Fraunhofer ISI

Fraunhofer Institute for Systems and Innovation Research ISI

October 2023

Truck Stop Locations in Europe – Documentation Version 0.1 – Public Version

Publishing Notes (1/2)

The following data are provided free of charge. The Fraunhofer ISI does not assume any liability for completeness, correctness and accuracy of the information. Coverage and completeness varies among countries.

The following geolocations (Longitude, Latitude) represent potential heavy-duty truck (HDT) parking locations in Europe (EU-27, EFTA, UK). These locations resulted from several data sources – mostly OpenStreetMap (OSM) and complemented with commercial data sources – and multiple filtering steps to ensure accuracy and select potential candidates. Individual nearby locations were then merged and clustered using the MeanShift algorithm. Thus, geolocations represent centroids of the respective cluster and may not match exact locations.

All locations should be considered as reference point for detailed local analyses of ambient conditions and truck parking suitability.

The indicated total area, along with the associated estimated number of parking spaces - provides an indication in terms of scale.

Publishing Notes (2/2)

This data are crucial for charging infrastructure or network operators to facilitate future low-carbon road freight traffic as battery electric trucks in long-haul operation will require public charging infrastructure. Ideally, some of today's truck parking locations will be equipped with charging infrastructure. Accordingly, megawatt charging would be useful next to major highways and lower charging power would be helpful in many locations for overnight charging.

Codebook (1/2)

Variable	Type	Info
name	categorical	Indicates the most likely location type. 4 types are available. This also indicates the availability of surrounding infrastructure or services.
lat	float	Latitude information from the respective cluster centroid. WGS-84 format
lon	float	Longitude information from the respective cluster centroid. WGS-84 format
totalArea_m2	int	The estimated total area of this location in m². Most likely only publicly accessible areas. We note that not the whole area must be accessible for truck parking and that this may also include roads and other service areas. Empty if this information is not available for the respective location.
truckParkingConfidence	categorical	Indicates the confidence about whether or not this location is equipped or accessible for truck parking. 2 types are available.
country	categorical	Assigned country. This datasets covers the EU-27, EFTA and UK.
clc_Code	categorical	CORINE Land Cover information as defined under https://land.copernicus.eu/en/products/corine-land-cover
TenTcore_km	float	Calculated aerial distance in kilometers (to the TenTec Core road network as provided by the European Commission – DG MOVE – TENtec Information System 2022. Precision level: around 0.1 decimal degress (~11 km). Empty if above.
TenTcomp_km	float	Calculated aerial distance in kilometers to the TenTec Comprehensive road network as provided by the European Commission – DG MOVE – TENtec Information System 2022 Precision level: around 0.1 decimal degress (~11 km). Empty if above.

Codebook (2/2)

Variable: name - most likely location type (mixed types may exist)

Types	Name	Info
Type 1	Truck Stop / Rest Area	Most likely a truck stop and service area, directly along the highways. Fuel for HDTs is provided. Other services such as restaurants, service facilities, sleeping and shower facilities are likely. Public access usually provided
Type 2	Fueling (and Truck Stop)	Most likely a truck stop and service area. Fuel for HDTs is provided. Other services may be limited. Public access usually provided
Type 3	Rest Area	A rest area - usually along a major highway – that provides parking areas and likely provides other service facilities such as restaurants, shops, or at least restrooms. Public access usually provided
Type 4	Parking	Other parking areas that are usually located close to industrial areas, but additional information is missing. Restricted access possible.

Variable: truckParkingConfidence

Types	Name	Info
Type 1	High	Truck parking and access is very likely
Type 2	Medium	Truck parking and access is likely, but occasionally restricted or not available

Agenda

1. Overview & Sources
2. Data
3. Results
4. Validation / Comparison
5. Others

Overview data sources

Sources:

OSM

Idea: Combine both sources to enhance accuracy and coverage / completeness

PTV Developer
HERE Developer
TomTom Developer

Issue: Limited validity and accuracy for truck suitability

Issue: May cover street-side parking. No statement about dimensions, but suspected higher coverage and accuracy as open source software.

OSM – Overview (1/2)

Tag overview

Relevant tags / osm objects: Where could truck parking happen? Which (public) areas may be suitable?

Parking Areas | **Rest Areas** | **Fueling Stations**

osm object types: Which object types need to be differentiated?

- **Points / Nodes:**
  - Latitude / Longitude: As specified
  - Area: No area (=0 m2)
- **Ways / Polygons (2D shape):**
  - Latitude / Longitude: Calculated via area-based centriod
  - Area: Calculated based on area enclosed by the envelope GPS cords
- **Relation:**
  - Group of nodes, ways, and/or relations

OSM – Overview (2/2)

Tag overview

Parking Areas

```
if "capacity" in element["tags"]: capacity.append(element["tags"]["capacity"])
else:  capacity.append("NA")

if "access" in element["tags"]: access.append(element["tags"]["access"])
else:  access.append("NA")

if "hgv" in element["tags"]: hgv.append(element["tags"]["hgv"])
else:  hgv.append("NA")

if "landuse" in element["tags"]: landuse.append(element["tags"]["landuse"])
else:  landuse.append("NA")

if "operator:type" in element["tags"]: optype.append(element["tags"]["operator:type"])
else:  optype.append("NA")

if "name" in element["tags"]: name.append(element["tags"]["name"])
else:  name.append("NA")

if "capacity:hgv" in element["tags"]: hgvCapac.append(element["tags"]["capacity:hgv"])
else: hgvCapac.append("NA")

if "hgv:lanes" in element["tags"]: hgvLane.append(element["tags"]["hgv:lanes"])
else: hgvLane.append("NA")
```

- *Nodes (osm total): 391,854 – coverage 7.7%**
- *Ways (osm total): 4,631,651 – coverage 91%**

99% coverage of all osm data ensured

Rest Areas

```
if "name" in element["tags"]: name.append(element["tags"]["name"])
else:  name.append("NA")

if "hgv" in element["tags"]: hgv.append(element["tags"]["hgv"])
else:  hgv.append("NA")
```

- *Nodes (osm total): 21,041 -> coverage 56%**
- *Ways (osm total): 16,542 -> coverage 43%**
- ~~*Relation (osm total): 323 – coverage 0.85%**~~

99% coverage of all osm data ensured

Fueling Stations

```
if "name" in element["tags"]: name.append(element["tags"]["name"])
else:  name.append("NA")

if "fuel:HGV_diesel" in element["tags"]: hgvFuel.append(element["tags"]["fuel:HGV_diesel"])
else: hgvFuel.append("NA")

if "brand" in element["tags"]: brand.append(element["tags"]["brand"])
else: brand.append("NA")

if "fuel:diesel" in element["tags"]: diesel.append(element["tags"]["fuel:diesel"])
else: diesel.append("NA")

if "capacity:hgv" in element["tags"]: hgvCapac.append(element["tags"]["capacity:hgv"])
else: hgvCapac.append(np.nan)

if "hgv" in element["tags"]: hgv.append(element["tags"]["hgv"])
else: hgv.append("NA")

if "hgv:lanes" in element["tags"]: hgvLane.append(element["tags"]["hgv:lanes"])
else: hgvLane.append("NA")
```

- *Nodes (osm total): 306,134 -> coverage 60%**
- *Ways (osm total): 203,093 -> coverage 40%**
- ~~*Relation (osm total): 2,461 – coverage 0.5%**~~

almost 100% coverage of all osm data ensured

High coverage ensured for all OSM data. Data for all EU27 (+ EFTA and UK) – Data extracion via OverPass API

***: as of Oct.2023**

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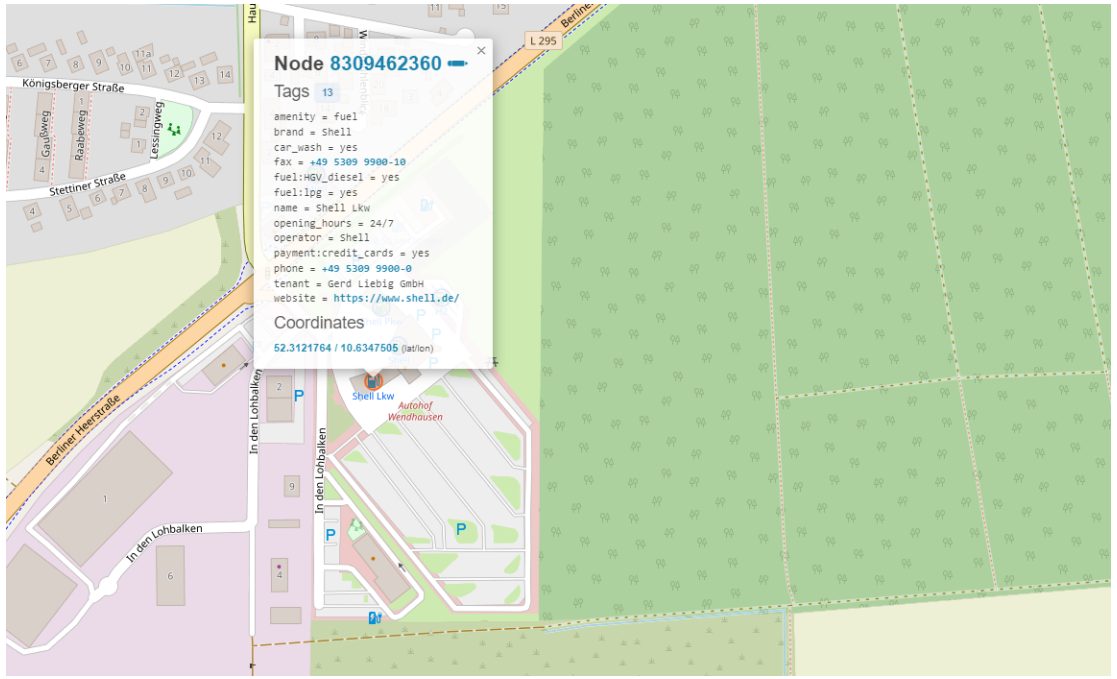
OSM Fueling Stations – Overview Nodes / Ways

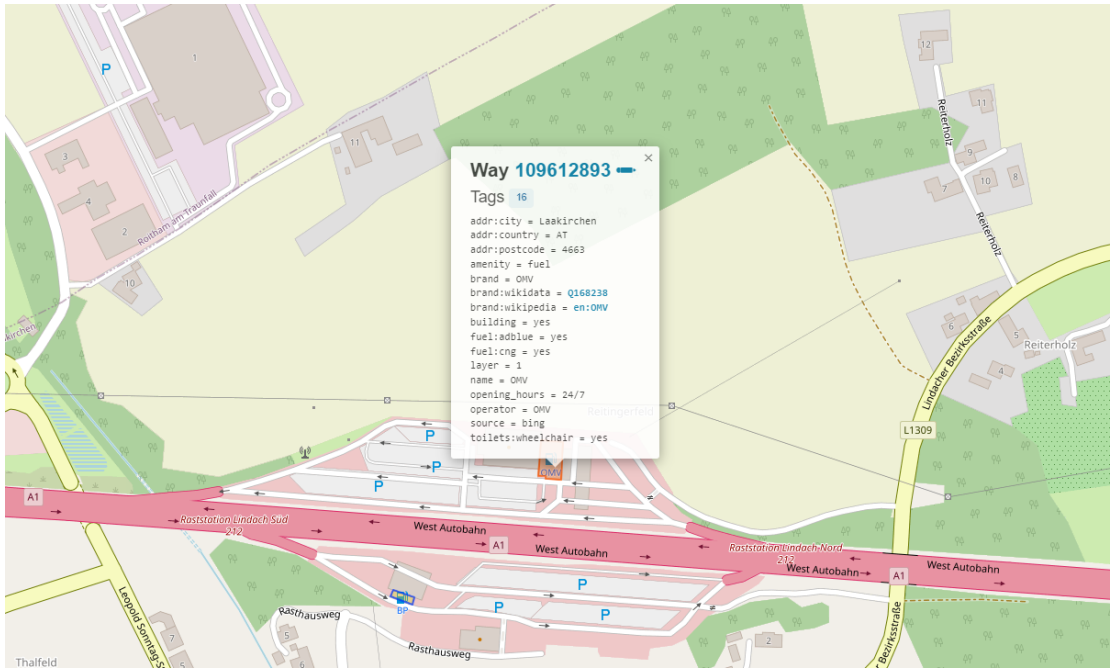
Fueling Stations

Nodes



Source: https://overpass-turbo.eu/

Ways



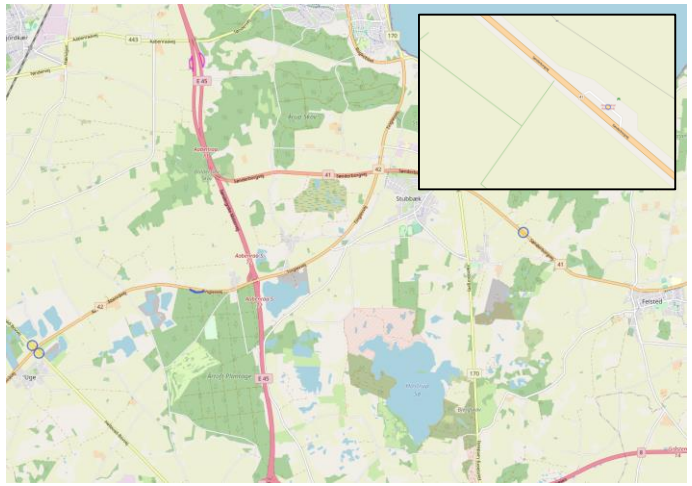
Source: https://overpass-turbo.eu/

Both tags may be relevant for fueling stations

OSM Rest Areas – Overview Nodes / Ways

Rest Areas

Nodes



Source: https://overpass-turbo.eu/

Relation

Source: https://overpass-turbo.eu/

Ways

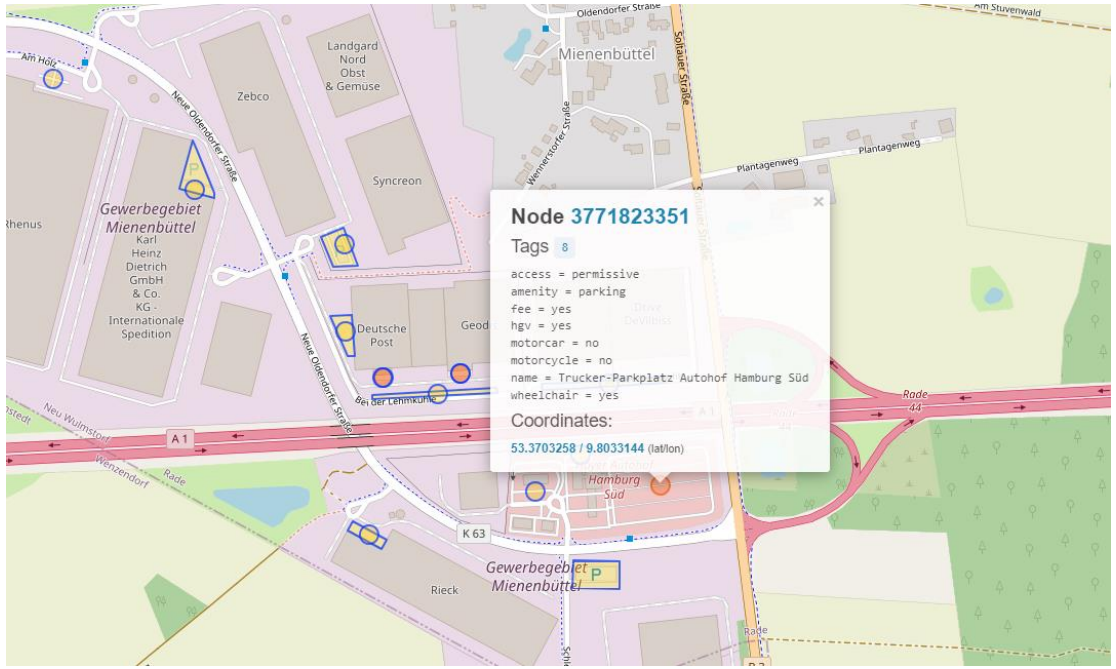
Source: https://overpass-turbo.eu/

All three tags may be relevant for (truck) rest areas

OSM Parking Areas – Overview Nodes / Ways

Parking Areas

Nodes



Source: https://overpass-turbo.eu/

Ways

Source: https://overpass-turbo.eu/

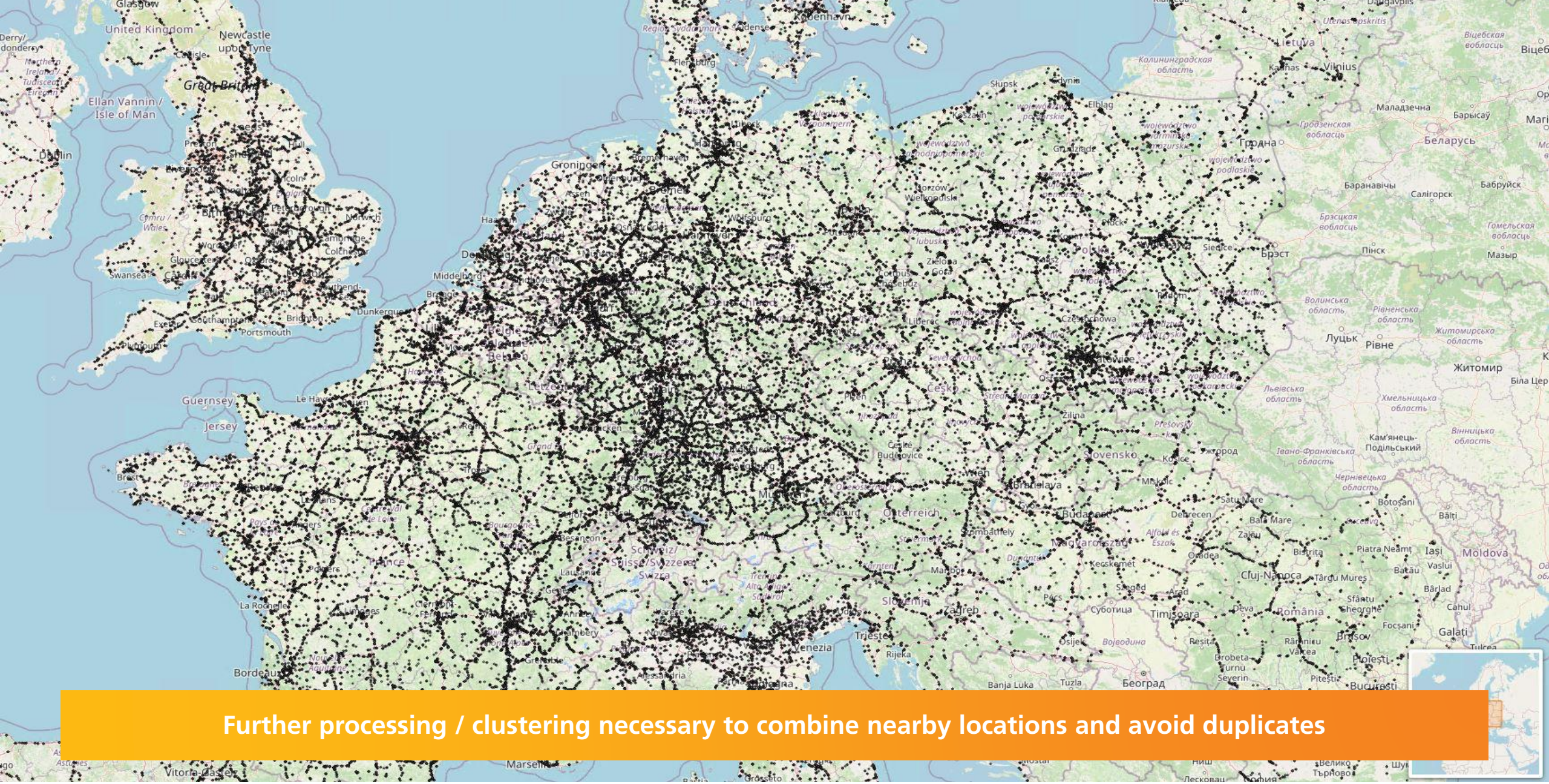
Both tags may be relevant for truck parking areas

Interim data – Results from pre-processing and filtering

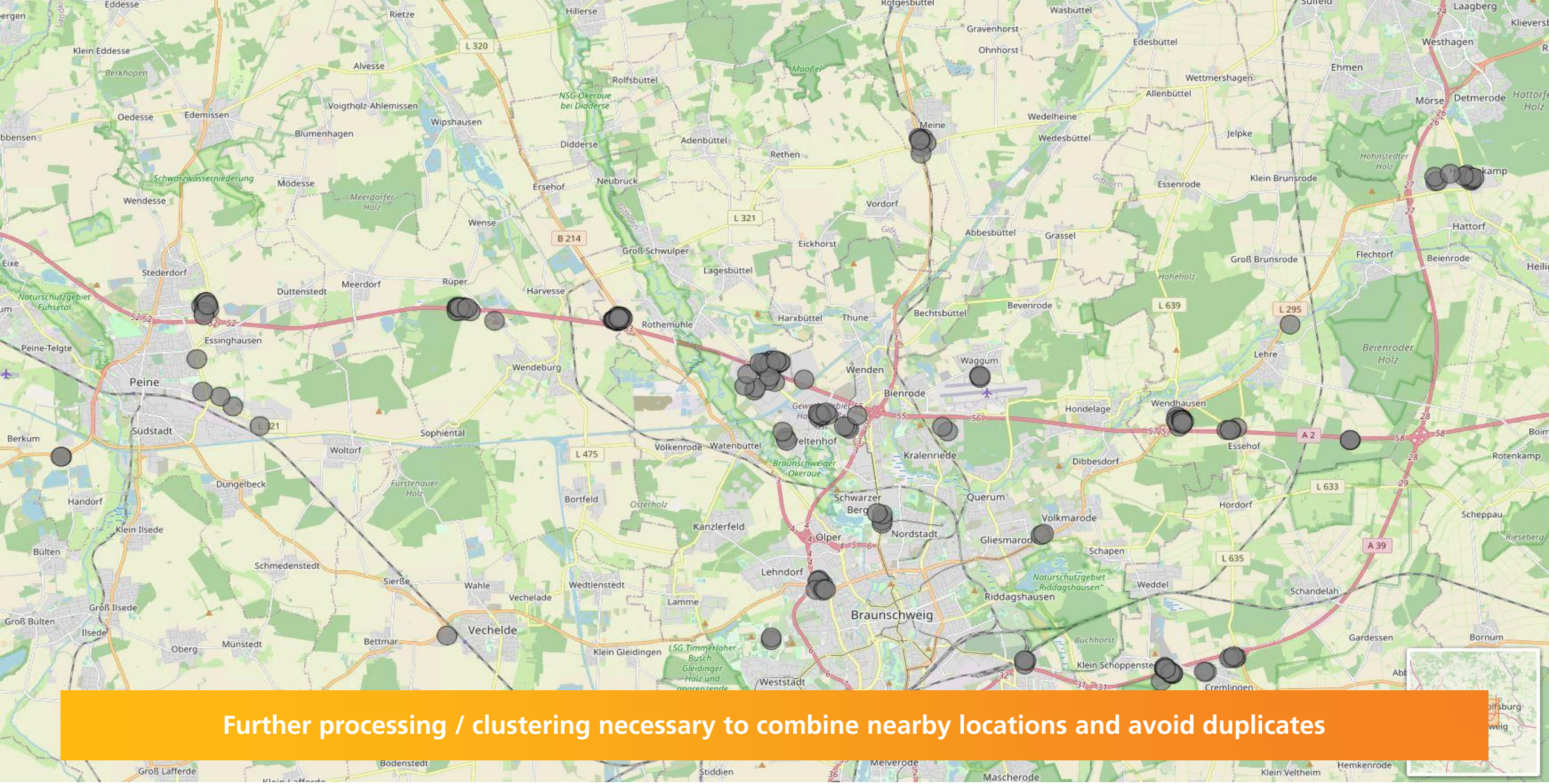
	Parking Areas	Rest Areas	Fueling Stations	Other Truck Data
Initial size	2,661,731	18,279	131,374	41,155
Final data	78,906 (3%)	8,337 (46%)	19,627 (15%)	41,155
Yes	*7,565 (10%)*	*3,293 (40%)*	*10,541 (54%)*	*41,155 (100%)*
Likely	*12,754 (16%)*	*2,355 (28%)*	*6,153 (31%)*	-
Insecure	*53,275 (68%)*	*2,689 (32%)*	*2,933 (15%)*	-
Private/Delivery	*5,312 (6%)*	-	-	-

Filtered for truck accessibility

The final data covers ∑ 142,654 data points for potential locations

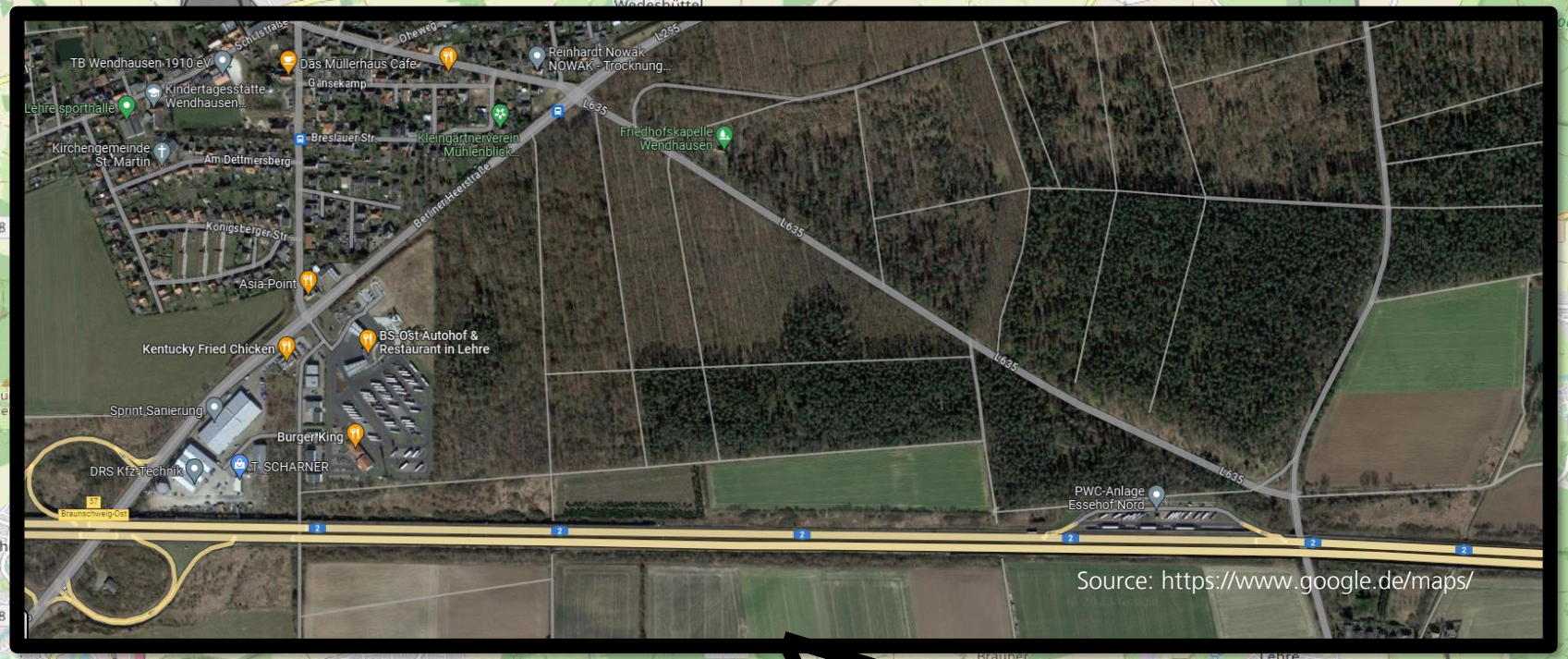


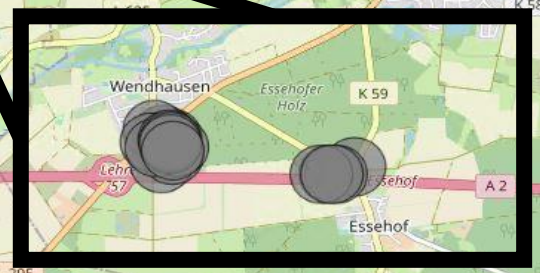
Source: Own illustration based on Leaflat map



Further processing / clustering necessary to combine nearby locations and avoid duplicates

Source: Own illustration based on Leaflat map





Further processing / clustering necessary to combine nearby locations and avoid duplicates

Source: Own illustration based on Leaflat map

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Methods – Overview (1/2)

Parking
n = 73,594 (w/o private)

Fueling
n = 19,627

Rest Areas
n = 8,337

Other Data
n = 41,155

Combine
n = 142,713

MeanShift
n = 53,699

Check
n = 51,964

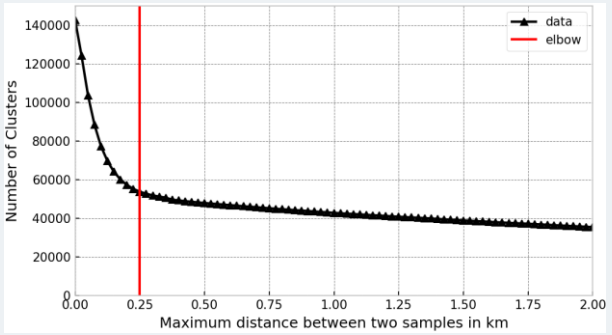
F

Final
n = 19,713

Check / Post Processing:
- ***Check within EU27 + EFTA + UK (53,412)***
- ***Calc distance between all points***
- ***Group if distance is below knee ~ 250m***

Final filtering and check for confidence and validity

MeanShift
- Test 25-2100m
- ***Knee ~ 250m***
- Time per run: 4-6min



Methods – Overview (2/2)

MeanShift Clustering

Centroid-based algorithm based on kernel density estimation (KDE)

Pros: **Variable number of centroids, robust to outliers, Universal application, no limitations on prior shape or data distribution, single parameter model (bandwith)**

Cons: **Bandwidth-sensitive output, Non-trivial bandwidth selection, computationally (relatively) expensive**

Examples on geo-coords:
http://dx.doi.org/10.1145/1631272.1631292
https://ceur-ws.org/Vol-2649/paper5.pdf
https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1475-4754.2010.00560.x

Steps

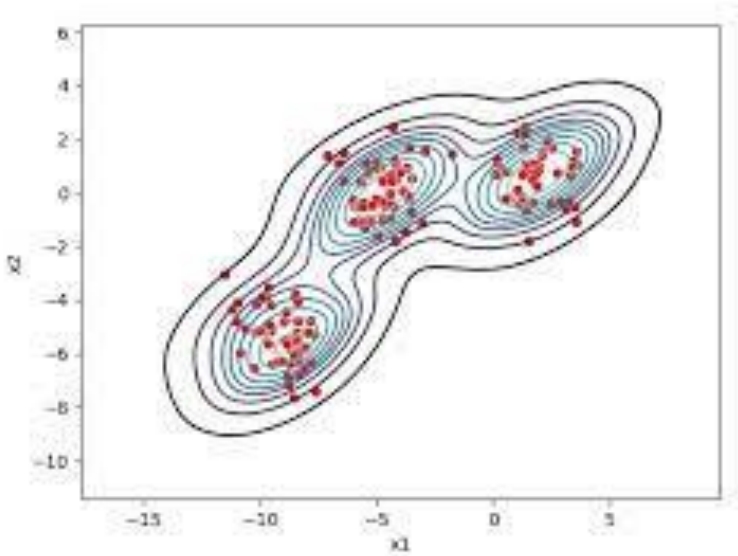
a) Kernel Density Estimation: The first step involves estimating the underlying probability density function (PDF) of the data points. This is typically done using kernel density estimation, where each data point is represented by a kernel function centered at that point. The kernel function specifies the weight assigned to each data point in the density estimation process.

b) Shifting Data Points: In the second step, the algorithm iteratively shifts the data points towards regions of higher density. The shift is determined by calculating the mean shift vector for each data point, which represents the direction and magnitude of the shift. The mean shift vector is calculated as the weighted average of the differences between the data point and its neighboring points, where the weights are determined by the kernel function.

c) Convergence and Cluster Identification: The algorithm continues shifting the data points until convergence is reached. Convergence occurs when the mean shift vectors become very small or negligible. Once convergence is achieved, the final position of each data point represents a cluster center. The algorithm assigns each data point to the closest cluster center, thereby identifying the clusters within the data.

Source: https://medium.com/@shruti.dhumne/mean-shift-clustering-a-powerful-technique-for-data-analysis-with-python-f0c26bfb808a

Mean Shift



Source: https://ml-explained.com/blog/mean-shift-explained

Interim results

Final filtering for each point whether there are only information from:

- OSM: n = 7 tag combinations (~25%)
- Others: n = 13 tag combinations (~25%)
- Mixed: n = 41 tag combinations (~ 50%)

Create final tags based on the joined information:

- Type 1: **Parking** – if only information about parking / parking areas is available
- Type 2: **Fueling** – if information about fueling and potentially parking is available. Truck services possible.
- Type 3: **Rest Area** – if information about rest areas is available
- Type 4: **Truck Stop / Rest Area** – if information about rest areas with fueling / service (truck stops) is available

Clustering creates 56 unique tag configurations from more than 53,000 potential locations

Final Filtering

For all types, check and evaluate each point based on:

- **available area information:** **Yes, No, Minimum threshold**
- **Proximity to the TenT network**
- **Land Cover information (Corinne CLC)**
- **Area access information (mostly OSM)**

and update to low confidence, medium confidence, high confidence

Fueling

Fueling	High	329
	Low	7742
	Medium	5793
Fueling / Truck Stop	High	1260

Parking

Parking	High	464
	Low	22663
	Medium	4204
Parking / Rest Area	High	525

Rest Area

Rest Area	High	4120
	Low	534
	Medium	1804

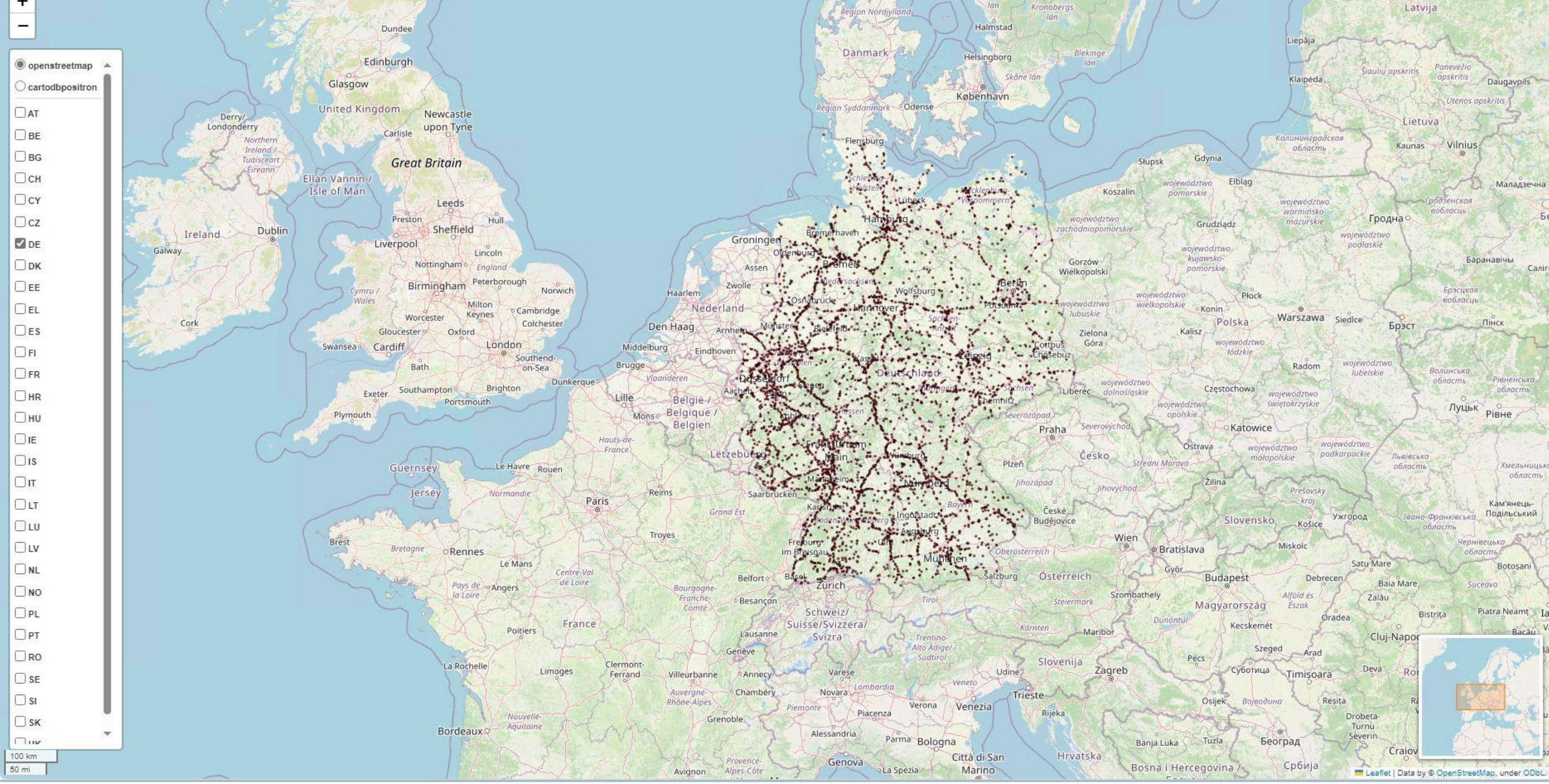
Parking

Truck Stop / Rest Area	High	275
	Medium	111

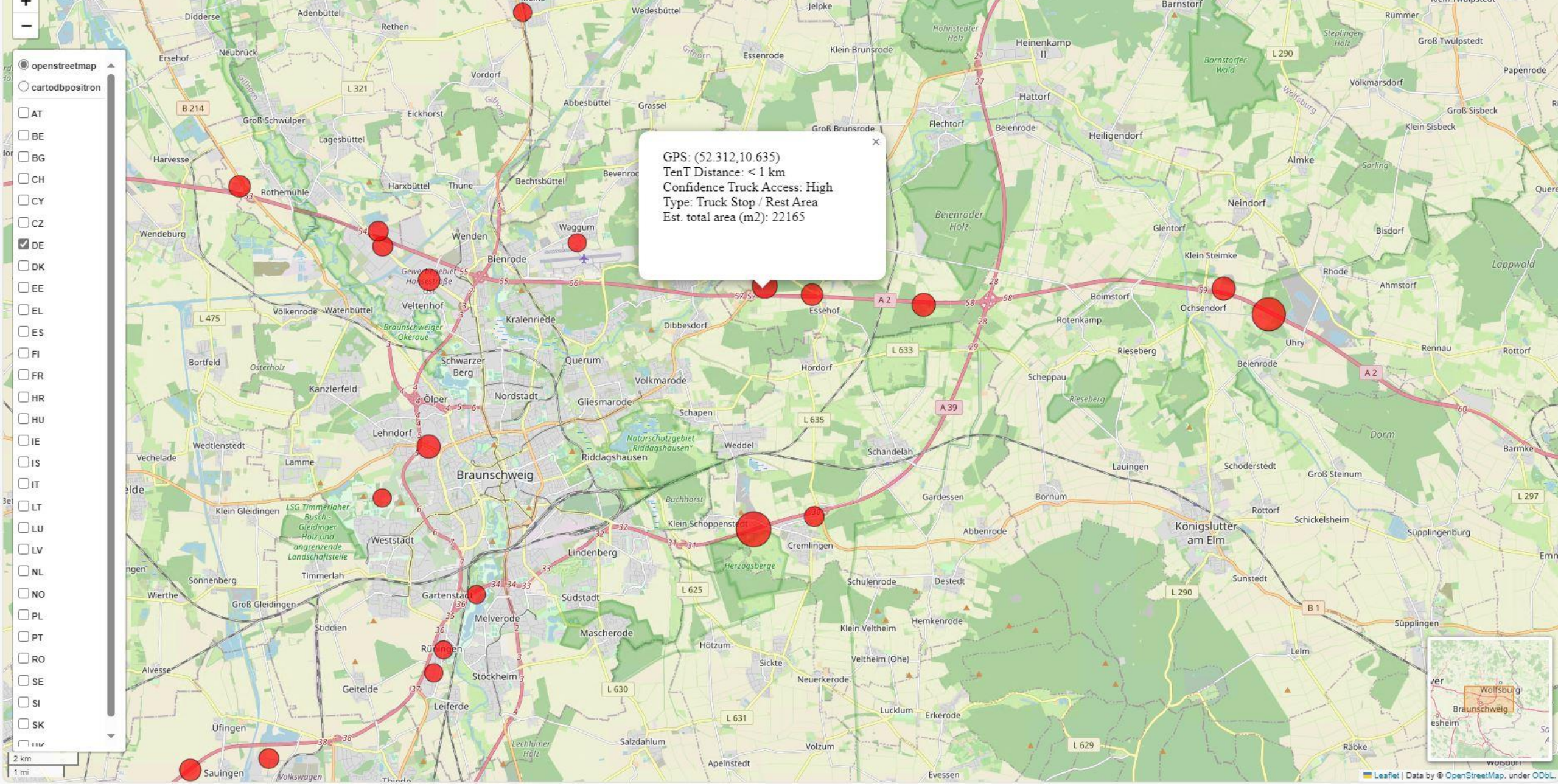
Keep only locations with HIGH or MEDIUM truck parking confidence: n = 19,713

Results (1/2)

Country	Fueling	Fueling / Truck Stop	Parking	Parking / Rest Area	Rest Area	Truck Stop / Rest Area	Total
FR	2039	246	782	86	1159	25	4337
AT	76	57	78	26	174	32	443
BE	40	25	118	41	70	5	299
BG	22	5	23	2	88	2	142
CH	36	15	71	9	77	10	218
CY	1			1	2		4
CZ	187	35	109	12	34	6	383
DE	1099	344	1144	104	1589	55	4335
DK	32	12	93	9	302	13	461
EE	33	1	19	1	11	2	67
EL	12		29		68	11	120
ES	235	20	196	8	283	21	763
FI	89	15	102	12	363	5	586
HR	21	7	27	4	54	4	117
HU	48	13	67	4	90	2	224
IE	34	5	17		14	1	71
IS	1		1		8		10
IT	238	84	536	42	352	38	1290
LT	49	6	37	4	46	4	146
LU	11	2	14	3	17		47
LV	32	5	20		16	1	74
NL	60	48	123	32	76	6	345
NO	377	9	74	13	469	34	976
PL	1171	204	433	54	229	53	2144
PT	31	6	23	1	25	5	91
RO	96	5	53	10	131	14	309
SE	125	18	125	22	309	27	626
SI	29	2	14	2	24	3	74
SK	39	19	52	8	45	4	167
UK	130	52	288	15	346	13	844
Total	**6393**	**1260**	**4668**	**525**	**6471**	**396**	**19713**



Fraunhofer ISI


GPS: (52.312,10.635)
TenT Distance: < 1 km
Confidence Truck Access: High
Type: Truck Stop / Rest Area
Est. total area (m2): 22165
openstreetmap
cartodbpositron
AT
BE
BG
CH
CY
CZ
DE
DK
EE
EL
ES
FI
FR
HR
HU
IE
IS
IT
LT
LU
LV
NL
NO
PL
PT
RO
SE
SI
SK
Braunschweig
Wolfsburg
Königslutter am Elm
Leaflet | Data by © OpenStreetMap, under ODbL.

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Area information (1/2)

Matching with NOW-Dataset for public truck parking spots along the German highway network

- **Total NOW data:** **2,271**
- **without NA:** **2,208**
- **Number of matches:** **1977 = 89.5% (within maximum 500m aerial distance)**

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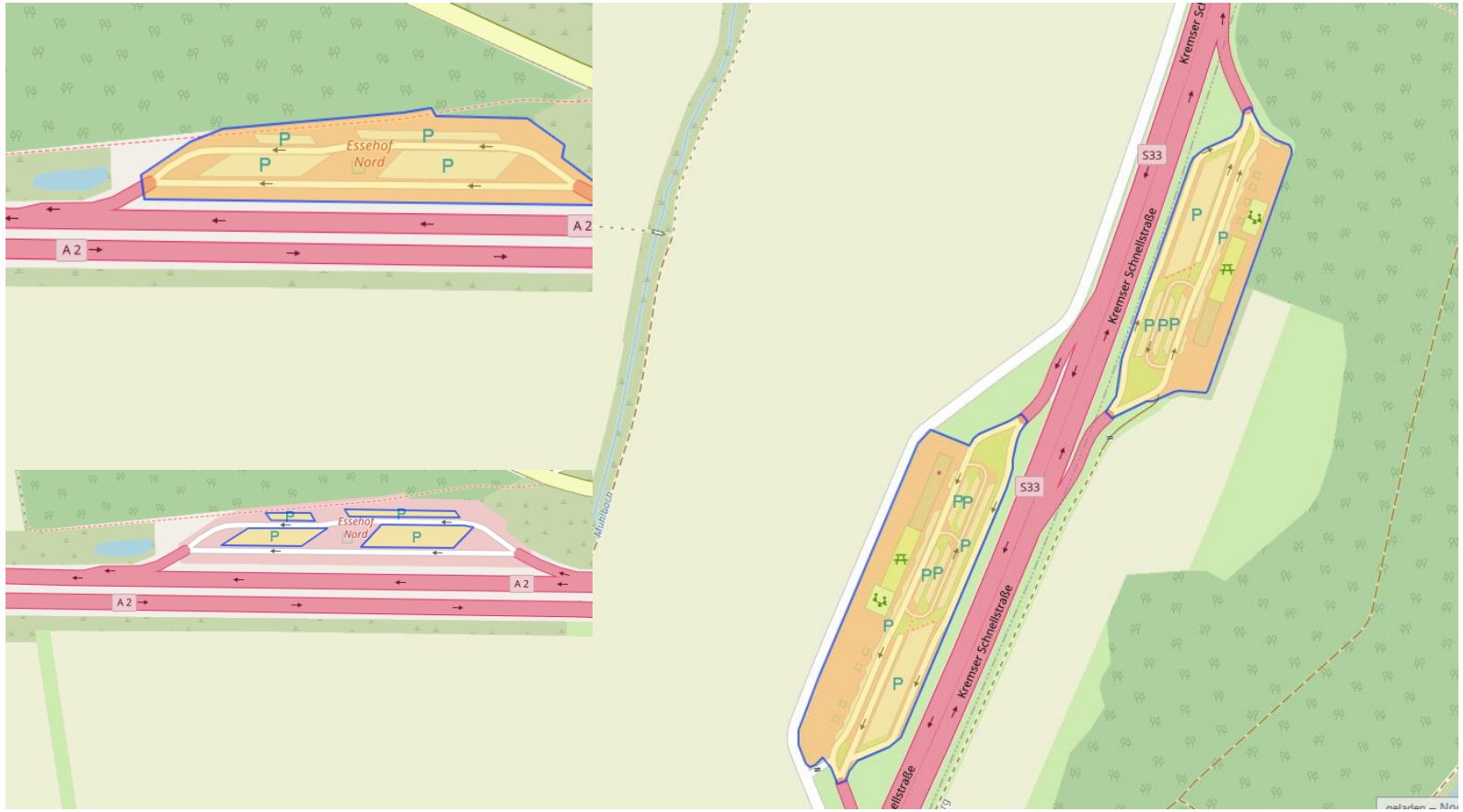
Particularities

Area Overlap

Avoid double counting when calculating the total area per location:

- Test whether parking areas are part of the rest area
- If true, delete area information (=0m²)

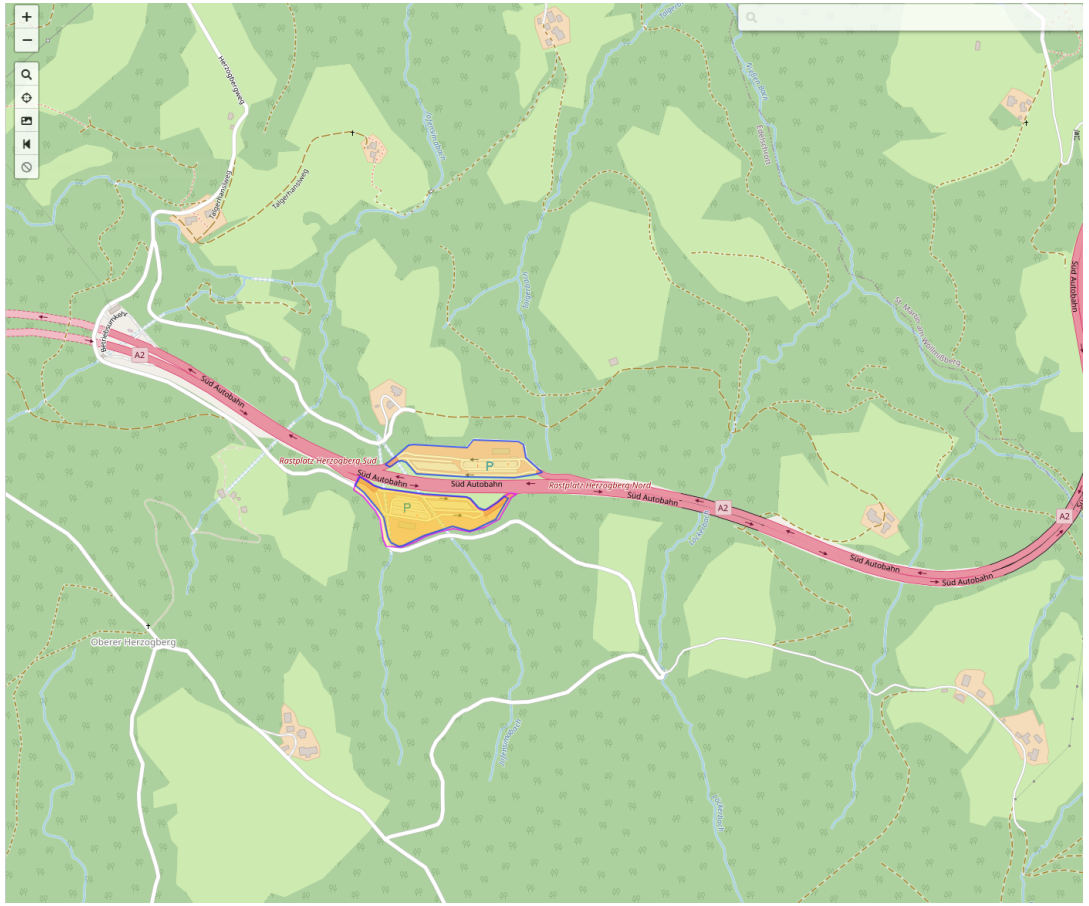


Particularities

Duplicates

Areas defined as Polygon and Relation:

- filter based on „name“ and remove dups to avoid area double accounting



Comparison to other methods: DBSCAN

DBSCAN:

Knee: **200 meter**

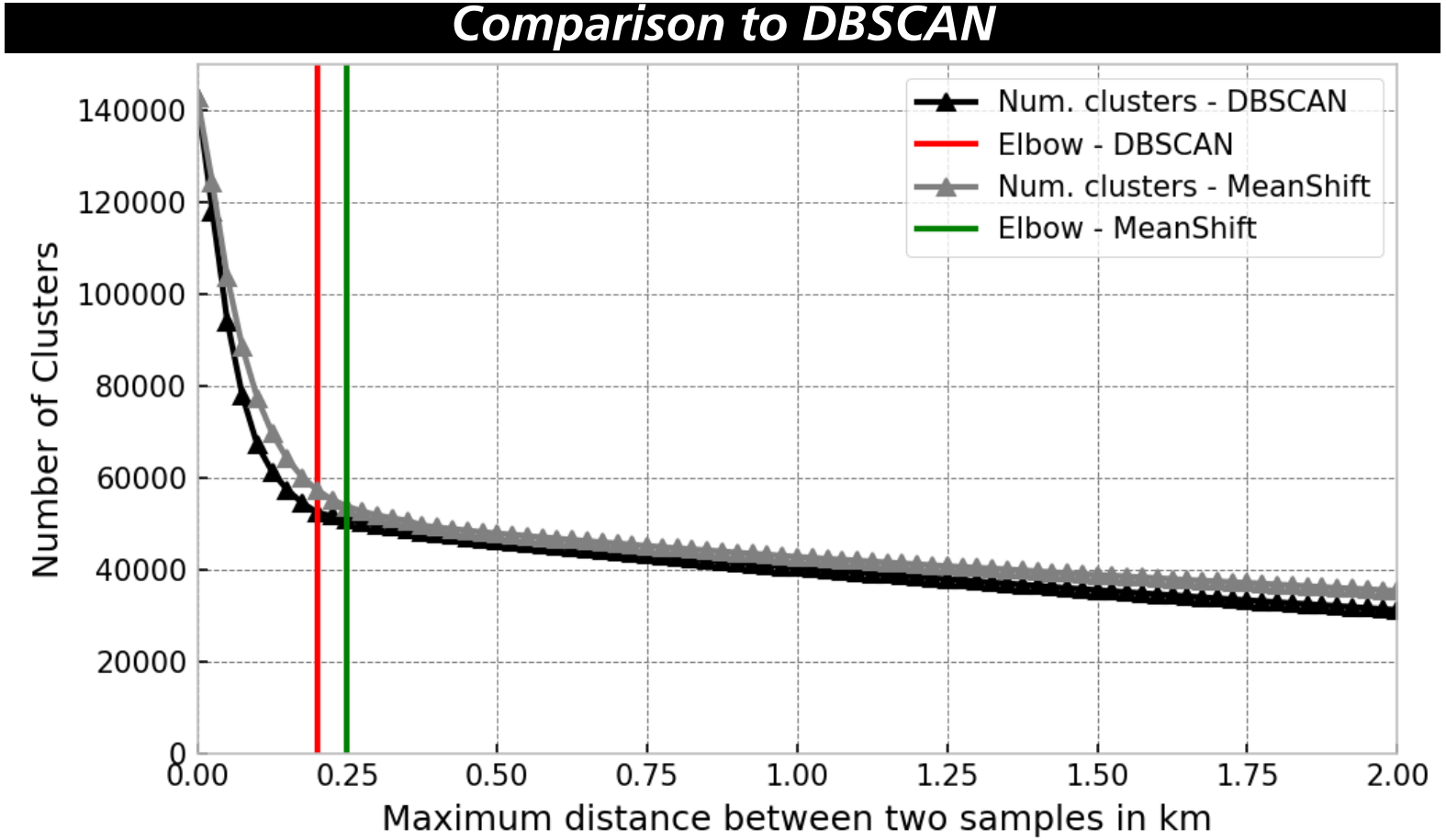
Num. of clusters: **52,364**

DBSCAN with stronger clustering effect (convex shapes) – decreases traceability, may increase data alienation.

MeanShift:

Knee: **250 meter**

Num. of clusters: **53,699**



References

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PTV Developer: Location Service APIs – Geocoding. Available at https://developer.myptv.com/en

HERE Developer: Location Service APIs – Geocoding. Available at https://developer.here.com/

TomTom Developer: Location Service APIs – Geocoding. Available at https://developer.tomtom.com/

Corinne Land Cover: Copernicus Land Monitoring Service (CLMS), "CORINE Land Cover Data Set: Reference Year 2018," 2023. [Online]. Available: https://land.copernicus.eu/pan-european/corine-land-cover

TenTec Network: European Commission – DG MOVE – TENtec Information System 2022.