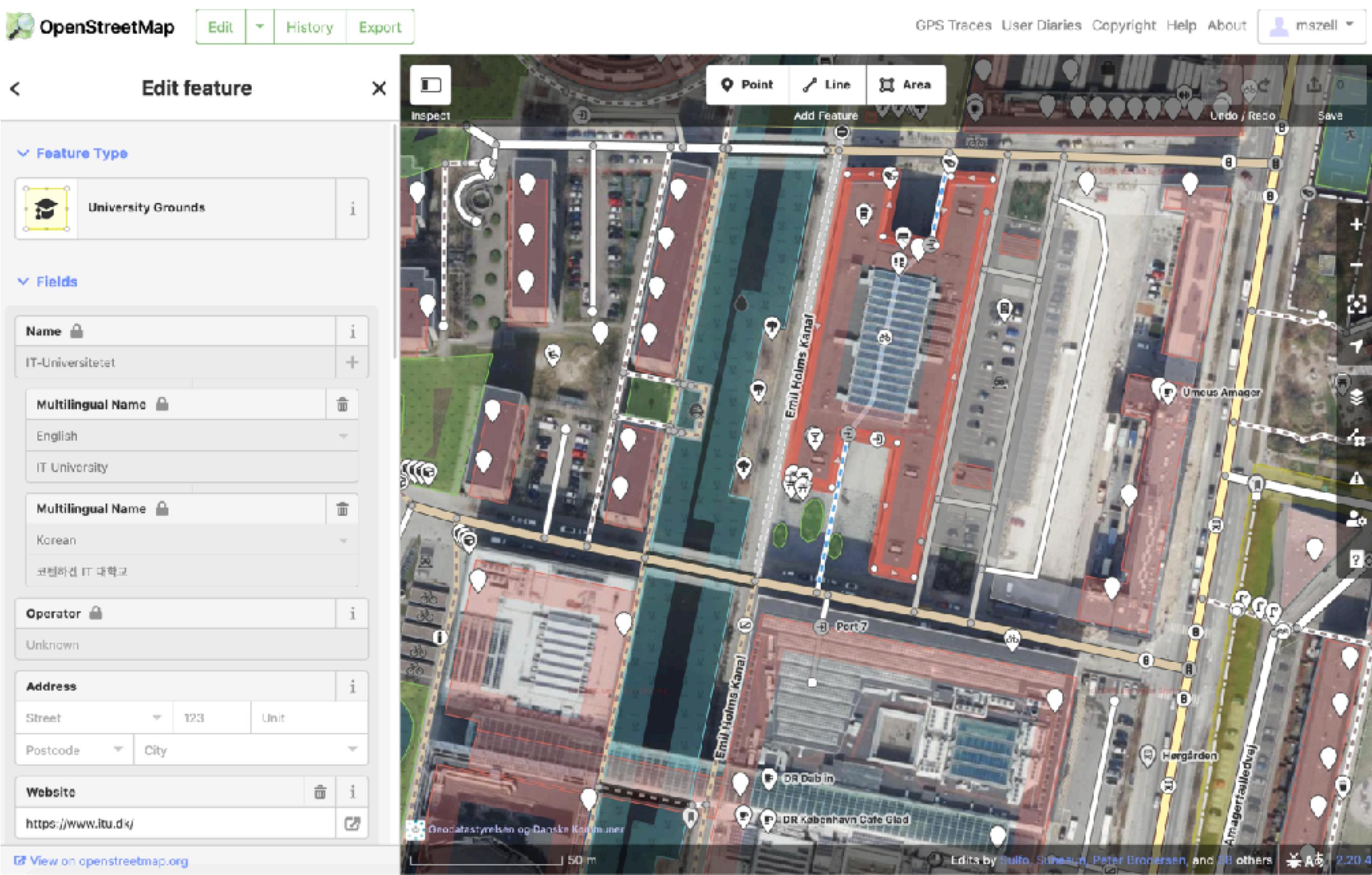
6 Mio contributors

9 Bio elements

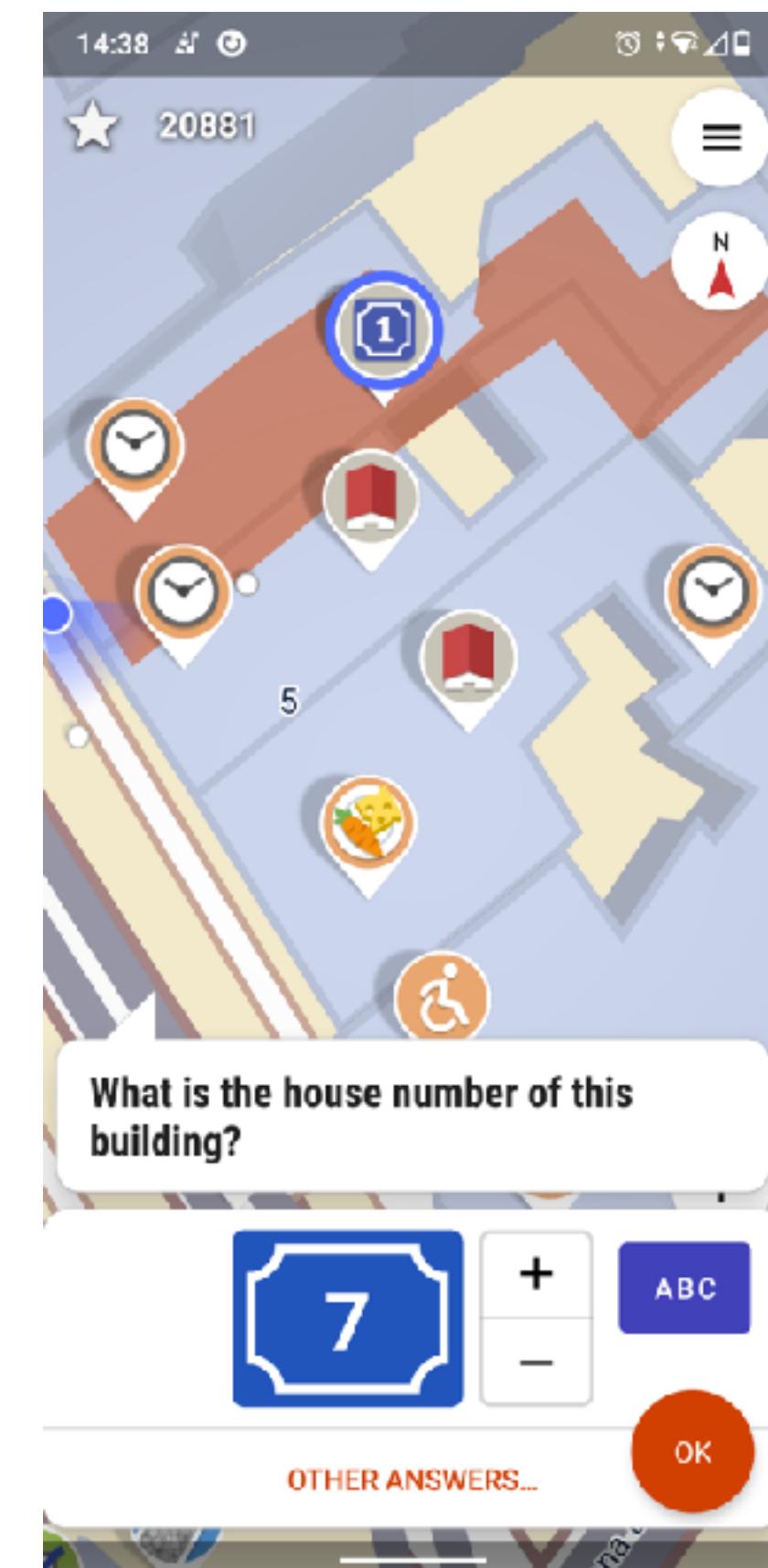


# How to contribute as local mapper?

Directly in the browser



StreetComplete  
(gamified mobile app)

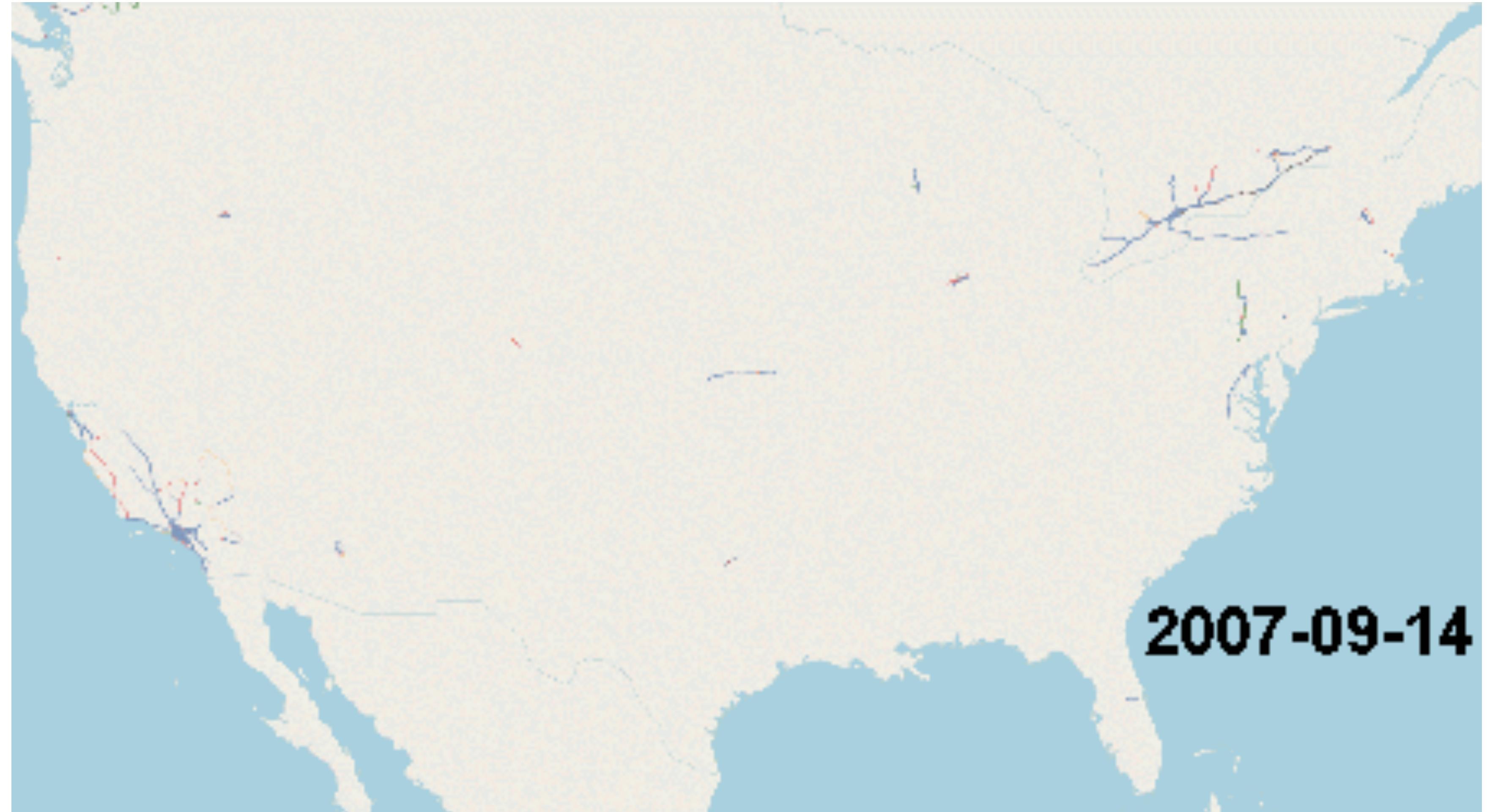


Software like JOSM

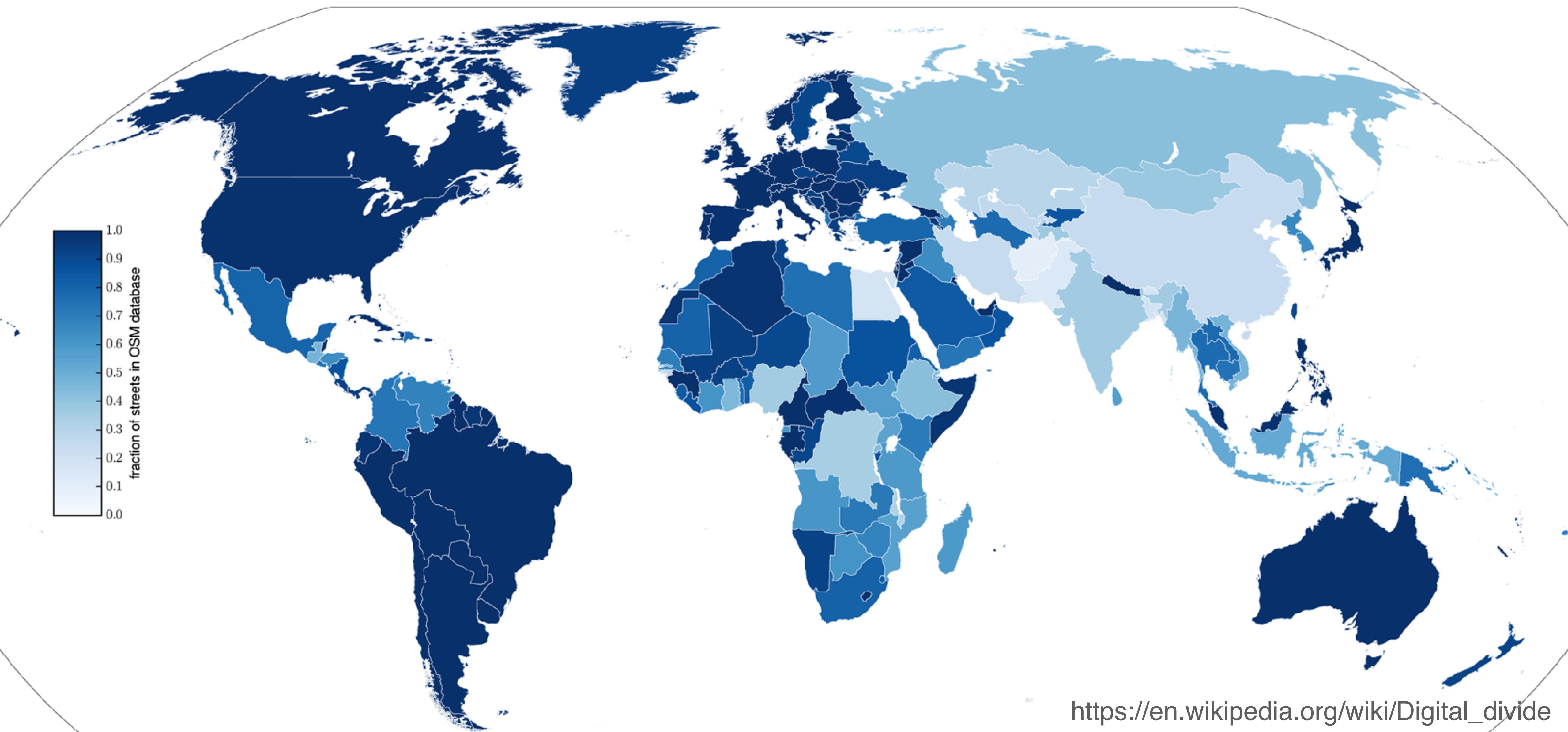
[openstreetmap.org](http://openstreetmap.org)

Batch imports from official sources are an important foundation

## TIGER (Topologically Integrated Geographic Encoding and Referencing)



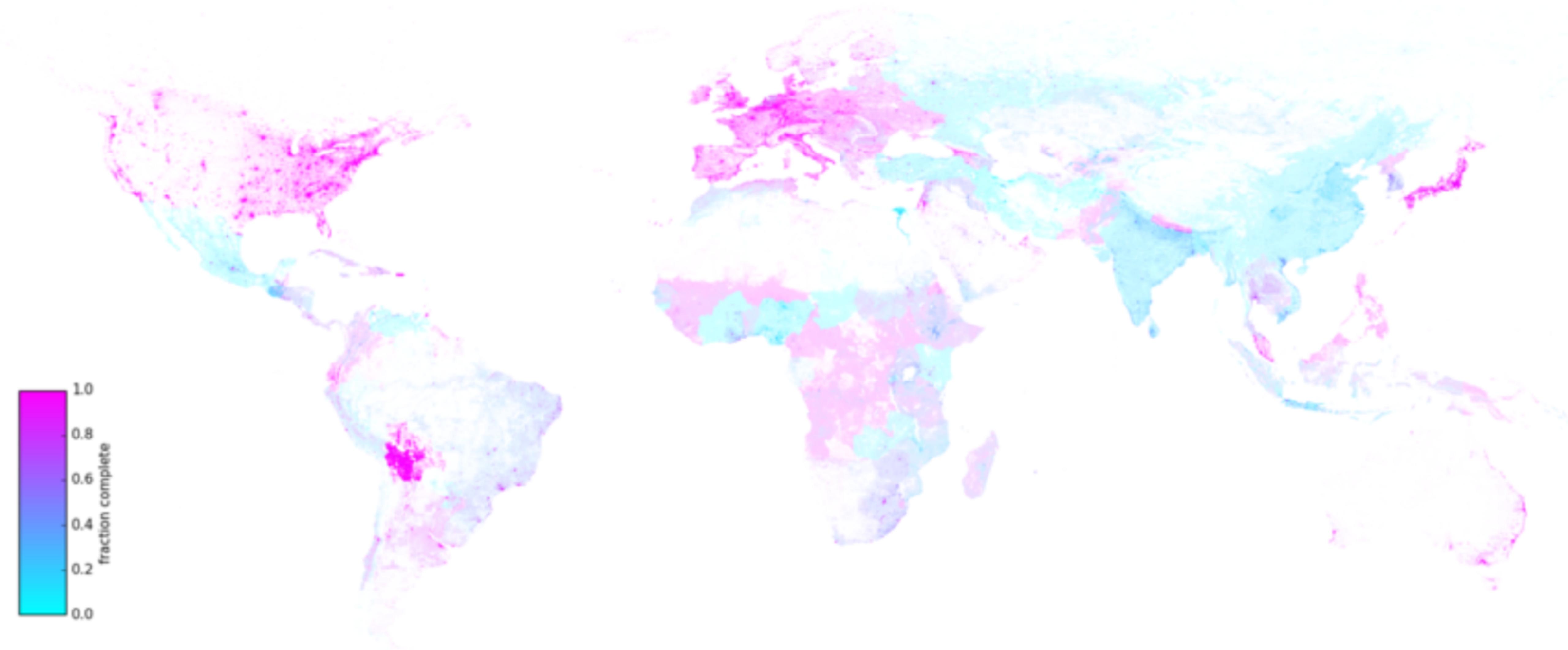
# OSM is relatively complete (in western countries)



[https://en.wikipedia.org/wiki/Digital\\_divide](https://en.wikipedia.org/wiki/Digital_divide)

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

# OSM is relatively complete (in western countries)

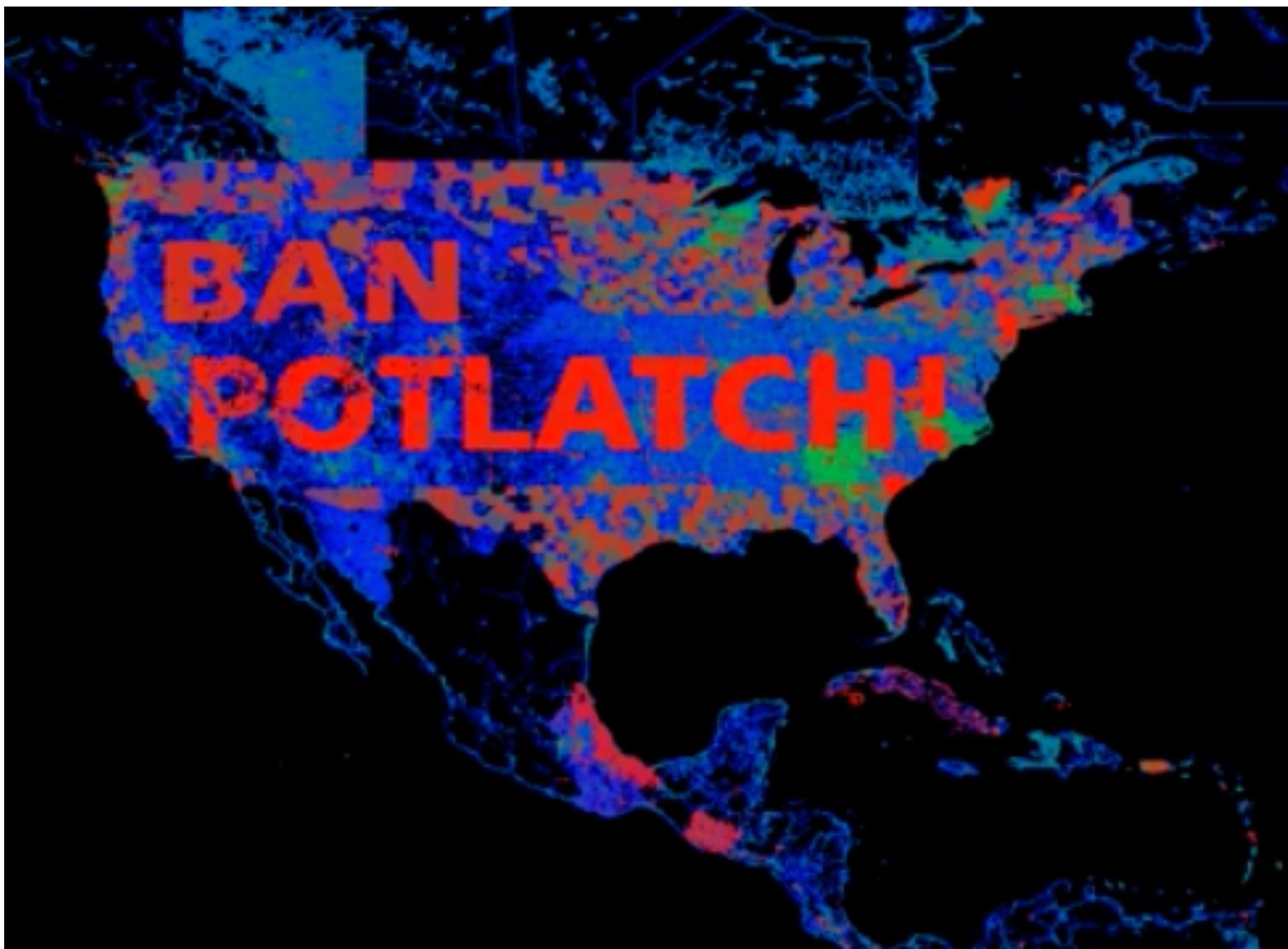


[https://en.wikipedia.org/wiki/Digital\\_divide](https://en.wikipedia.org/wiki/Digital_divide)

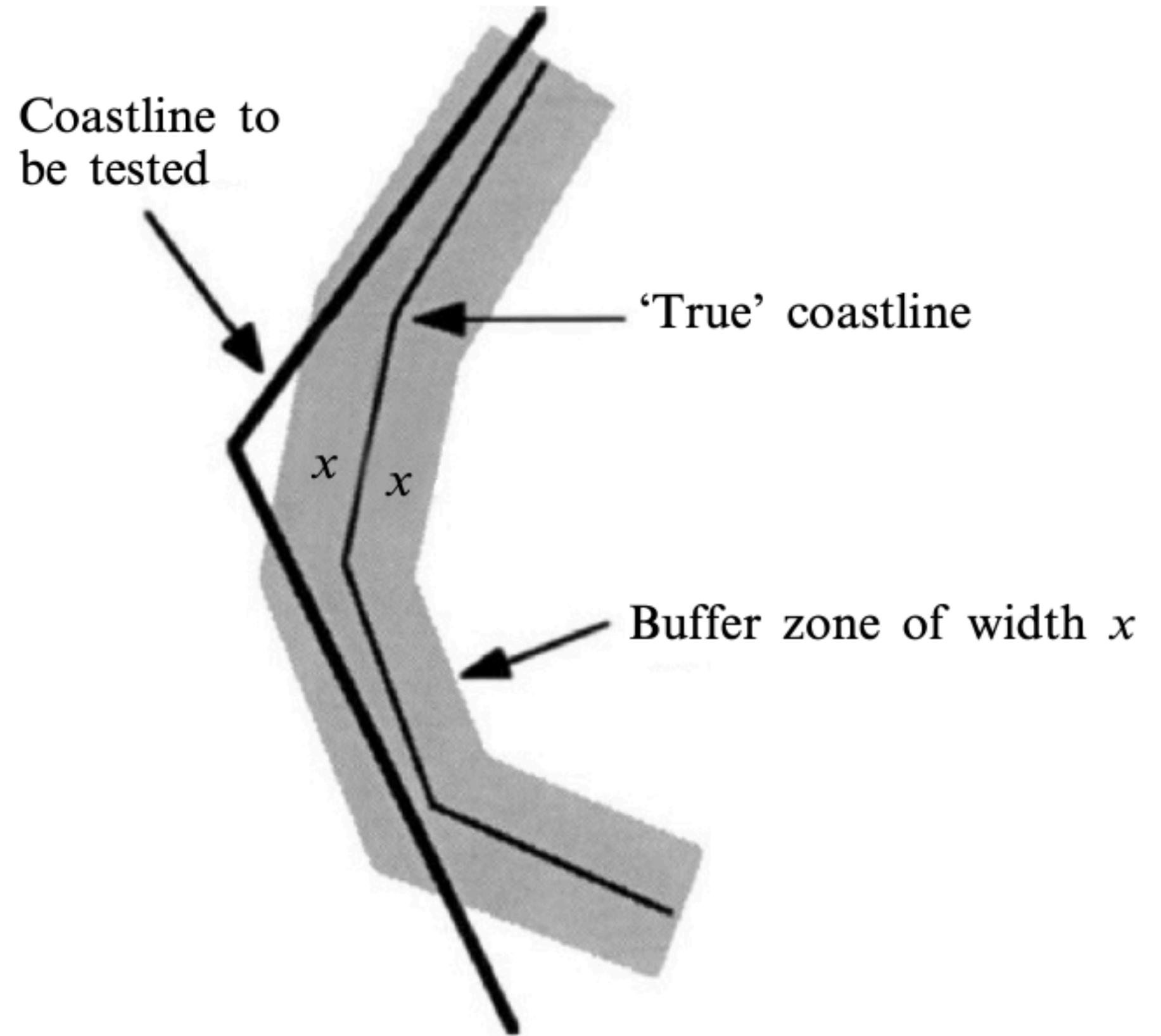
Barrington-Leigh and Millard-Ball, PLOS ONE (2017)

# OSM is relatively accurate

Temporary vandalism is possible

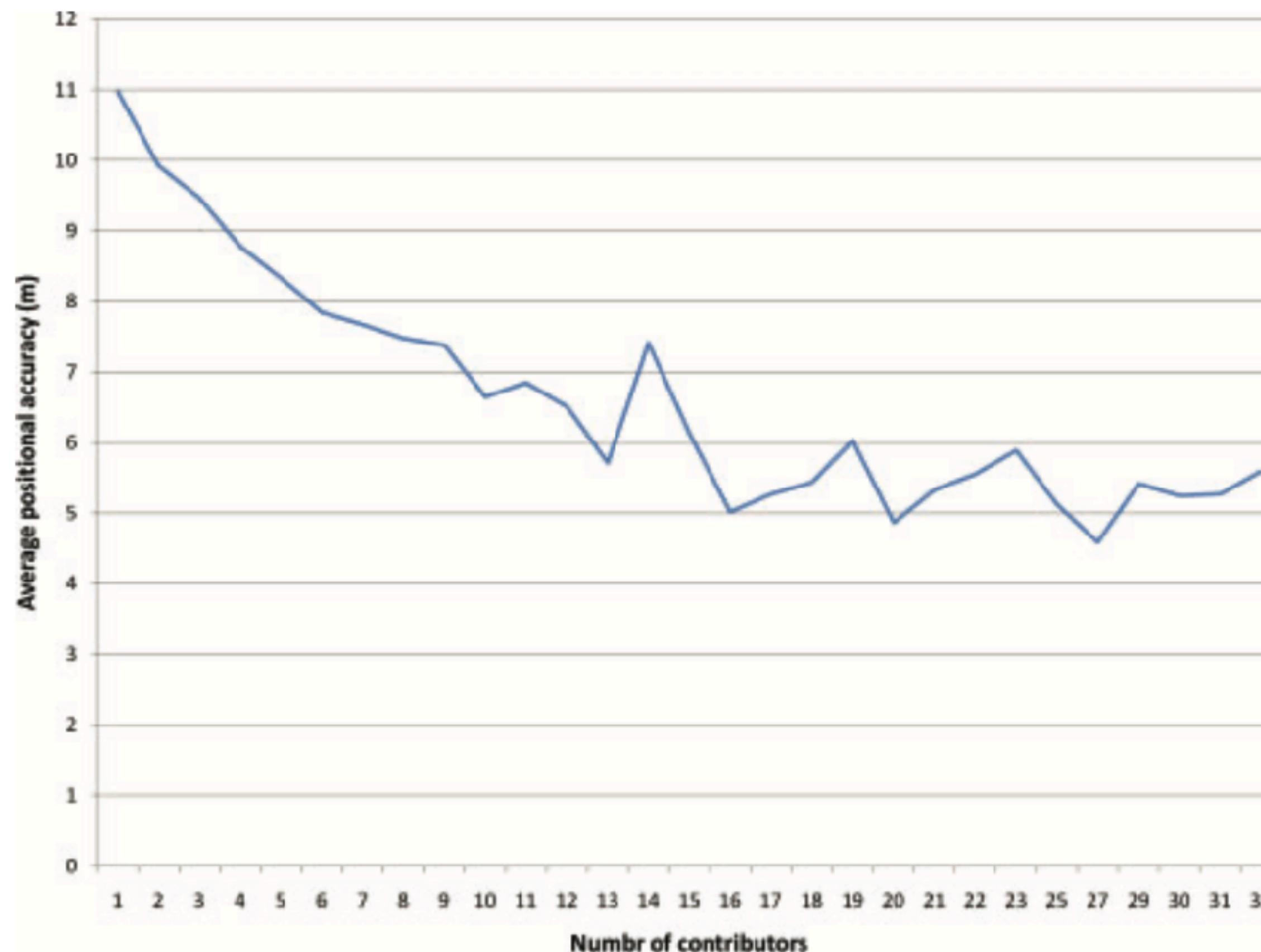


Buffer-zone method between OSM and ground truth

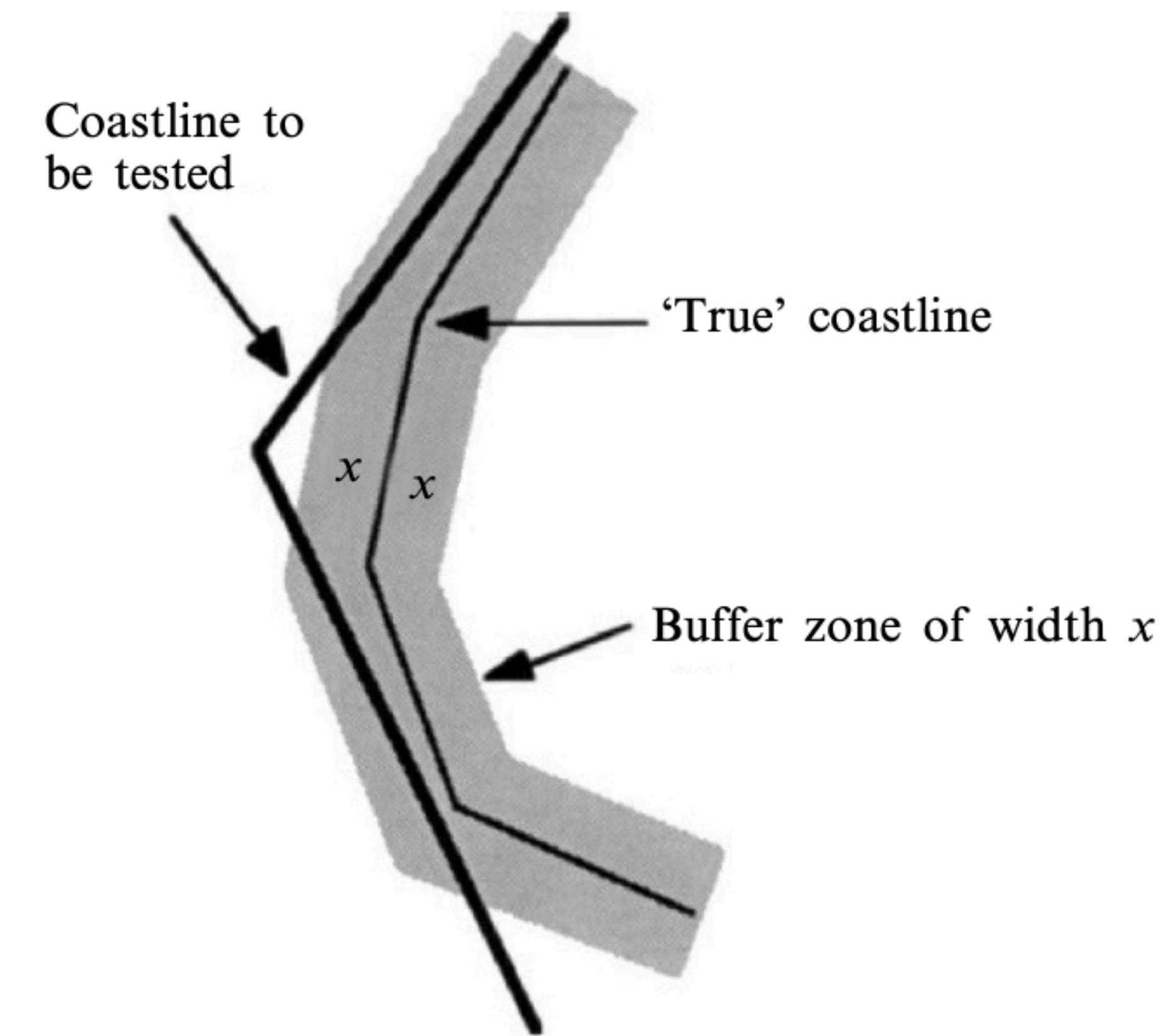


# OSM is relatively accurate

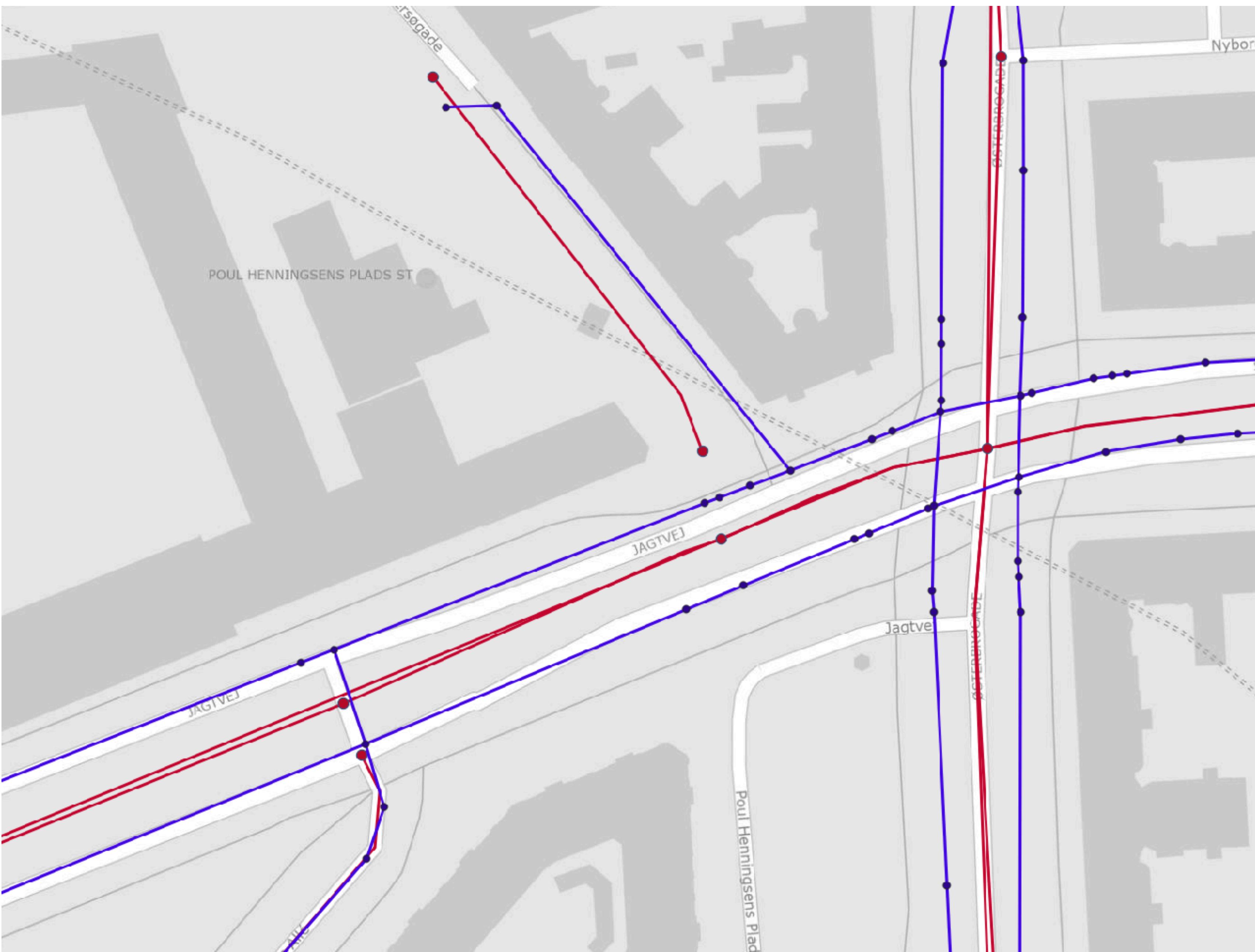
The more contributors,  
the better the accuracy



Buffer-zone method between  
OSM and ground truth

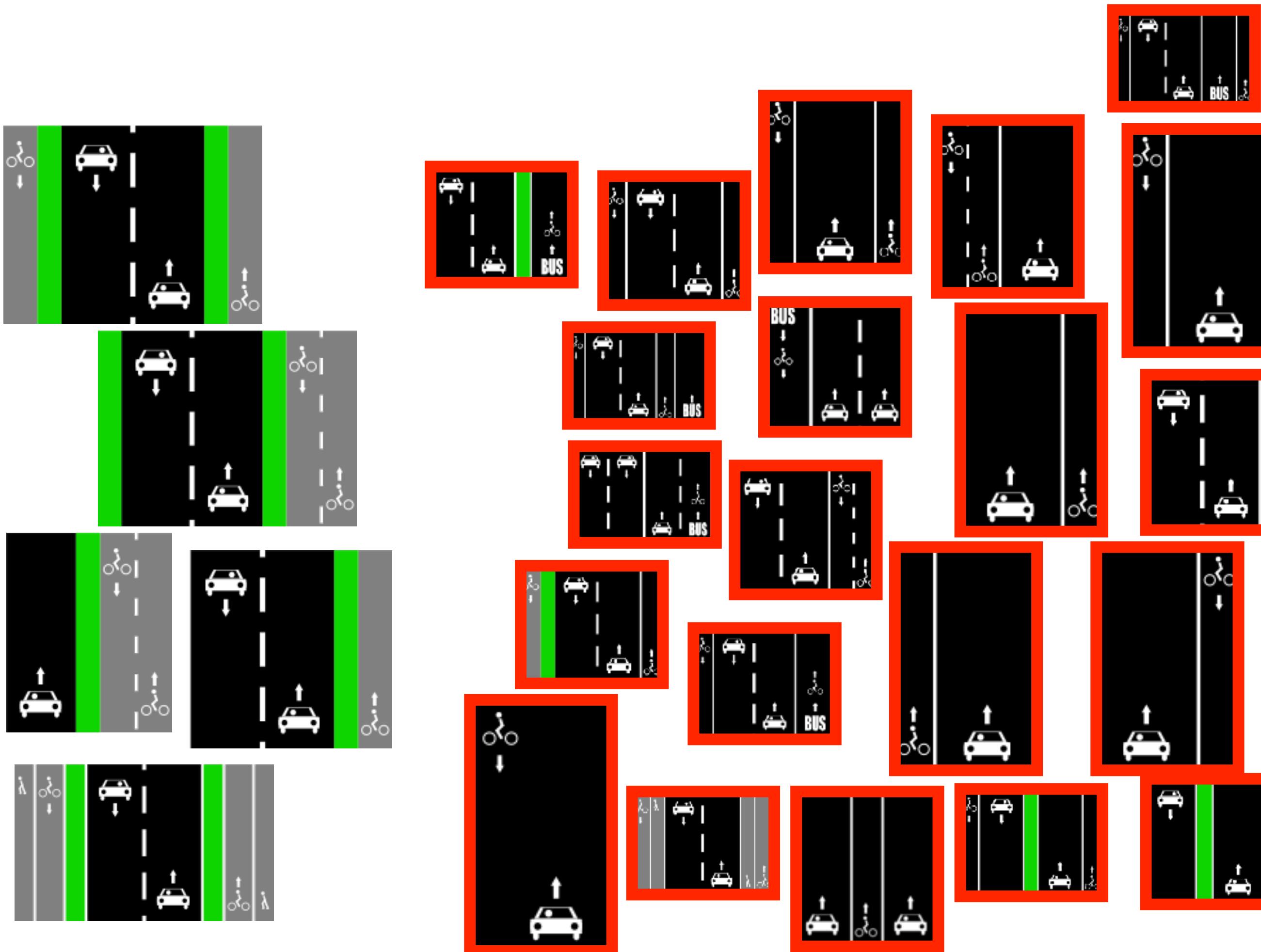


# OSM often has much better quality than official geodata



# OSM is ever evolving and can be very messy

## Dozens of ways to encode bicycle infrastructure!



# 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,  
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Ecosystem of open tools, research

## Google maps

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Proprietary

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Underlies most map-based software

## Google maps

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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, less complete

# 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

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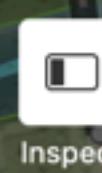
OSM data consists generally of graphs: nodes+links

3 elements / primitives:

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

## Edit feature

X



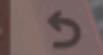
Inspect

Point

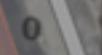
Line

Area

Add Feature



Undo / Redo



Save

## Feature Type



Parking Ticket Vending Machine

i

A machine selling tickets for parking

[View documentation](#)

## Fields

## Tags (3)



amenity

vending\_machine



check\_date

2021-02-18



vending

parking\_tickets

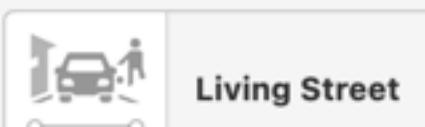


## Relations (0)



## Edit feature

## Feature Type



Living Street

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

[View documentation](#)

## &gt; Fields

## Tags (6)

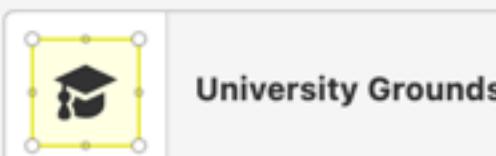
bicycle	yes			
highway	living_street			
lit	yes			
maxweight	3.5			
name	Emil Holms Kanal			
surface	paving_stones			

## Relations (0)

+

## Edit feature

## Feature Type



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



## 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	<a href="https://www.itu.dk/">https://www.itu.dk/</a>		
wheelchair	yes		
wikidata	Q124882		
wikipedia	da:IT-Universitet...		

+

Point Line Area

Add Feature

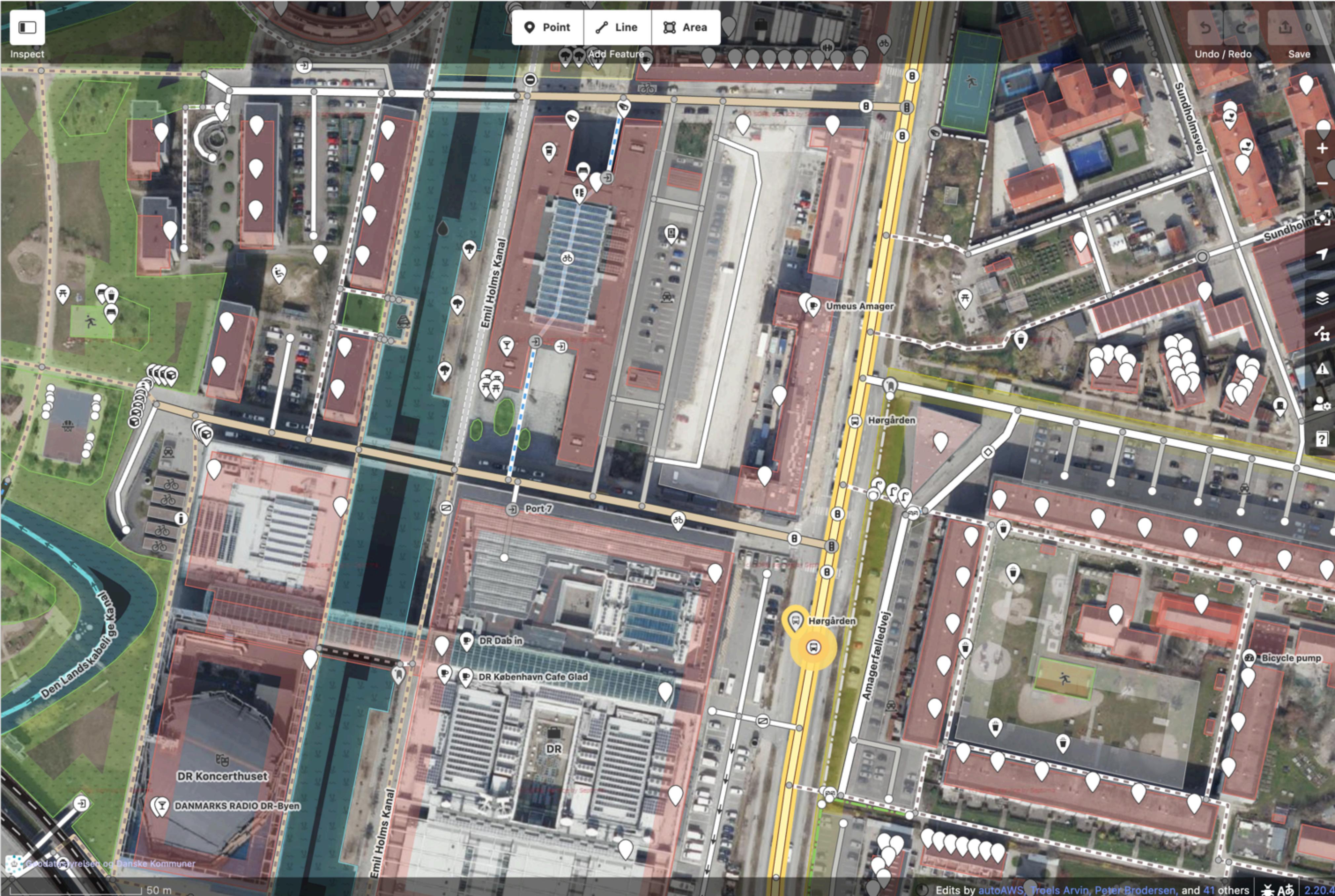
Undo / Redo

Save



## Edit feature

X



## Feature Type



Bus Route

i

## Fields

## Tags (12)

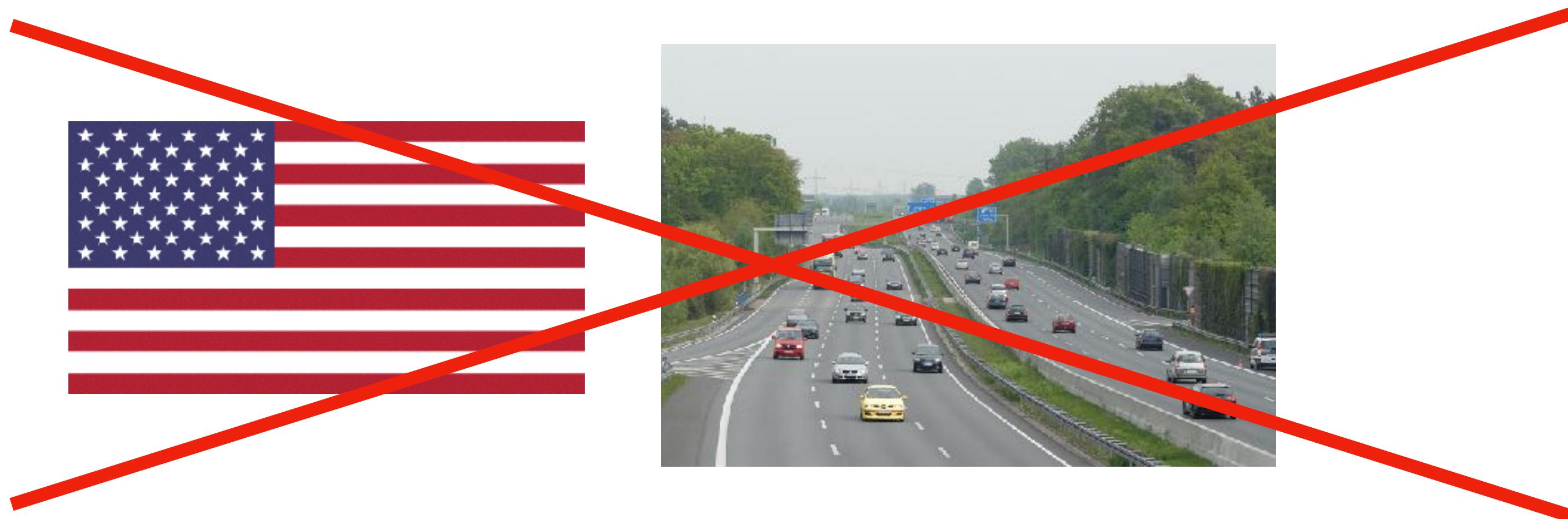
check_date	2019-11-09		
colour	gold		
from	Rådhuspladsen		
name	Bus 33: Rådhuspl...		
network	Movia		
network:wikipedia	Q3359392		
network:wikidata	da:Movia		
public_transport	2		
ref	33		
route	bus		
to	Dragør Stationspl...		
type	route		

+

## Members (249)

Node <not downloaded>	
stop_entry_only	
Node <not downloaded>	
stop	
Node <not downloaded>	
stop	

"highway" = any road or way for any non-rail transport



# 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

smaller, and faster than gzip

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 distributor

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. The map includes various buildings, parks, and water bodies. A bounding box is drawn around a specific area in the center-left of the map.

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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)

[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_QL](https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL)

[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_API\\_by\\_Example](https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_API_by_Example)

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It uses **Overpass Query Language** (Overpass QL). You can select and filter node, way, rel, 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)

[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_QL](https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL)

[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_API\\_by\\_Example](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 */
```

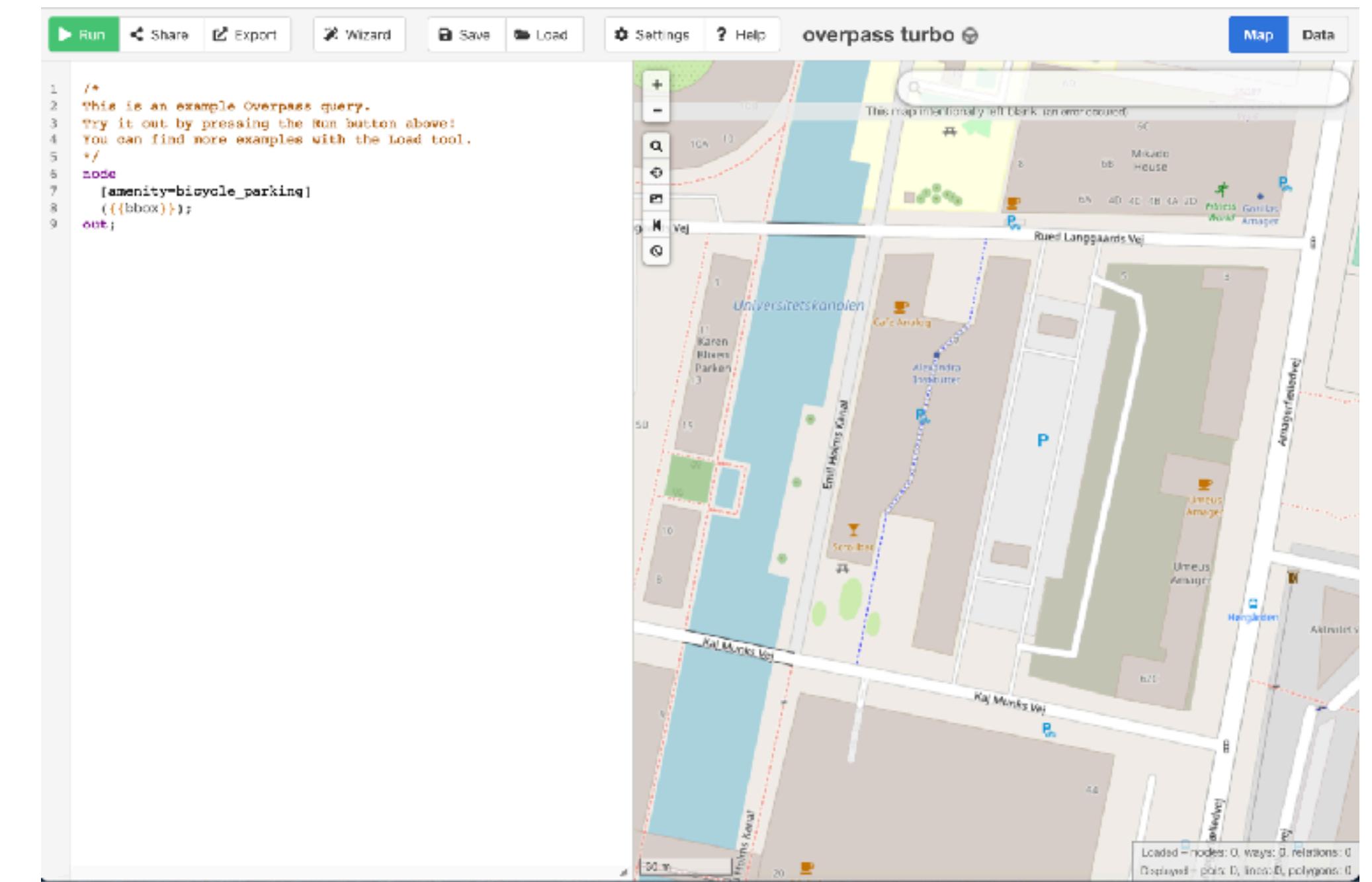
[https://wiki.openstreetmap.org/wiki/Overpass\\_API](https://wiki.openstreetmap.org/wiki/Overpass_API)

[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_QL](https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL)

[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_API\\_by\\_Example](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's a toolbar with buttons for Run, Share, Export, Wizard, Save, Load, Settings, Help, and a link to 'overpass turbo'. Below the toolbar is a code editor containing an Overpass query. The map view shows a geographic area with several buildings and roads labeled. A legend in the bottom right corner provides information about the data loaded and displayed.

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

[https://wiki.openstreetmap.org/wiki/Overpass\\_API](https://wiki.openstreetmap.org/wiki/Overpass_API)

[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_QL](https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL)

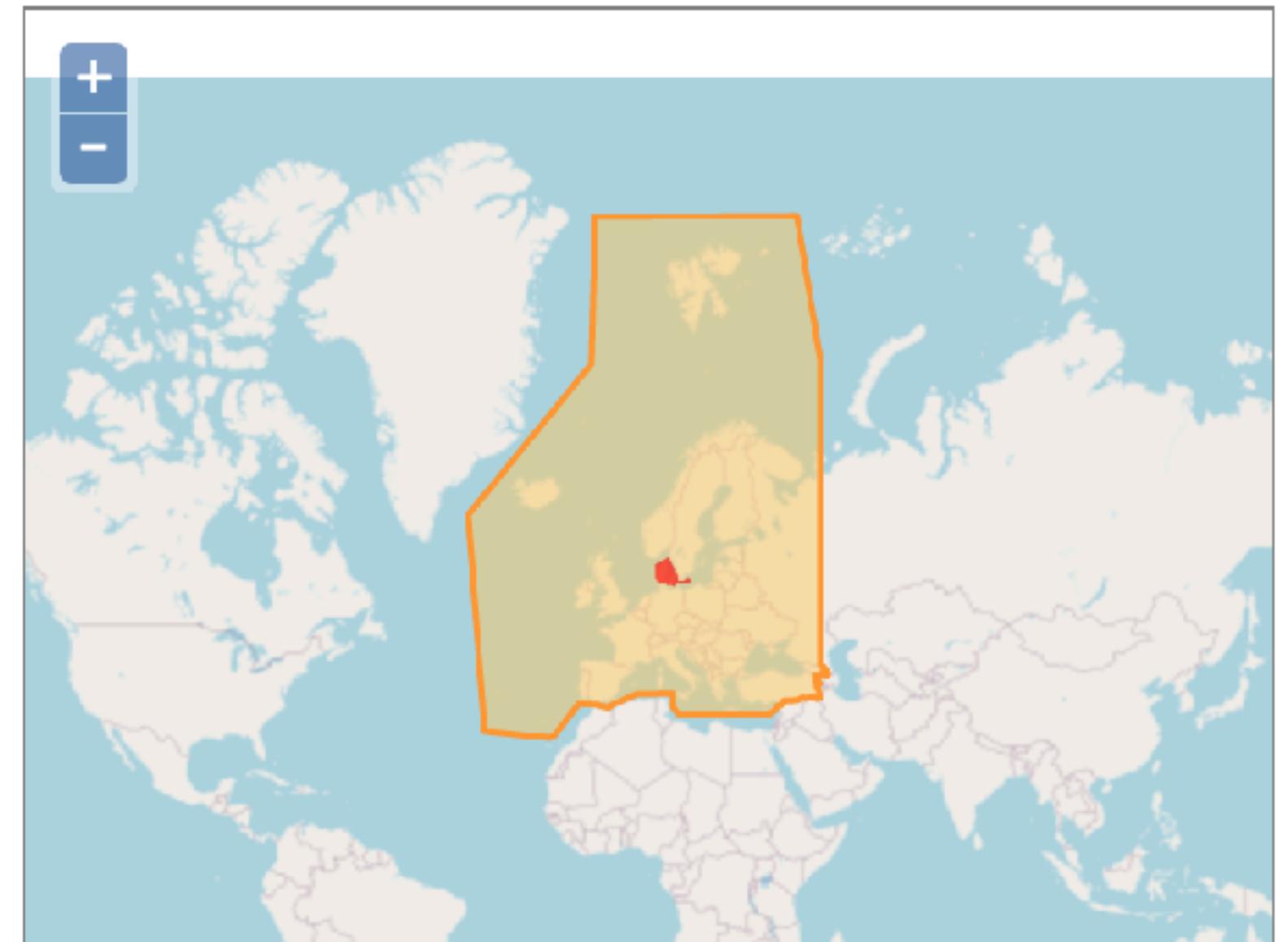
[https://wiki.openstreetmap.org/wiki/Overpass\\_API/Overpass\\_API\\_by\\_Example](https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_API_by_Example)

# Download extracted region from distributor

## Sub Regions

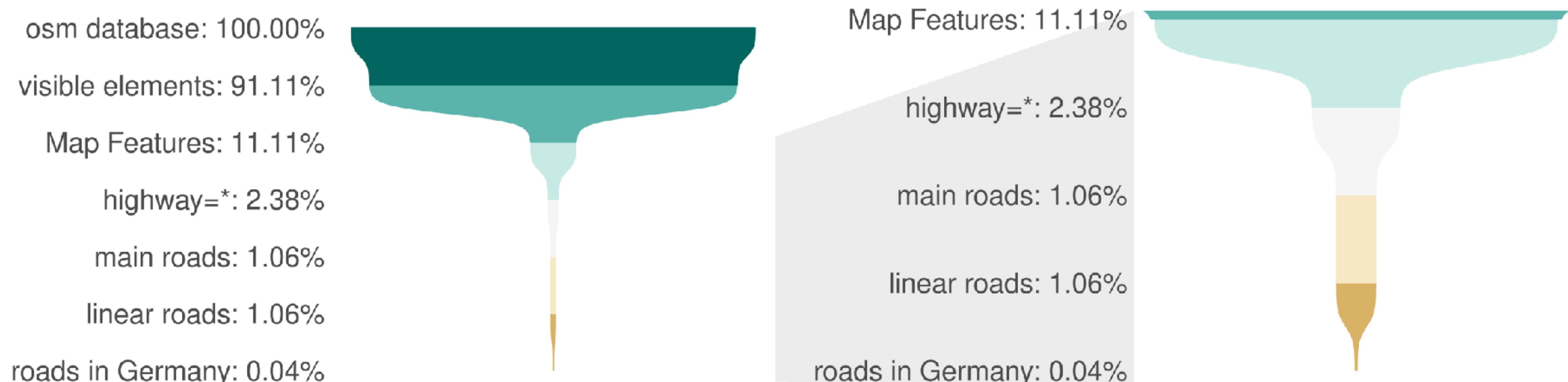
Click on the region name to see the overview page for that region, or select one of the file extension links for quick access.

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



# 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>

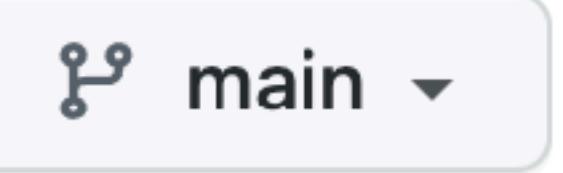
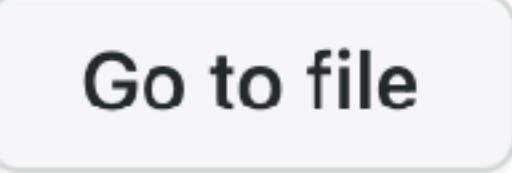
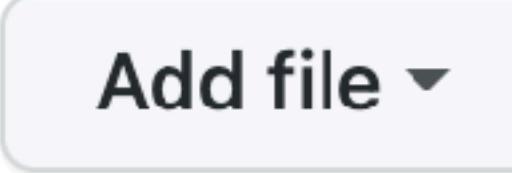
Osmosis

<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

 [Code](#)  [Issues](#) 7  [Pull requests](#) 1  [Actions](#)  [Projects](#) 

 [main](#)   

 [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

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Small area or <100,000 elements

Download and network analysis

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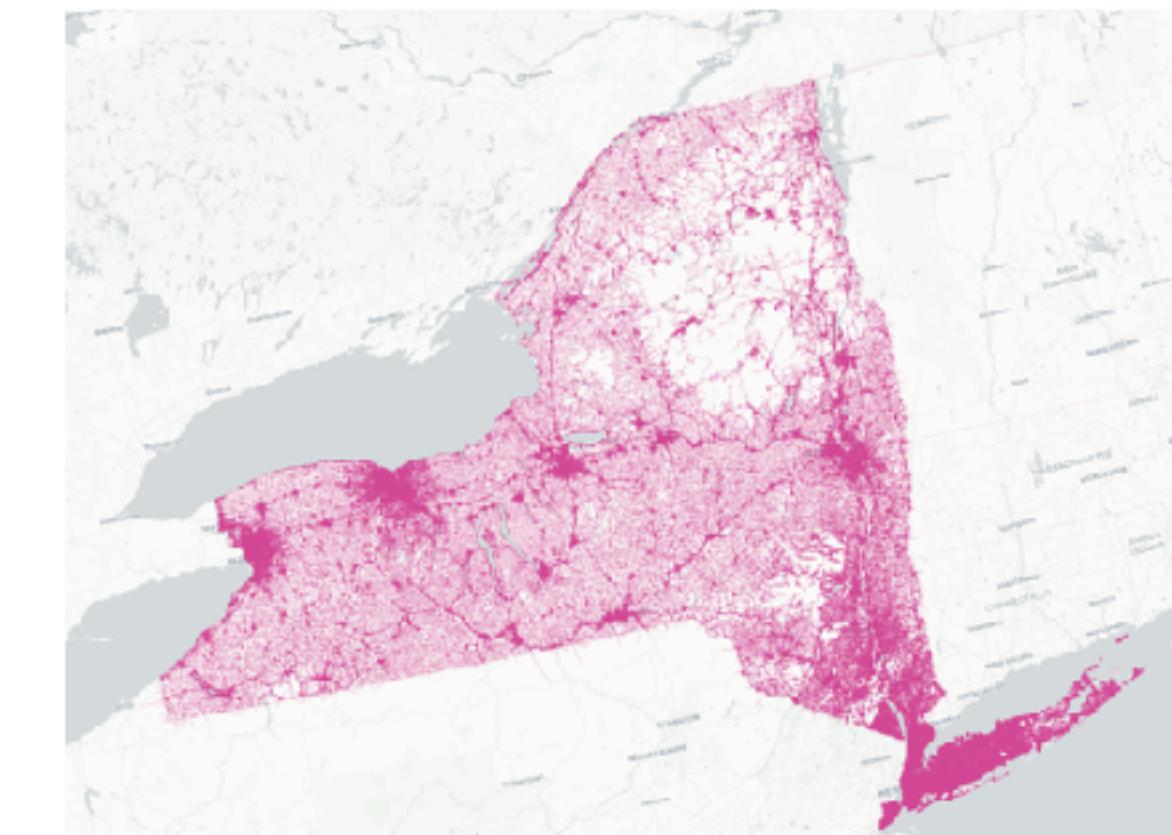
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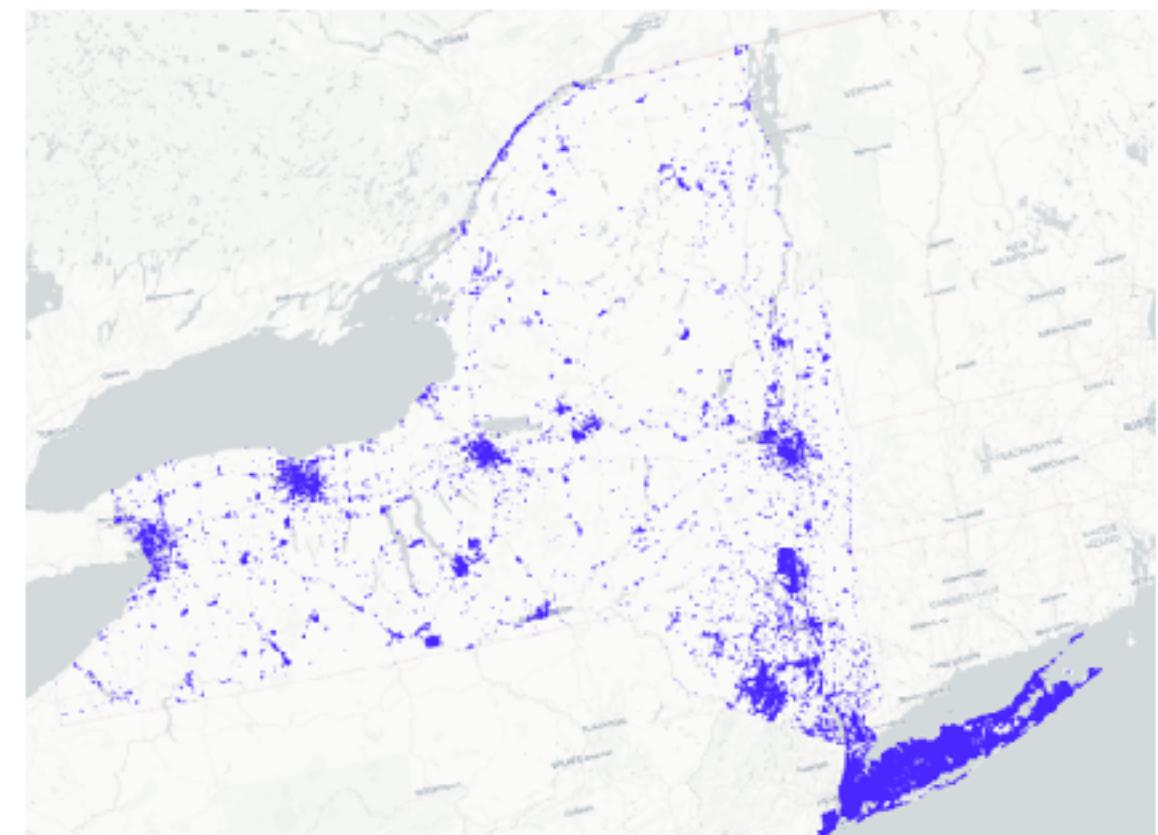
## **pyrosm**

Large area or >100,000 elements

Downloads and parses pbf



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

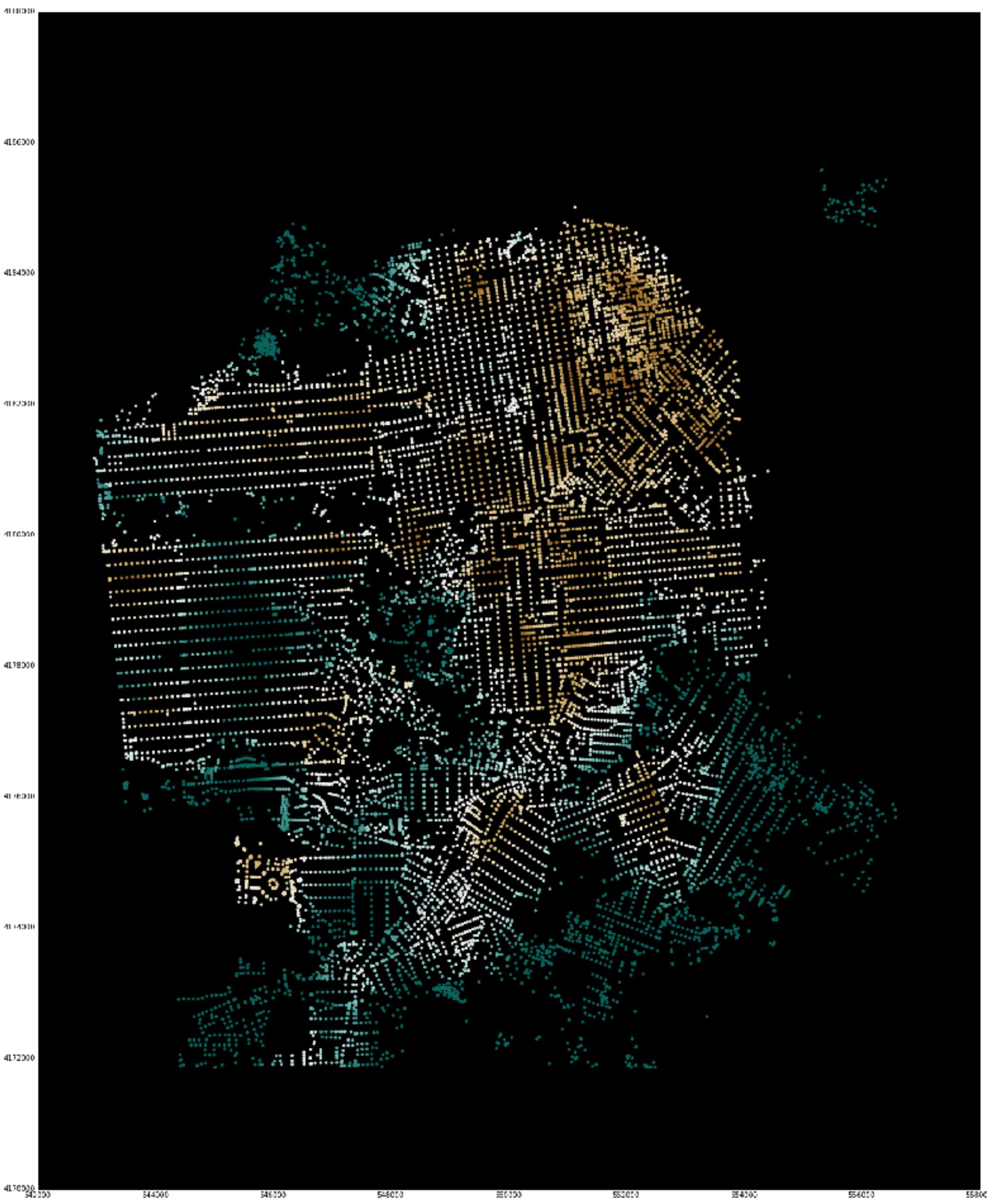


N.Y. buildings (N = 2,200,000)

# How to use OSM for research

**pandana**

Fast calculation  
of accessibility



# Useful OSM-related tools

Nominatim

Geocoding

<https://nominatim.openstreetmap.org/>

Leaflet

JS for interactive maps

<https://leafletjs.com/>

Mapbox

Online map provider

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

Folium

Python+Leaflet

<https://python-visualization.github.io/folium/>

Graphhopper

Routing

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

Extract.bbbike

Custom extract

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

# 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>