# *Supplementary Material: Metropolitan Segment Traffic Speeds from Massive Floating Car Data in 10 Cities*

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## SUPPLEMENT A
## COMPLEMENTS ON INPUT DATA AND DATA PIPELINE

### A. Input Data

Here, we describe the two input data sources in terms of their data model, collection, provisioning, and license.

*1) Traffic Map Movies:*

*a) Dataset presentation:* Raw GPS data face privacy issues if individual users' behavior can be deduced from the data [1]–[3]. There are methods to preserve privacy by transforming the data, such as obfuscation, aggregation, privacy thresholds or snipping [4]–[6]. HERE Traffic Map Movies use spatio-temporal aggregation and privacy thresholding – we use the term *spot binning* for this aggregation method. Another motivation for framing a geo-spatial time series forecasting as a video prediction task [7] is to leverage state-of-the-art deep-learning methodologies in image and video processing [8]. The data was made available for the *Traffic4cast* competition series [7], [9], [10] at NeurIPS, an annual machine learning conference. A third motivation for bringing up GPS data in a map-free form is that spatio-temporal binning of GPS probes is computationally cheap in contrast to map-matching, and that it is also applicable in situations where no appropriate maps are available or not accurate enough [11].

Traffic Map Movies Data are provisioned in HDF5 (.h5), a format for typed multidimensional arrays [12], [13]. It can be downloaded for free from the HERE sample data website [14]. The data must be used solely for academic and non-commercial purposes and under standard HERE terms & conditions [15], which in particular explicitly forbid re-distribution of HERE materials or derivatives thereof in combination with any open source or open data licenses.

*b) Dataset generation:* GPS probes are binned spatially for each heading direction quadrant of North–East (heading 0°–90°), North–West (heading 270°–0°), South–East (heading 90°–180°), and South–West (heading 180°–270°) into an 8-channel encoding (see Figure 2), where two features are calculated :

- Volume: The number of probe points recorded from the collection of HERE sources capped both above and below and normalized and discretized to an integer number between 0 and 255 ($\mathbb{Z}_{256}$).
- Mean speed: The average speed from the collected probe points. The values are capped at a maximum level and then discretized to $\{1, 2, \ldots, 255\}$, by linearly scaling the capping speed to 255 and rounding the resulting values to the nearest integer. If no probes were collected (*i. e.* the volume is 0), the speed value is 0. This has to be taken into account when averaging speeds.

More formally, a GPS probe $(t, x, y, \alpha, v) \in \mathbb{R}\times\mathbb{R}\times[0, 360]\times\mathbb{R}^+$ consists of a timestamp $t$, a position $(x, y)$, an angle $\alpha$ and a speed $v$. A spatio-temporal binning is a projection $\pi$ to bins $(day, t, row, col, heading) \in \mathbb{N}\times\mathbb{Z}_{288}\times\mathbb{Z}_{495}\times\mathbb{Z}_{436}\times\{\text{NE}, \text{NW}, \text{SE}, \text{SW}\}$. The aggregation of a set $P$ of GPS probes produces

$$vol_{d,t,r,c,h} = \ulcorner\left((\left|\{_{\pi(tt,x,y,\alpha,v)=(d,t,r,c)}^{(tt,x,y,\alpha,v)\in P:}\}\right| - \theta)^{\top_\kappa}_{\perp 0}\frac{255}{co}\right)\lrcorner \quad (1)$$

and

$$speed_{d,t,r,c,h} = \begin{cases} \ulcorner\left(\overline{\{v^{\top 120}_{\perp 0} : {}^{(tt,x,y,\alpha,v)\in P,}_{\pi(tt,x,y,\alpha,v)=(d,t,r,c)}\}}\frac{255}{120}\right)\lrcorner \\ \qquad \text{if } vol_{d,t,r,c,h} > 0 \\ 0 \text{ if } vol_{d,t,r,c,h} = 0 \end{cases} \quad (2)$$

where clipping below is denoted by $x_{\perp b} = \max(x, b)$, clipping above by $x^{\top a} = \min(x, a)$, integer rounding as $\ulcorner\cdot\lrcorner$, and where $\theta$ is a privacy volume threshold and $\kappa$ a volume cutoff. This means volume is set to 0 if the probe volume does not reach the privacy threshold.

Intuitively, this *spot binning* favors lower speeds as slower cars stay longer in the same spatio-temporal bin and are counted multiple times. Under idealized conditions (see Supplement B), the spatio-temporally aggregated speed $speed_B$ represents the total distance divided by the total travel time (see Eq. (4)), which is the harmonic sum of the speeds of Eq. (3), *i. e.*

$$speed_B = \frac{\sum_k 1}{\sum_k v_k^{-1}} \quad (3)$$

$$= \frac{s\cdot\sum_k 1}{\sum_k t_k} \quad (4)$$

for a bin $B$ covering a road segment of length $s$ and for virtual vehicles indexed by $k$ at speeds $v_k$ taking time $t_k$. In particular, this requires controlling the probe rate of vehicles and depends on traffic volume and homogeneity. Future work could establish bounds to control these factors, *e. g.* through simulations.

*2) OpenStreetMap:* OpenStreetMap (OSM) is a database of GIS data built by an open community of contributors [16]. Its data model [17] has three main elements: *nodes* represent a specific point on the earth's surface (id number and a pair of coordinates), *ways* define polylines (ordered list of nodes), and *relations* between two or more data elements (nodes, ways, and/or other relations), optionally with different *roles*. Hence, the OSM data model does not directly describe a road graph, a traversable graph needs to be derived from the OSM elements. OSM data comes under the Open Database License (ODbL) [18], requiring attribution of public use, share-alike (under the same license) and open redistribution. We use the Overpass API [19] to download OSM data.

### B. Data Pipeline

Referring to Figure 1, we now describe the steps of our data pipeline in more detail. Each step is prefixed by `dp<N>` and corresponds to a standalone Python script in our public GitHub repo (see *Data and Code Availability* below). Our code is released under Apache License 2.0 [20]. This allows our method and code to be used and improved permissively in research and even in commercial use cases. The GitHub repo also contains a more technical data specification of all the (intermediate) data formats.

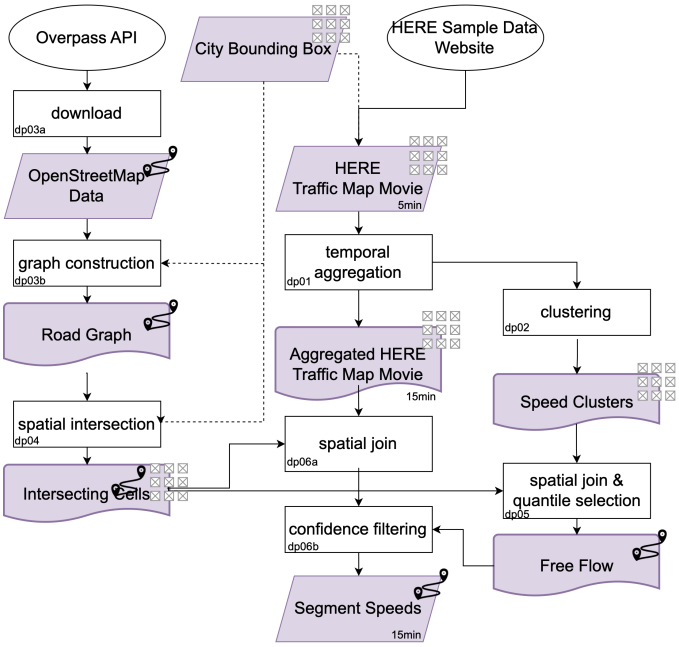



Fig. 1: Methods and data flowchart. Rectangles represent processing steps; ovals represent data repositories; rhomboids represent input and output; rectangles with wavy base represent data artifacts. There are two reference schemes (top-right of rectangles): spatial grid and road graph; both are georeferenced to allow for spatial joining. The temporal resolution is marked bottom-right on rectangles. Arrows represent data flow. Processing steps are labeled by `dp<N>` bottom left referring to the prefix of the corresponding Python script of the data pipeline (some processing steps are implemented in the same script, indicated by suffixes `a`/`b`).

*1) OpenStreetMap Data Download and Road Graph Construction (dp03):* The resulting graph is a primal (road junctions are vertices and road links are edges), non-planar, weighted multidigraph with self-loops and preserves one-way directionality [21], [22]. Formally, an edge is uniquely identified by a triplet $(u, v, g)$ where $u, v$ are node ids and where $g$ is a road geometry; we use OSM node IDs for $u, v$ and an integer hash of the road geometry for $g$.

In addition, we add the legal speed limit as an edge attribute. The source is the OSM `maxspeed` tag. Due to graph simplification, multiple such `maxspeed` values can be present per edge or can be missing. By default, we use the `OSMnx` implementation which assigns the mean of multiple values. In some cases (*e. g.* in Madrid) the `OSMnx` implementation sees parsing errors. Therefore, we also provide an alternative implementation that takes the max if multiple values are present. In the presence of missing values, the `OSMnx` implementation imputes the mean of the corresponding OSM highway type in the data, whereas our implementation uses hard-coded defaults for different OSM highway types.

Note that any other road graph present in this form could be used instead of a road graph downloaded from OSM.

*2) Spatial Intersection of Road Graph and City Cells (dp04):* This step generates lists of intersecting cells for each road segment in the corresponding Traffic Movie Grid. By interpolation over the edge geometries with a constant step size, we get a list of $(row, column, heading, fraction)$ where $(row, column, heading)$ denotes a directed cell and $fraction$ is the percentage of the length of the segment overlapping with this cell. The fraction can be zero as we add data from neighboring cells (up to a margin of $0.0005° \sim 5\,\mathrm{m}$ by default), and the sum of fractions in the intersecting cells can be larger than one as we add data from neighboring headings (margin of $10°$ by default); for edges going over the city boundary, the sum of fractions can also be smaller than one, obviously. See illustration in Figures 2–3. These fractions are currently not used in our pipeline, but they could used for a weighting the contributions of different intersecting cells.

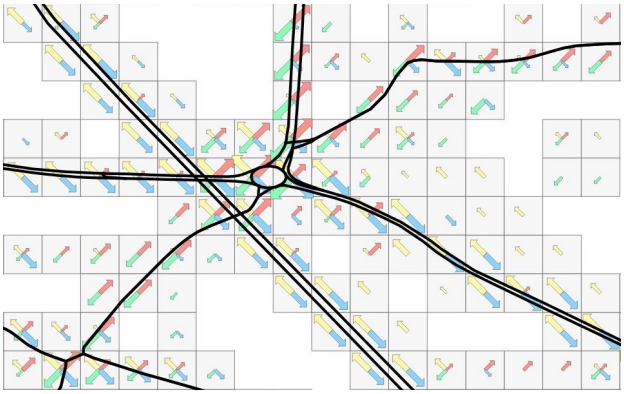


Fig. 2: Probe data and road network example from London. Black lines are the road centerline segments, grey boxes show grid cells with probe data, the sizes of the arrows correspond to the summed volumes of a sample day along the 4 headings, each heading with a different color. Only the data aligned with the road are mapped to the edge. There are some cells with data but without a road graph intersecting.

*3) Temporal Aggregation of HERE Traffic Map Movies (dp01):* By default, we aggregate 3 consecutive 5-minute movie time bins into 15-minute bins by summing volumes and taking the mean of speeds after invalidating speeds with zero volume.

*4) Confidence Filtering of Segment Speeds (dp06b) :* The confidence-based filtering $conff$ is given by

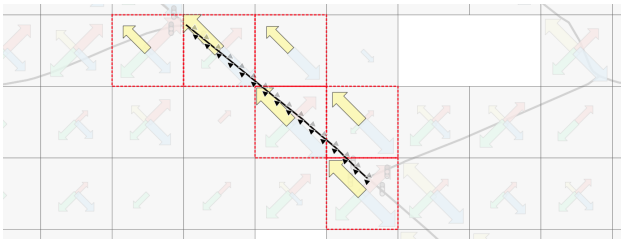
$$conff(ssp, vol, ff) = \begin{cases} \texttt{nan} & \text{if } vol < 5 \text{ or } cf < 0.4 \\ \texttt{nan} & \text{elif } vol < 3 \text{ or } cf < 0.8 \\ \texttt{nan} & \text{elif } vol < 1 \\ ssp & \text{else} \end{cases} \tag{5}$$

for median segment speed $ssp$, probe volume $vol$, free flow $ff$ (opt. normalized) and congestion factor

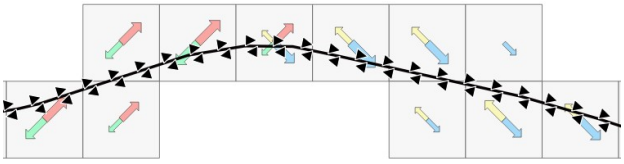
$$cf = \frac{ssp}{ff}. \tag{6}$$

In order not to need to keep the intermediate results, confidence filtering is implemented in the same script dp06 as the derivation of median speeds.

*5) Speed Clustering (dp02) and Free Flow speeds from Spatial Join and Quantile Selection (dp05):* Here, we describe



(a) Intersecting cells for one road segment in only one direction (bottom right to top left as indicated by the black arrow heads). The red boxes and yellow arrows in the foreground show the intersecting cells of this road segment. The data from non-intersecting cells of this road segment are greyed out – only the data along the NW heading are mapped on this road segment as the road segment is well aligned with the NW heading.



(b) Intersecting cells of both the two road segments going from left to right and from right to left (as indicated by the arrow heads in both directions). When the road is close to horizontal, data from NE and SE are used for the direction left to right while both NW and SW are used for right to left. When the road is close to the diagonal, there is only data from the corresponding headings. On the upper right, there is also one cell not intersecting with the road segment but within the 5m margin, so its data is mapped onto the corresponding direction of the edge as well. In this example, all data shown are mapped to either one of the two road segments.

Fig. 3: Intersecting cells example from London illustrating the mapping for individual roads.

the derivation of free flow speeds from the data. This step derives free-flow speeds for each road segment using the speeds clusters in the Traffic4cast Movie Grid data.

We compute the 5 most dominant speeds clusters for every cell and heading from the aggregated 15 minute traffic map movies. By default, all speed values from 20 days of data are clustered using the K-means clustering algorithm for every cell/heading combination (495x436x4≈860K). Hence, this process is computationally expensive and can easily take 2–3 hours per city on a standard consumer laptop. We then take the cluster median as the center representation of the speed clusters. More formally, for each directed cell, the output is a list of 5 pairs consisting of $(center, size)$, *i. e.* a $(495, 436, 4, 5, 2)$ tensor per city.

For each road segment, we start by merging the speed clusters from the intersecting cells by collecting all speed cluster medians from all the intersecting cells and sorting them. We then take as free flow the 80% percentile of these cluster medians based on the corresponding volumes; we default to 20 if there is no data; and we clip above to the signalized speed limit from OSM. More formally, for an edge with intersecting cells $intersecting\_cells$, speed limit $sl$ and for $cl(r, ch)$ denoting the 5 clusters (structures with attributes center and size) computed above, we derive its free flow speed as

$$center\left(q_{0.8,20}\Big(\bigcup_{\substack{(r,c,h)\in\\ intersecting\_cells}} cl(r,c,h), size\Big)\right)^{\top sl} \tag{7}$$

where $q_{v,d}(X, a)$ is the $v$ quantile of the set $X$ based on attribute $a$ defaulting to $d$ if $X = \emptyset$ and $(X)^{\top b} = \{\min(x, b) : x \in X\}$.

Optionally, we normalize free flow speed before computing the congestion factor. In normalization, we first use the signalized speed limit to make sure the free flow speed $ff$ is not below the signalized limit $sl$ from OSM and not above 60% of that speed limit:

$$\begin{cases} \max(\text{clip}(ff)_{20}^{sl}), 0.6 \cdot sl) & \text{if } sl \geq 5 \\ \max(\text{clip}(ff)_{20}), 0.6 \cdot sl) & \text{else} \end{cases} \tag{8}$$

where $\text{clip}(x)_l^u = \min(\max(x, l), u)$.

## Supplement B
## Analysis of Spot Binning under Idealized Conditions

Here, we give details on Spot Binning as introduced in Section IV-A1 of the main text. Consider the following idealized conditions. For vehicles $i$ in a bin $B$ and $r_i$ the number of their readings within $B$,

- $(i)$ all vehicles travel the same distance $s = s_i$
- $(ii)$ constant speed $v_{ij} = v_i$ for all readings $ij$ of vehicle $i$
- $(iii)$ vehicles not fully covering the distance negligible, *i. e.* for every vehicle not traveling the full distance $s_i$ within the temporal extension of $B$, there is another vehicle compensating with the same speed (not having left is compensated by another vehicle leaving). Technically, we have classes of vehicles $[i]$ merged together, so we can re-index vehicles $i$ (possibly partially covering the full distance within the temporal extension of $B$) to virtual vehicles $k$ going the full distance during the temporal extension of $B$, $v_k = v_{[i]} = v_i$) and $r_k = \sum_{ij:[i]=k} 1$.
- $(iv)$ same probe rate $R$, *i. e.* a vehicle with speed $v$ will have $r = c \cdot v^{-1}$ readings

Then,

$$speed_B = \frac{\sum_{ij} v_{ij}}{\sum_{ij} 1} \quad (9)$$

$$\overset{(ii)}{=} \frac{\sum_i r_i v_i}{\sum_i r_i} \quad (10)$$

$$\overset{(iii)}{\approx} \frac{\sum_k r_k v_k}{\sum_k r_k} \quad (11)$$

$$\overset{(iv)}{=} \frac{\sum_k \frac{c}{v_k} v_k}{\sum_k \frac{c}{v_k}} \quad (12)$$

$$= \frac{\sum_k 1}{\sum_k v_k^{-1}} \quad (13)$$

$$\overset{(i)}{=} \frac{\sum_k 1}{\sum_k \frac{t_k}{s}} \quad (14)$$

$$= \frac{s \cdot \sum_k 1}{\sum_k t_k} \quad (15)$$

Hence, under these assumptions, the spatio-temporally aggregated speed $speed_B$ represents the total distance divided by the total travel time as per Eq. (15), which is the harmonic sum of the speeds of Eq. (13). Assumption $(iii)$ depends on the temporal and spatial extension of bins and on the probe rate. Assumption $(i)$ of the same distance is satisfied if the binning comes from the same underlying road segment. The assumption $(ii)$ of constant speed can be relaxed as long as the probe rate represents the speed changes well and as long as the number of vehicles not fully counted in a bin is negligible (implying a trivial variant of $(iii)$). Condition $(iv)$ is hard to control in many settings; if vehicles do not have the same probe rate $(iv)$ or even a correlation between speed and probe rate, then this can have a substantial impact in low-flow situations. This analysis shows the importance to control homogeneity of probe rates, the probe frequency and the bin extensions in time and space, especially under low-flow conditions.

## Supplement C
## Complements on Validation

### A. Comparison with Uber Movement Speeds

*1) Historic Road Graph:* Uber matches their data to the OSM data of the time of collection [23], only storing the OSM node and way IDs of the segments without feature attributes like position. Therefore, we download the historic OSM data closest to the collection period and take OSM start node ID, end node ID, and OSM way ID from the Uber data and match it with the OSM data to construct the same structure as issuing from dp03 above. We then run our pipeline on this road graph. Notice that this road graph is potentially incomplete due to divergences between the OSM IDs in Uber and the OSM data snapshot; in addition, as this approach does not use the `OSMnx` road graph simplification, its segments are shorter in general. We refer to the Supplementary Material [24] for the key figures of the road graph properties and the *MeTS-10* speeds.

*2) Spatial and Temporal Coverage:* Figure 4 shows the difference in spatial temporal coverage between the Uber and *MeTS-10* datasets for London (color coded). Spatially, we see

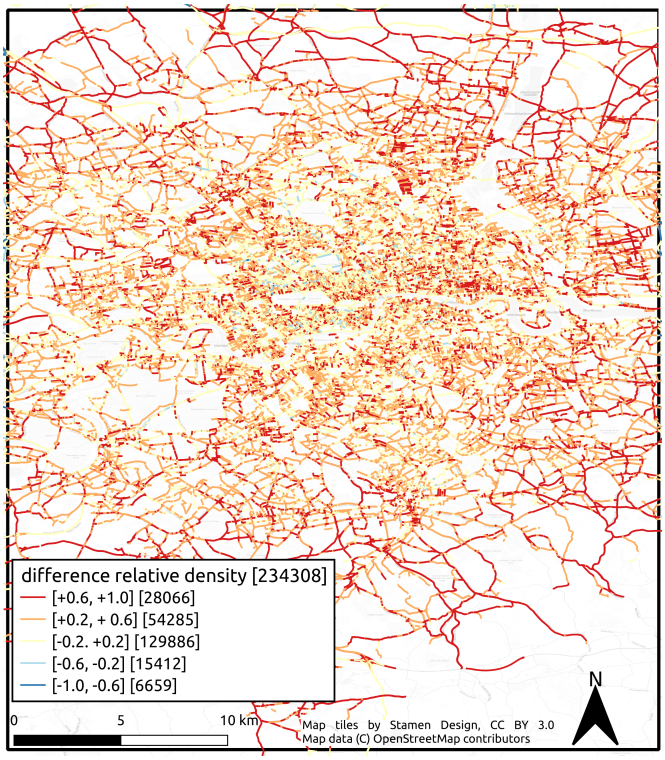



Fig. 4: Segment density differences of Uber and *MeTS-10* on the historic road graph London (8am–6pm). The color encoding shows the edge density difference, higher values mean higher temporal coverage of *MeTS-10*. In particular, the negative values outside of the bounding box are due only Uber having data there. The numbers of edges are shown in brackets.

that Uber has data outside of the *MeTS-10* bounding box, mainly including roads that lead to the airports outside of the city. Roughly speaking, we see similar temporal coverage in the city center (light yellow and light green colors), higher coverage of *MeTS-10* in the outer city areas, and negative values outside of the *Traffic4cast* bounding box.

Figure 5 shows a comparison of the temporal coverage of all three cities. It shows that temporal coverage in Barcelona and Berlin is in general higher in *MeTS-10* than in Uber. *MeTS-10* has high coverage for many segments in Berlin and low coverage for Uber. For London, many segments have similar temporal coverage, but also a considerable amount of segments with differences – slightly more segments with better coverage in *MeTS-10*. We refer to the Supplementary Material [24] for additional figures.

*3) Speed Differences:* We match the 1h Uber and *MeTS-10* segment speeds for one week of data in London, achieving a high number of samples that overlap spatio-temporally, namely 3.1 M data points. This corresponds to 77% of the 4.67 M data points for Uber within the bounding box, and to 47% of 6.63 M data points for *MeTS-10*; the higher absolute number of data points and the lower matching rate for *MeTS-10* is plausible in light of the previous paragraph. See Figure 6.

*a) Speed Differences: Qualitative Analysis:* Figure 7 shows the concentration of Uber and *MeTS-10* speeds along the diagonal. There are few cases with much higher *MeTS-10*

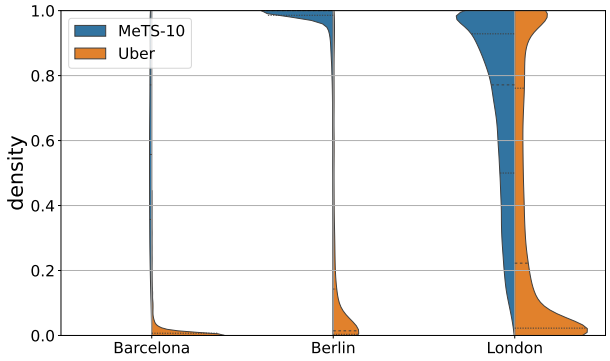



Fig. 5: Distribution of segment-wise temporal coverage of Uber and *MeTS-10* data for the 3 cities Barcelona, Berlin and London, bounding box only.

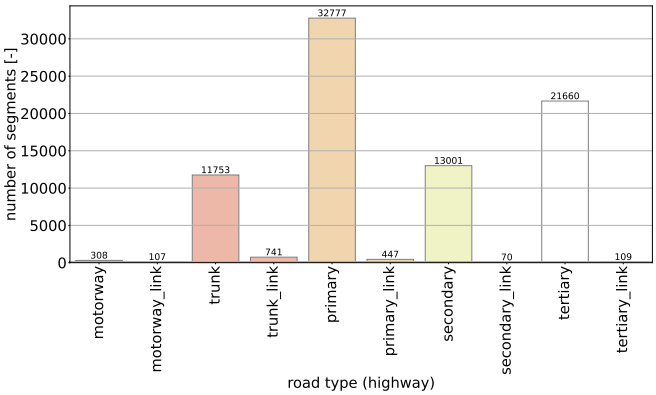



Fig. 6: Segment counts *MeTS-10* – Uber matched data.

speeds (bumps lower right) – inspection of examples shows that these tend to be due to high-speed GPS outliers above the signalized speed in low-flow situations which are not smoothed out by our median approach. On the other hand, there are many cases with *MeTS-10* close to zero and higher Uber speeds (bumps on the left) – here, an inspection of examples shows these tend to happen in junction situations, where spot binning of GPS probes from standing vehicles leads to much lower aggregated speed values compared to the per-vehicle mean speeds on the segment.

*b) Speed Differences: Quantitative Analysis:* The qualitative interpretation is confirmed by the quantitative analysis of Figure 8 and Figure 9: longer and non-link segments tend to have lower absolute percentage error comparing *MeTS-10* to Uber. We use absolute percentage error as used in the traffic simulation calibration literature [25]: in this context, a rule of thumbs asks for 85% of the counts measured in the simulation should deviate less than 15%.

*c) Speed Differences: Effect of Segment Length:* In order to also quantitatively assert the effect of segment length on APE, we further distinguish three ad-hoc sizes in Figure 9: S for segments up to 100 m, M for segments between 100 m and 500 m, and L for segments longer than 500 m. Apart from the link road types (with higher variance as discussed in Section V and low number of segments as per Figure 6), we see that longer segments tend to be better aligned with Uber

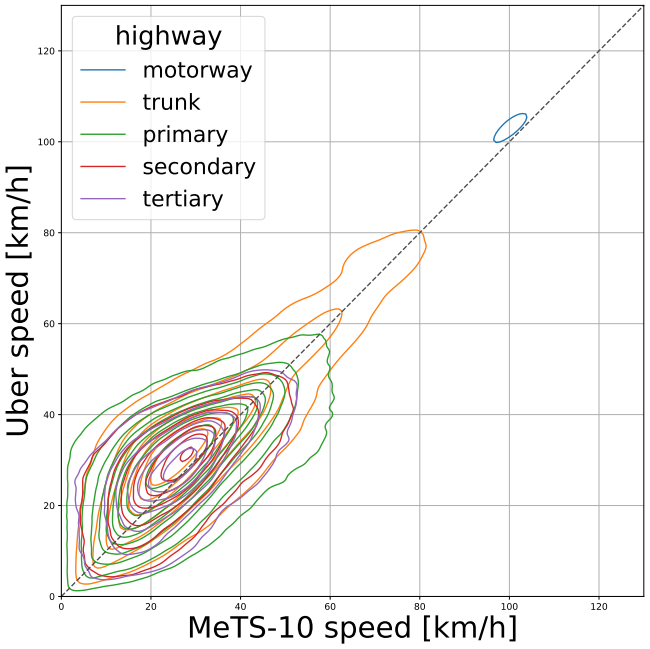



Fig. 7: Kernel density estimation of speeds of *MeTS-10* and Uber on the historic road graph London daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment, for the most important road types.

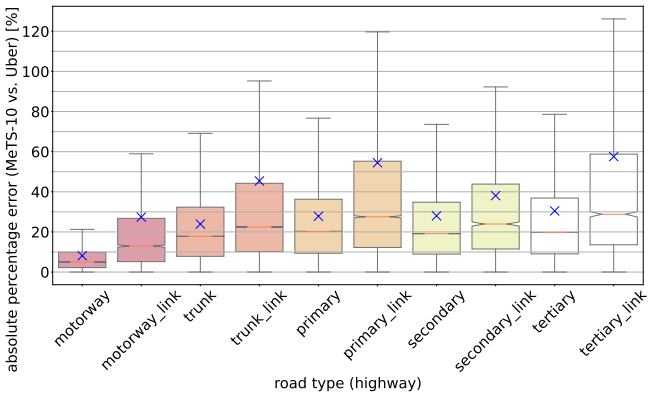



Fig. 8: London absolute percentage error *MeTS-10* vs. Uber by road type. Blue crosses indicate the mean per road type.

than shorter ones.

*d) Speed Differences: Effect of Road Segment Complexity:* In order to quantiatively assert the sensitivity to complex road situations, we differentiate between complex and non-complex road segments: we consider those road segments as complex which have at least one intersecting cell shared by at least 4 further road segments. The case of sharing with 1 further segment is trivial as this happens for every node not exactly at a cell border. See Figure 10 and Figure 11.

### B. Comparison with Stationary Vehicle Detector Data

The sensor locations were matched to the *MeTS-10* road graph in order to find the corresponding road segment. The

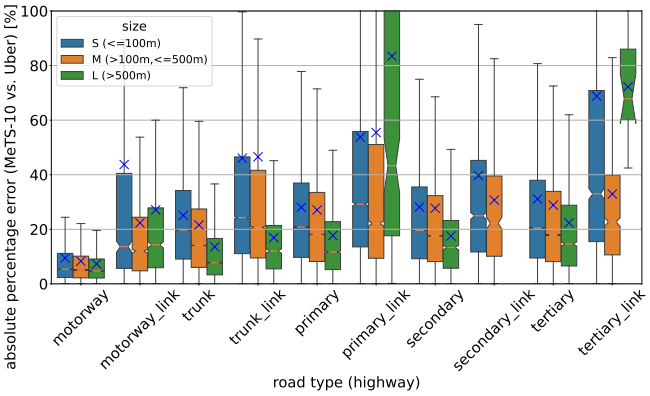



Fig. 9: London absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

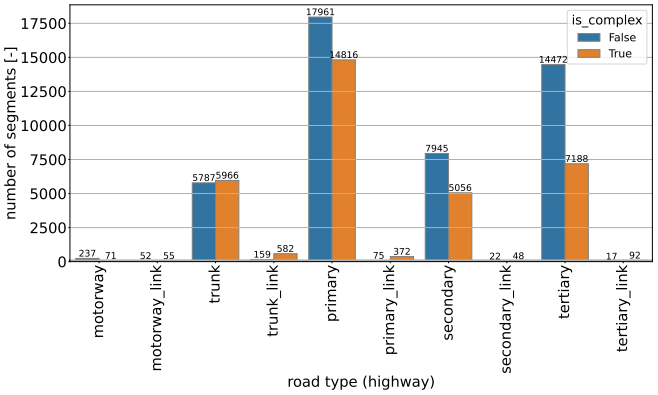
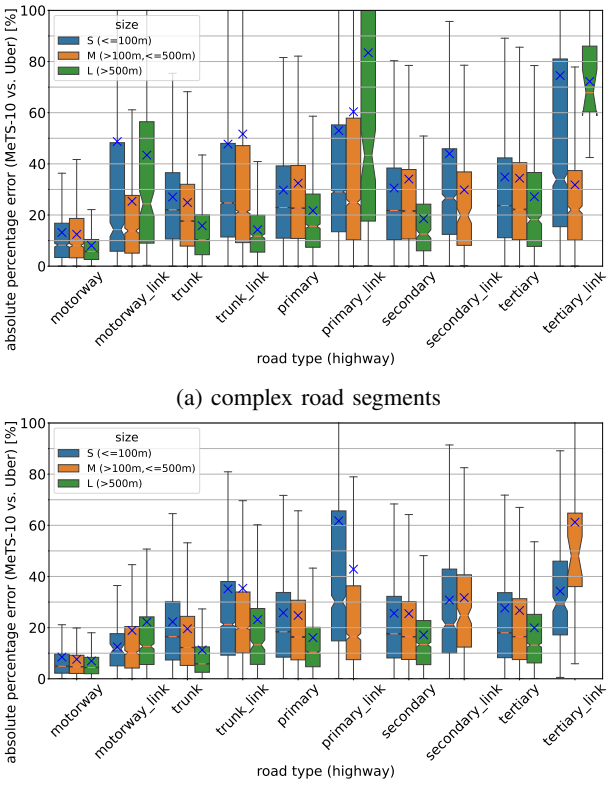



Fig. 10: Segment counts *MeTS-10* – Uber matched data.




(a) complex road segments

(b) non-complex road segments

Fig. 11: London absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

TABLE I: Percentage and absolute count of matched stationary vehicle detector with *MeTS-10* speed measurements by OpenStreetMap highway type [26]).

| | Berlin | | London | | Madrid | |
|---|---|---|---|---|---|---|
| motorway | 1 % | 4 | 95 % | 237 | 85 % | 345 |
| trunk | 1 % | 6 | 5 % | 12 | 5 % | 21 |
| primary | 41 % | 218 | | | 4 % | 16 |
| secondary | 52 % | 280 | | | | |
| tertiary | 4 % | 22 | | | 1 % | 4 |
| other | 1 % | 8 | | | 4 % | 18 |

matching logic uses the distance as well as, if provided, the heading angle and/or the name of the segment for determining the best match.

The spatial distribution of the speed sensors can be seen in Figure 12. These different distributions are also clearly visible in the differences in covered highway types in Table I. In Berlin, sensors cover the whole city with the majority of them located on primary and secondary roads. In contrast, in London and Madrid, speed sensors are mostly located on motorways and trunks. In London, these motorways are only located on the outskirts of the city where roads have fewer tunnels and overall higher speeds. In Madrid, the available speed counter data is mostly for motorways of the inner-city ring road, where we see more significant speed limits and other effects of traffic control. We consider sensors on motorways that are not disturbed by traffic lights or other effects to be close to real ground truth values. This ignores the quality of the sensor, malfunctioning sensors, and potential temporal aggregation effects.

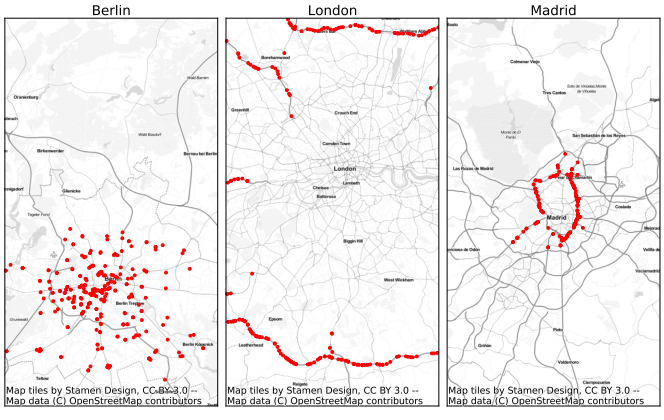



Fig. 12: Distribution of Vehicle Detectors with speed measurement in the corresponding *MeTS-10* bounding boxes.

Erroneous sensor readings were filtered before comparing the speed measurements. There were two main sources of erroneous readings: a) values at night due to maintenance

TABLE II: Percentage and absolute count (matched/total) of stationary vehicle detector with Uber Movement Speeds by OpenStreetMap highway type [26]).

| | Berlin | | London | |
|---|---|---|---|---|
| motorway | 1 % | 4 | 95 % | 210/237 |
| trunk | | 0/6 | 5 % | 11/12 |
| primary | 41 % | 192/218 | | |
| secondary | 53 % | 249/280 | | |
| tertiary | 4 % | 19/22 | | |
| other | 1 % | 3 | | |

or impaired averaging when no speed was detected in the measurement interval. Hence, we only looked at readings between 6 am and 11 pm. b) readings in situations where GPS signals are disturbed, such as tunnels. Hence, sensors in tunnels were filtered out as well. For more details on the pre-processing, see our code base referenced in *Data and Code Availability* below.

### C. Baseline comparison of Uber Movement Speeds with Stationary Vehicle Detector Data

As a baseline of the used validation datasets we compare here the Uber Movement Speeds with the speed readings from the Stationary Vehicle Detectors. This was done for Berlin and London were we had overlapping time ranges for the comparison.

The same matching procedure was used as for the comparison of the *MeTS-10* speeds with the stationary vehicle detectors. Table II shows the statistics of the used vehicle detectors with matching Uber speeds. Uber coverage is lower, hence compared to MeTS-10 (see also Table I) less counters did have a corresponding Uber speed on the associated street segment.

Figure 13 shows the Binned Kernel Distribution Estimation (KDE) Plots of Uber and the detectors as well as box plots of the speed differences between Uber Movement Speeds and vehicle detector speeds.

In both cities we see a good alignment with the majority of the points along the diagonals in the KDE plots. The shapes of the plots are very similar to the KDE plots in the comparison between *MeTS-10* and the detectors. Hence, also here we see the differences in sensor placement on predominantly inner city roads (Berlin) vs mostly motorways (London) as shown in Table II. In the box plots by highway type we can see a very good alignment for this higher class highway types in London as well as for the lower class highway types in Berlin.

## Supplement D
## Complements on Discussion

### A. Complements Spatial Intersection (dp04)

In Table III, we contrast edges whose geometry is along the N/E/S/W axis (horizontal/diagonal $\pm 10°$) or along the NE/SE/SW/NE (diagonal $\pm 10°$). We sample 10 days of speed data. We see that the coverage along the diagonal is slightly lower. This is plausible in light of the horizontal/diagonal edges getting values from two headings.

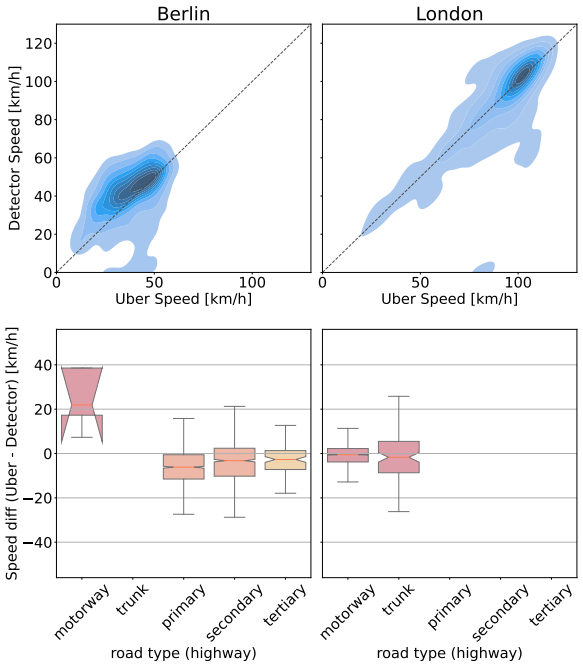



Fig. 13: Comparisons of Uber Movement Speeds and vehicle detector speeds. Top: Binned Kernel Distribution Estimation Plots of speeds; Bottom: Box plots of speed differences by highway type (OSM carto color scheme)

## Supplement E
## Extended Dataset Overview

Referring to Table IV, the dataset comprises 10 cities with data from 108 up to 361 days publicly available: **t4c year** is the competition year which the was published for by HERE (relevant for download); **days** is the number of full days of data (288 5 minute bins of full bounding box each); **date ranges** are the corresponding date ranges – in the 2022 competition, every second week in the date range was held back for tests in the competition, so there is not a consecutive range of dates available; *Traffic4cast* bounding box is given by **lat_min**,**lat_max**,**lon_min**,**lon_max**; number of **nodes** and **edges** in the road graph; **total segment length** is the sum of all lengths of all directed edges; **ratio covered edges** is the ratio of edges in the road graph with at least one speed value (from 20 sampled days); **mapped ratio** is the ratio of GPS probes mapped to the road graph; **daily fcd volume** is the daily GPS probe volume sum (from 20 sampled days); **8–18 coverage** is the ratio of edges with speed values between 8am and 6pm (from 20 sampled days); **mean segment volume** is mean volume sum of all intersecting cells for segments with speed value (from 20 sample days).

TABLE III: Coverage for segments along the diagonals vs. segments along the horizontal/vertical axes.

| city (year) | #edges | #N/E/S/W | #NE/SE/SW/NW | coverage | coverage N/E/S/W | coverage NE/SE/SW/NW | difference |
|---|---|---|---|---|---|---|---|
| Antwerp (2021) | 81667 | 17349 (21.2%) | 21443 (26.3%) | 0.13 | 0.16 | 0.11 | +0.03 |
| Bangkok (2021) | 694818 | 201316 (29.0%) | 91609 (13.2%) | 0.03 | 0.04 | 0.03 | +0.00 |
| Barcelona (2021) | 118813 | 22003 (18.5%) | 34724 (29.2%) | 0.06 | 0.07 | 0.06 | +0.01 |
| Berlin (2021) | 88882 | 20875 (23.5%) | 19940 (22.4%) | 0.29 | 0.37 | 0.29 | +0.08 |
| Chicago (2021) | 187570 | 118970 (63.4%) | 9399 (5.0%) | 0.07 | 0.07 | 0.10 | -0.00 |
| Istanbul (2021) | 270109 | 61255 (22.7%) | 61564 (22.8%) | 0.52 | 0.61 | 0.48 | +0.09 |
| Melbourne (2021) | 230654 | 103833 (45.0%) | 31915 (13.8%) | 0.05 | 0.05 | 0.04 | +0.00 |
| Moscow (2021) | 47877 | 10177 (21.3%) | 13259 (27.7%) | 0.69 | 0.71 | 0.67 | +0.03 |
| London (2022) | 271075 | 59654 (22.0%) | 65380 (24.1%) | 0.15 | 0.19 | 0.15 | +0.04 |
| Madrid (2022) | 143402 | 32018 (22.3%) | 35551 (24.8%) | 0.33 | 0.39 | 0.32 | +0.06 |
| Melbourne (2022) | 230654 | 103833 (45.0%) | 31915 (13.8%) | 0.05 | 0.06 | 0.04 | +0.01 |

TABLE IV: Extended dataset overview.

| city (t4c year) | days | date ranges | lat_min, lat_max, lon_min, lon_max | nodes | edges | total segment length [m] | mean segment length [m] | ratio covered edges | mapped ratio | daily fcd data | 8–18 cover-age | mean segment volume |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Antwerp (2021) | 361 | 2019-01–2019-06, 2020-01–2020-06 | (51.001, 51.437, 4.153, 4.648) | 34722 | 81667 | 13833313.7 | 169.4 | 0.99 | 0.89 | 3.247e+06 | 0.17 | 7.10 |
| Bangkok (2021) | 361 | 2019-01–2019-06, 2020-01–2020-06 | (13.554, 14.049, 100.308, 100.744) | 317797 | 694818 | 58792833.8 | 84.6 | 0.76 | 0.91 | 4.576e+06 | 0.05 | 7.50 |
| Barcelona (2021) | 361 | 2019-01–2019-06, 2020-01–2020-06 | (41.253, 41.748, 1.925, 2.361) | 58106 | 118813 | 14081313.2 | 118.5 | 0.97 | 0.81 | 1.811e+06 | 0.09 | 6.24 |
| Berlin (2021) | 180 | 2019-01–2019-06 | (52.359, 52.854, 13.189, 13.625) | 34308 | 88882 | 14045121.9 | 158.0 | 1.00 | 0.94 | 6.270e+07 | 0.36 | 57.31 |
| Chicago (2021) | 180 | 2019-01–2019-06 | (41.601, 42.096, -87.945, -87.509) | 68430 | 187570 | 27117716.0 | 144.6 | 0.98 | 0.93 | 4.684e+06 | 0.11 | 9.82 |
| Istanbul (2021) | 180 | 2019-01–2019-06 | (40.81, 41.305, 28.794, 29.23) | 102754 | 270109 | 22126616.3 | 81.9 | 1.00 | 0.96 | 7.065e+07 | 0.63 | 24.53 |
| Melbourne (2021) | 180 | 2019-01–2019-06 | (-38.106, -37.611, 144.757, 145.193) | 103062 | 230654 | 24277388.0 | 105.3 | 0.95 | 0.93 | 2.519e+06 | 0.08 | 5.56 |
| Moscow (2021) | 361 | 2019-01–2019-06, 2020-01–2020-06 | (55.506, 55.942, 37.358, 37.853) | 22627 | 47877 | 10906823.2 | 227.8 | 1.00 | 0.81 | 7.292e+07 | 0.71 | 46.88 |
| London (2022) | 110 | 2019-07–2019-12, 2020-01 | (51.205, 51.7, -0.369, 0.067) | 116304 | 271075 | 26738400.4 | 98.6 | 0.99 | 0.95 | 1.119e+07 | 0.24 | 8.15 |
| Madrid (2022) | 109 | 2021-06–2021-12 | (40.177, 40.672, -3.927, -3.491) | 71757 | 143402 | 15799502.4 | 110.2 | 0.99 | 0.93 | 2.977e+07 | 0.36 | 22.05 |
| Melbourne (2022) | 108 | 2020-06–2020-12 | (-38.106, -37.611, 144.757, 145.193) | 103062 | 230654 | 24277388.0 | 105.3 | 0.95 | 0.90 | 2.086e+06 | 0.08 | 4.52 |

## SUPPLEMENT F
## KEY FIGURES

When a city has appeared in multiple competition years, we add the competition year for data download. The code to reproduce the figures, as well as additional figures can be found in our code repository.

## A. Key Figures Antwerp (2021)

### 1) Road graph map Antwerp (2021):

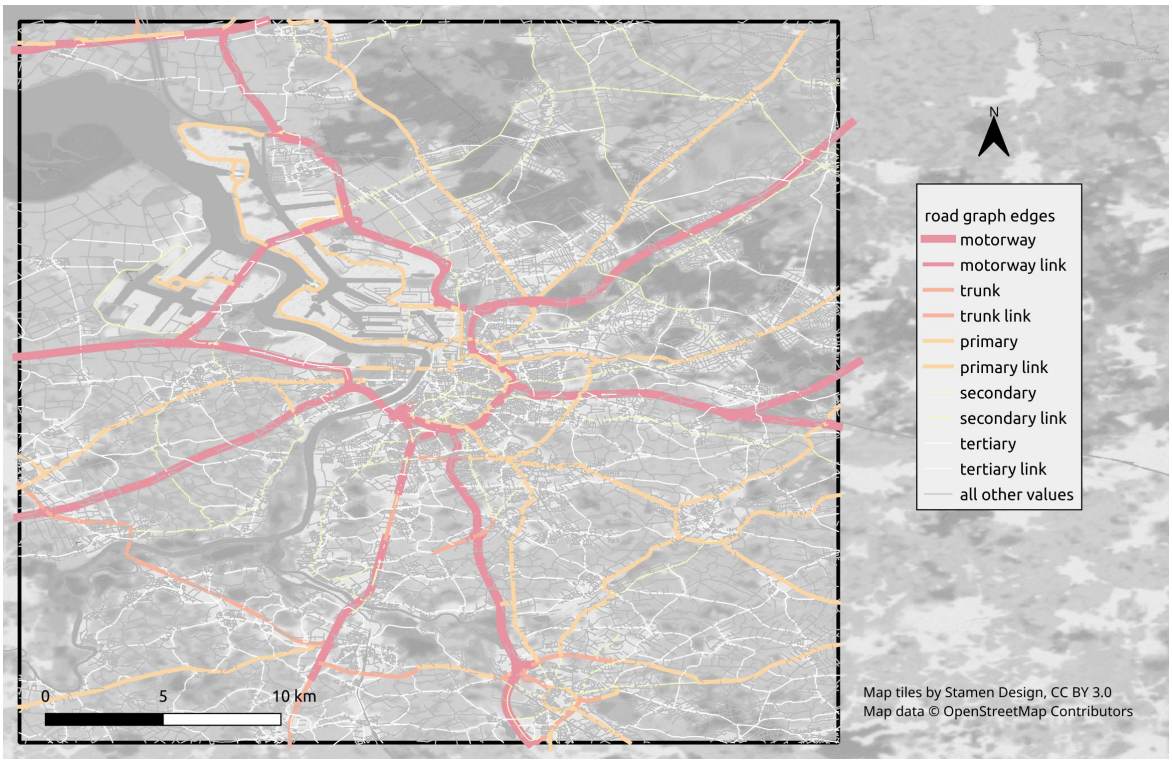



Fig. 14: Road graph Antwerp, OSM color scheme (2021).

### 2) Static data Antwerp (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 4.153–4.648 / 51.001–51.437 | |
| num_edges | | | | | | 81'667 | |
| motorway | | | | | | 232 | |
| motorway_link | | | | | | 483 | |
| trunk | | | | | | 274 | |
| trunk_link | | | | | | 67 | |
| primary | | | | | | 2798 | |
| primary_link | | | | | | 152 | |
| secondary | | | | | | 3348 | |
| secondary_link | | | | | | 69 | |
| tertiary | | | | | | 10929 | |
| tertiary_link | | | | | | 42 | |
| unclassified | | | | | | 11700 | |
| residential | | | | | | 51573 | |
| num_nodes | | | | | | 34722 | |
| num_edges_per_cell | 1.0 | 0.2 | 1.0 | 1.0 | 2.0 | 385'170 | |
| num_intersecting_cells | 4.9 | 5.1 | 4.0 | 1.0 | 25.0 | 81'667 | |
| node_degree | 2.7 | 0.9 | 3.0 | 1.0 | 4.0 | 34'722 | |
| length_meters | 169.4 | 240.4 | 100.8 | 6.6 | 1'113.6 | 81'667 | 1.4e+07 |
| motorway | 1'496.8 | 1'426.3 | 954.9 | 93.1 | 6'717.8 | 232 | 3.5e+05 |
| motorway_link | 313.5 | 330.0 | 218.0 | 11.0 | 1'684.1 | 483 | 1.5e+05 |
| trunk | 370.6 | 468.1 | 184.0 | 7.6 | 2'112.0 | 274 | 1.0e+05 |
| trunk_link | 162.4 | 156.1 | 121.7 | 15.4 | 646.1 | 67 | 1.1e+04 |
| primary | 201.6 | 273.3 | 106.4 | 5.4 | 1'393.4 | 2'798 | 5.6e+05 |
| primary_link | 49.6 | 66.0 | 24.4 | 4.1 | 288.3 | 152 | 7.5e+03 |
| secondary | 171.1 | 246.4 | 95.5 | 5.5 | 1'142.0 | 3'348 | 5.7e+05 |
| secondary_link | 63.1 | 69.7 | 42.6 | 6.7 | 300.2 | 69 | 4.4e+03 |
| tertiary | 176.7 | 237.1 | 103.4 | 5.4 | 1'116.8 | 10'929 | 1.9e+06 |
| tertiary_link | 52.2 | 42.7 | 39.7 | 15.8 | 207.5 | 42 | 2.2e+03 |
| unclassified | 299.4 | 348.2 | 184.3 | 7.2 | 1'541.1 | 11'700 | 3.5e+06 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| residential | 128.7 | 137.1 | 92.4 | 6.9 | 650.5 | 51’573 | 6.6e+06 |
| speed_kph | 42.0 | 12.0 | 36.3 | 30.0 | 80.0 | 81’667 | |
| motorway | 109.2 | 15.9 | 120.0 | 50.0 | 120.0 | 232 | |
| motorway_link | 82.6 | 16.6 | 81.4 | 50.0 | 120.0 | 483 | |
| trunk | 77.9 | 14.4 | 70.0 | 50.0 | 120.0 | 274 | |
| trunk_link | 61.5 | 9.0 | 61.2 | 50.0 | 90.0 | 67 | |
| primary | 61.7 | 11.0 | 66.5 | 30.0 | 80.0 | 2’798 | |
| primary_link | 55.5 | 5.7 | 55.5 | 50.0 | 70.0 | 152 | |
| secondary | 56.0 | 9.4 | 50.0 | 30.0 | 70.0 | 3’348 | |
| secondary_link | 58.4 | 7.9 | 59.2 | 43.6 | 76.4 | 69 | |
| tertiary | 49.6 | 9.7 | 50.0 | 30.0 | 70.0 | 10’929 | |
| tertiary_link | 49.7 | 7.0 | 48.9 | 30.0 | 70.0 | 42 | |
| unclassified | 48.1 | 6.6 | 48.2 | 30.0 | 70.0 | 11’700 | |
| residential | 36.1 | 6.8 | 36.3 | 30.0 | 50.0 | 51’573 | |
| free_flow_kph | 38.9 | 18.0 | 35.8 | 5.6 | 116.7 | 77’109 | |
| motorway | 109.6 | 12.9 | 117.1 | 71.5 | 120.0 | 232 | |
| motorway_link | 87.4 | 28.5 | 93.9 | 26.3 | 120.0 | 483 | |
| trunk | 66.5 | 22.9 | 65.2 | 23.3 | 120.0 | 272 | |
| trunk_link | 74.1 | 25.1 | 74.6 | 27.1 | 120.0 | 67 | |
| primary | 52.2 | 16.3 | 50.5 | 24.0 | 95.8 | 2’798 | |
| primary_link | 41.4 | 23.1 | 36.8 | 7.4 | 92.0 | 148 | |
| secondary | 49.4 | 16.8 | 46.6 | 20.7 | 108.8 | 3’344 | |
| secondary_link | 53.8 | 31.4 | 41.8 | 13.6 | 118.4 | 68 | |
| tertiary | 46.0 | 15.5 | 43.8 | 19.8 | 104.0 | 10’915 | |
| tertiary_link | 43.9 | 18.6 | 41.2 | 21.1 | 95.0 | 42 | |
| unclassified | 44.1 | 21.7 | 41.9 | 3.5 | 119.5 | 10’392 | |
| residential | 33.6 | 13.9 | 32.0 | 3.3 | 80.0 | 48’348 | |
| free_flow_kph-speed_kph | -3.3 | 15.8 | -3.9 | -36.6 | 53.6 | 77’109 | |
| motorway | 0.4 | 11.9 | -1.4 | -25.2 | 42.8 | 232 | |
| motorway_link | 4.9 | 28.8 | 6.8 | -55.6 | 62.1 | 483 | |
| trunk | -11.5 | 19.8 | -7.2 | -57.4 | 30.5 | 272 | |
| trunk_link | 12.6 | 24.8 | 10.8 | -34.1 | 70.0 | 67 | |
| primary | -9.5 | 14.5 | -7.9 | -44.3 | 23.9 | 2’798 | |
| primary_link | -14.1 | 23.7 | -15.5 | -55.7 | 38.9 | 148 | |
| secondary | -6.7 | 16.1 | -7.2 | -39.3 | 48.9 | 3’344 | |
| secondary_link | -4.6 | 30.2 | -17.6 | -45.6 | 58.4 | 68 | |
| tertiary | -3.6 | 14.2 | -3.9 | -32.4 | 48.6 | 10’915 | |
| tertiary_link | -5.9 | 20.2 | -7.7 | -37.1 | 46.1 | 42 | |
| unclassified | -4.0 | 21.6 | -6.1 | -45.4 | 71.1 | 10’392 | |
| residential | -2.5 | 14.1 | -3.2 | -33.1 | 42.3 | 48’348 | |

TABLE V: Key figures Antwerp for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Antwerp (2021):*

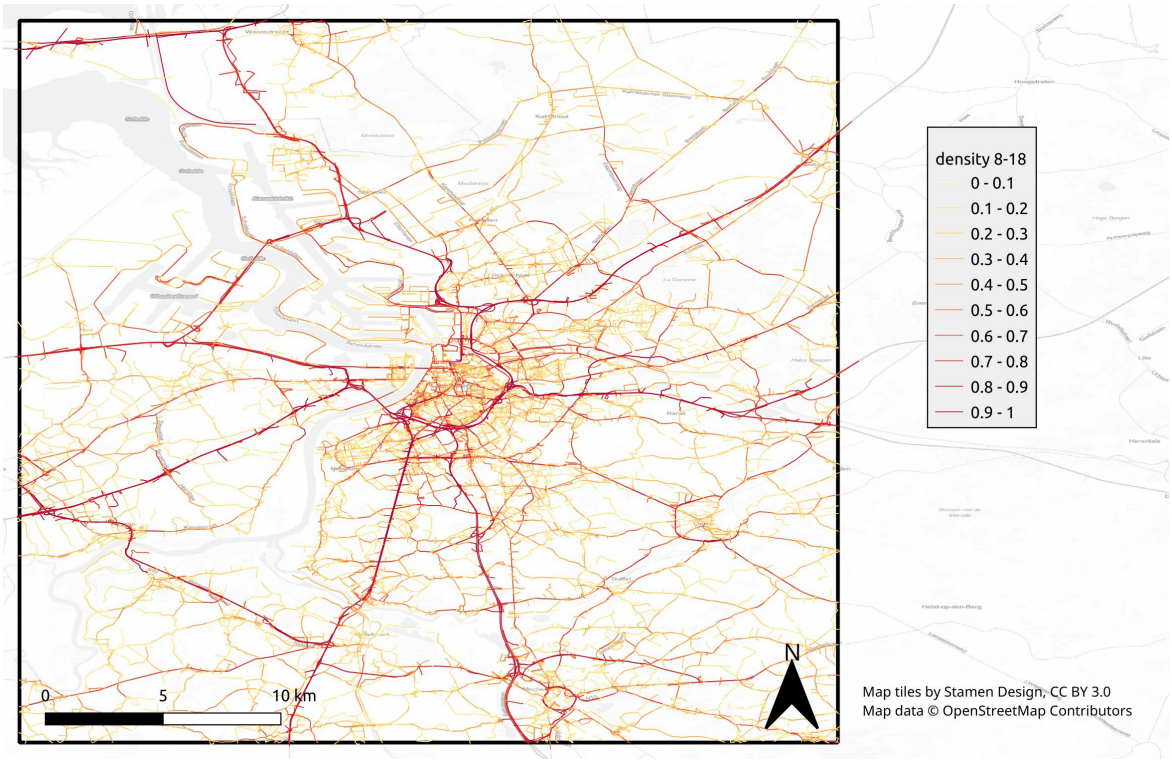



Fig. 15: Segment-wise density 8am–6pm Antwerp from 20 randomly sampled days.

*4) Daily density profile Antwerp (2021) :*

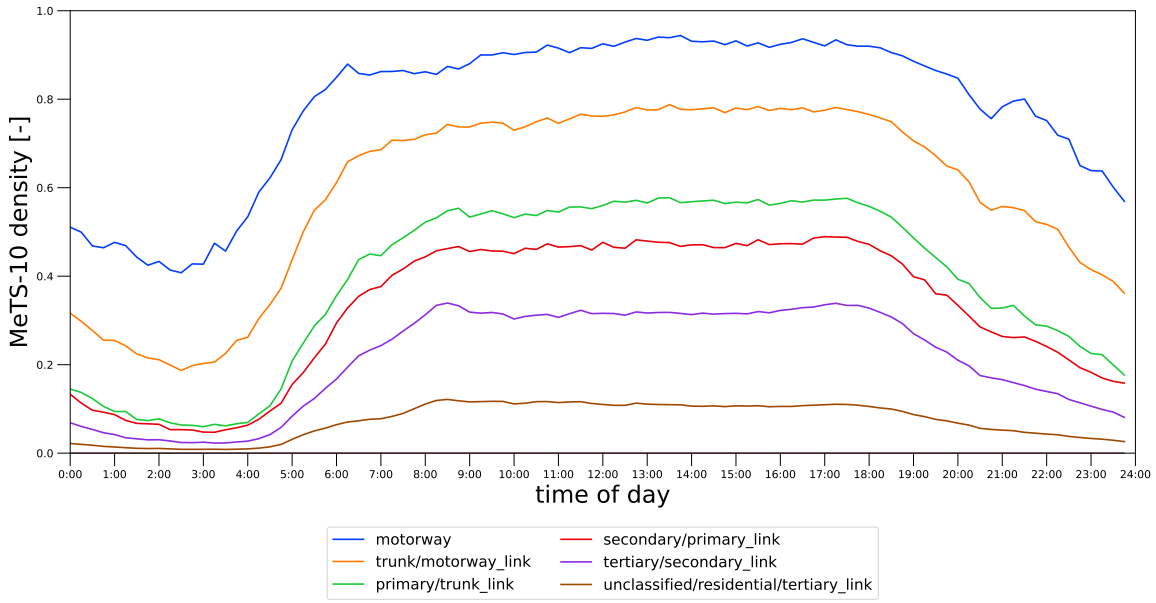



Fig. 16: Daily density profile for different road types for Antwerp . Data from 20 randomly sampled days.

*5) Daily speed profile Antwerp (2021) :*

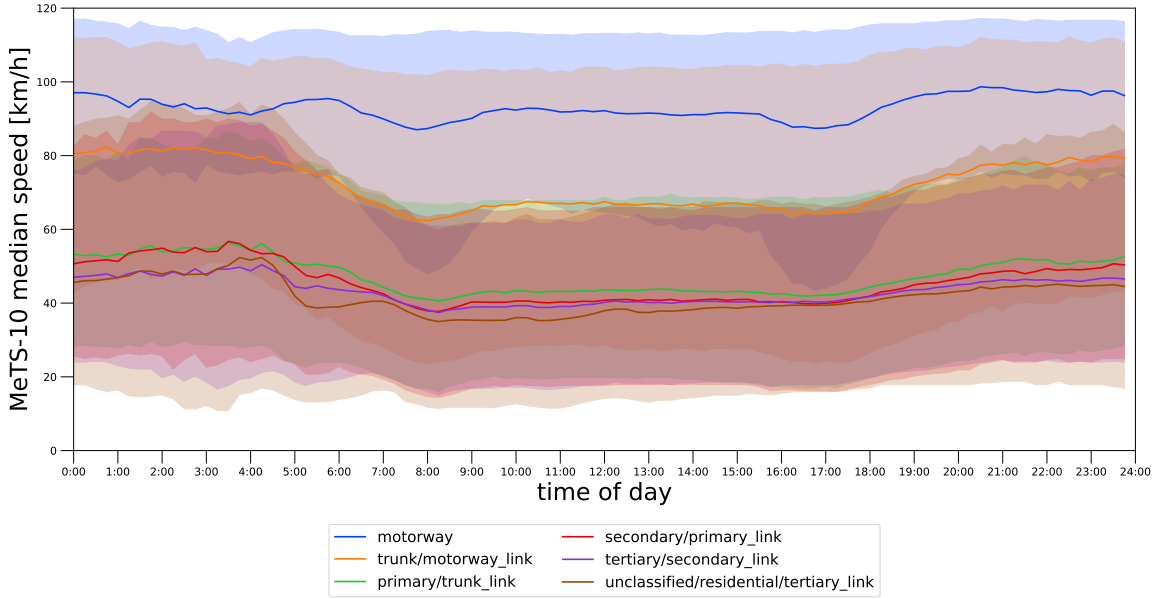



Fig. 17: Daily median 15 min speeds of all intersecting cells profile for different road types for Antwerp . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

## B. Key Figures Bangkok (2021)

### 1) Road graph map Bangkok (2021):


Fig. 18: Road graph Bangkok, OSM color scheme (2021).

### 2) Static data Bangkok (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 100.308–100.744 / 13.554–14.049 | |
| num_edges | | | | | | 694’818 | |
| motorway | | | | | | 378 | |
| motorway_link | | | | | | 878 | |
| trunk | | | | | | 1579 | |
| trunk_link | | | | | | 682 | |
| primary | | | | | | 7160 | |
| primary_link | | | | | | 1974 | |
| secondary | | | | | | 15319 | |
| secondary_link | | | | | | 1510 | |
| tertiary | | | | | | 25096 | |
| tertiary_link | | | | | | 342 | |
| unclassified | | | | | | 16290 | |
| residential | | | | | | 623610 | |
| num_nodes | | | | | | 317797 | |
| num_edges_per_cell | 1.2 | 0.7 | 1.0 | 1.0 | 5.0 | 1’827’614 | |
| num_intersecting_cells | 3.1 | 2.5 | 2.0 | 1.0 | 12.0 | 694’818 | |
| node_degree | 2.3 | 1.1 | 3.0 | 1.0 | 4.0 | 317’797 | |
| length_meters | 84.6 | 118.3 | 49.6 | 5.2 | 538.4 | 694’818 | 5.9e+07 |
| motorway | 1’443.2 | 1’511.9 | 961.7 | 36.7 | 7’006.2 | 378 | 5.5e+05 |
| motorway_link | 366.4 | 357.8 | 297.5 | 9.2 | 1’518.2 | 878 | 3.2e+05 |
| trunk | 299.6 | 439.6 | 115.9 | 6.4 | 2’025.4 | 1’579 | 4.7e+05 |
| trunk_link | 138.9 | 189.5 | 76.1 | 11.1 | 914.0 | 682 | 9.5e+04 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 159.8 | 263.3 | 78.3 | 5.1 | 1’190.7 | 7’160 | 1.1e+06 |
| primary_link | 112.9 | 202.2 | 52.6 | 6.6 | 864.2 | 1’974 | 2.2e+05 |
| secondary | 107.7 | 148.3 | 59.3 | 4.0 | 773.0 | 15’319 | 1.6e+06 |
| secondary_link | 111.4 | 178.4 | 45.2 | 6.5 | 837.9 | 1’510 | 1.7e+05 |
| tertiary | 87.9 | 125.2 | 49.5 | 3.5 | 635.1 | 25’096 | 2.2e+06 |
| tertiary_link | 57.2 | 121.8 | 14.8 | 4.9 | 752.7 | 342 | 2.0e+04 |
| unclassified | 124.7 | 175.4 | 63.6 | 3.7 | 877.5 | 16’290 | 2.0e+06 |
| residential | 80.0 | 95.0 | 49.0 | 5.5 | 463.3 | 623’610 | 5.0e+07 |
| speed_kph | 31.8 | 7.5 | 29.7 | 29.7 | 67.0 | 694’818 | |
| motorway | 108.3 | 10.6 | 109.0 | 40.6 | 120.0 | 378 | |
| motorway_link | 40.6 | 0.0 | 40.6 | 40.6 | 40.6 | 878 | |
| trunk | 54.9 | 1.4 | 54.9 | 54.9 | 54.9 | 1’579 | |
| trunk_link | 54.9 | 0.0 | 54.9 | 54.9 | 54.9 | 682 | |
| primary | 62.8 | 2.3 | 62.9 | 50.0 | 62.9 | 7’160 | |
| primary_link | 43.8 | 1.4 | 43.8 | 43.8 | 43.8 | 1’974 | |
| secondary | 67.0 | 2.1 | 67.0 | 67.0 | 67.0 | 15’319 | |
| secondary_link | 54.9 | 0.8 | 54.9 | 54.9 | 54.9 | 1’510 | |
| tertiary | 36.4 | 1.9 | 36.4 | 30.0 | 36.4 | 25’096 | |
| tertiary_link | 54.9 | 0.0 | 54.9 | 54.9 | 54.9 | 342 | |
| unclassified | 49.7 | 1.6 | 49.7 | 49.7 | 49.7 | 16’290 | |
| residential | 29.7 | 0.6 | 29.7 | 29.7 | 29.7 | 623’610 | |
| free_flow_kph | 34.9 | 24.3 | 29.6 | 0.0 | 120.0 | 350’957 | |
| motorway | 83.3 | 17.3 | 81.5 | 37.8 | 120.0 | 378 | |
| motorway_link | 74.4 | 21.3 | 77.4 | 16.9 | 120.0 | 877 | |
| trunk | 57.1 | 16.0 | 53.6 | 28.5 | 91.3 | 1’579 | |
| trunk_link | 63.6 | 19.9 | 68.7 | 9.3 | 93.6 | 682 | |
| primary | 54.5 | 17.6 | 51.8 | 19.8 | 89.9 | 7’156 | |
| primary_link | 58.5 | 22.3 | 60.2 | 8.5 | 93.3 | 1’965 | |
| secondary | 54.1 | 20.1 | 50.8 | 18.8 | 100.6 | 15’314 | |
| secondary_link | 59.0 | 22.4 | 60.7 | 8.5 | 96.9 | 1’507 | |
| tertiary | 44.3 | 19.9 | 40.0 | 15.6 | 120.0 | 24’594 | |
| tertiary_link | 50.9 | 21.8 | 49.2 | 10.7 | 96.9 | 327 | |
| unclassified | 41.8 | 20.9 | 37.6 | 5.6 | 120.0 | 13’506 | |
| residential | 31.5 | 23.7 | 26.4 | 0.0 | 119.1 | 283’072 | |
| free_flow_kph-speed_kph | 1.2 | 23.5 | -3.3 | -34.1 | 83.6 | 350’957 | |
| motorway | -25.0 | 20.7 | -28.1 | -71.2 | 37.4 | 378 | |
| motorway_link | 33.8 | 21.3 | 36.8 | -23.7 | 79.4 | 877 | |
| trunk | 2.2 | 16.1 | -1.3 | -26.5 | 36.4 | 1’579 | |
| trunk_link | 8.7 | 19.9 | 13.8 | -45.6 | 38.7 | 682 | |
| primary | -8.3 | 17.4 | -11.1 | -43.1 | 27.0 | 7’156 | |
| primary_link | 14.7 | 22.3 | 16.4 | -35.3 | 49.5 | 1’965 | |
| secondary | -12.9 | 20.2 | -16.4 | -48.2 | 40.0 | 15’314 | |
| secondary_link | 4.0 | 22.4 | 5.8 | -46.4 | 42.0 | 1’507 | |
| tertiary | 7.9 | 19.8 | 3.6 | -20.9 | 83.6 | 24’594 | |
| tertiary_link | -4.0 | 21.8 | -5.7 | -44.2 | 42.0 | 327 | |
| unclassified | -7.9 | 20.9 | -12.1 | -44.1 | 70.3 | 13’506 | |
| residential | 1.8 | 23.7 | -3.3 | -29.7 | 89.4 | 283’072 | |

TABLE VI: Key figures Bangkok for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Bangkok (2021):*

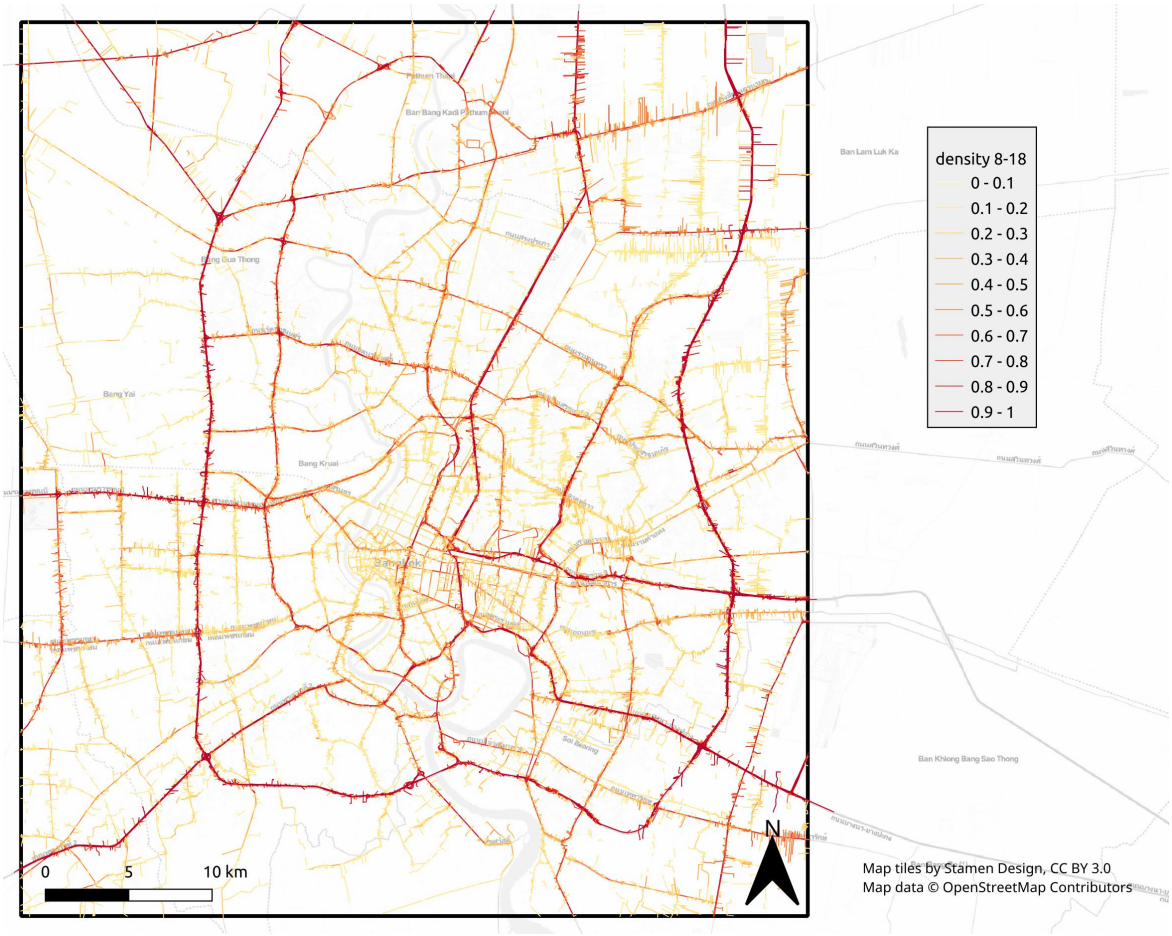



Fig. 19: Segment-wise density 8am–6pm Bangkok from 20 randomly sampled days.

*4) Daily density profile Bangkok (2021) :*

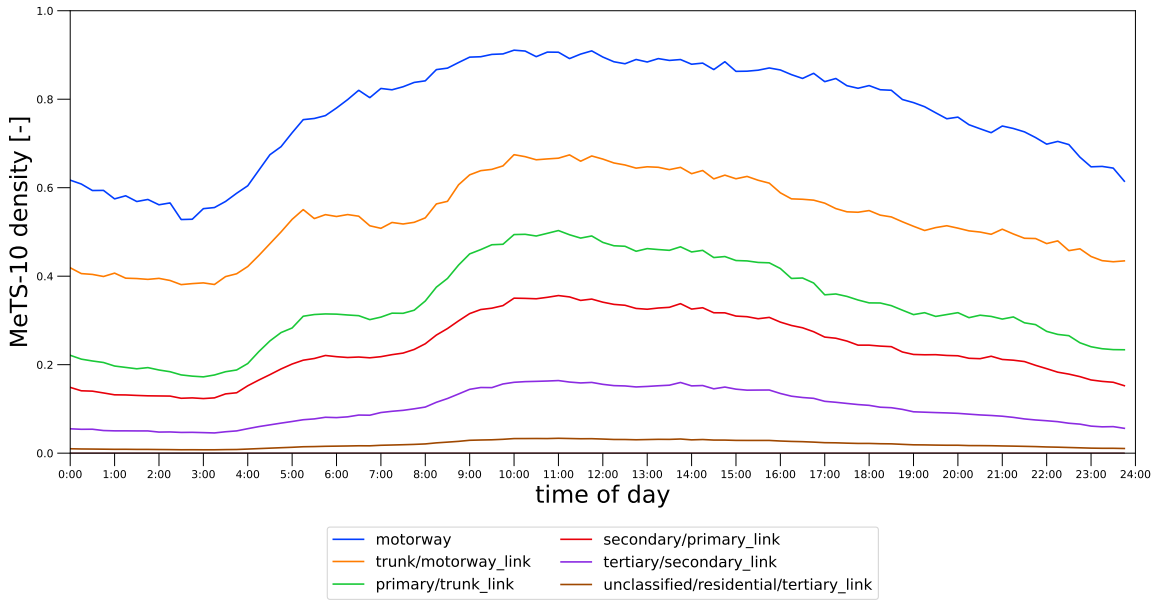



Fig. 20: Daily density profile for different road types for Bangkok . Data from 20 randomly sampled days.

*5) Daily speed profile Bangkok (2021) :*

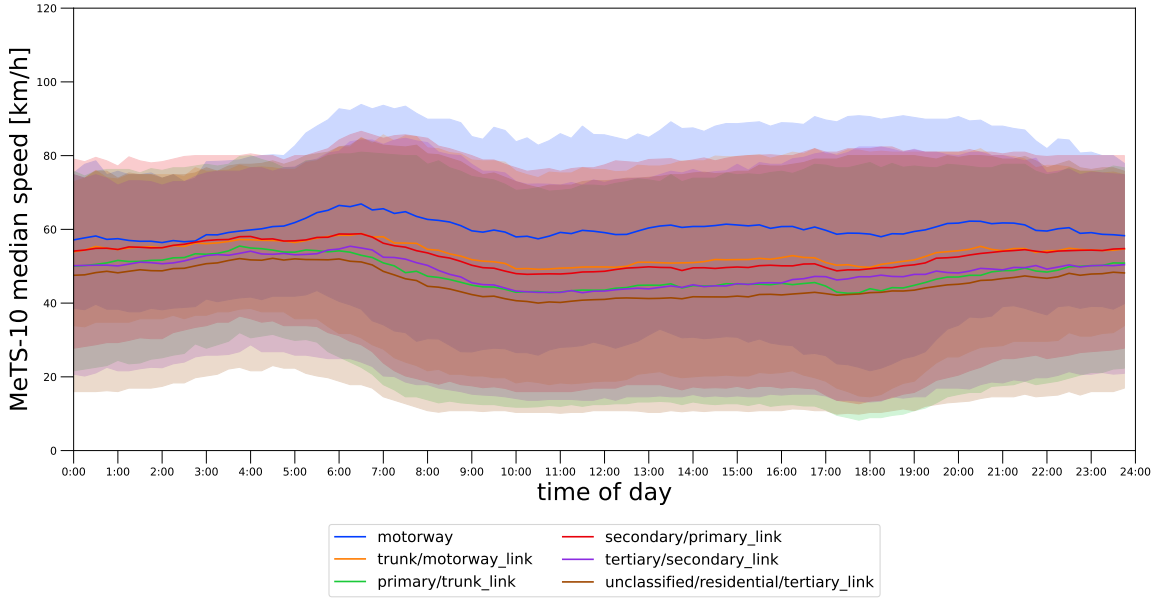



Fig. 21: Daily median 15 min speeds of all intersecting cells profile for different road types for Bangkok . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

### C. Key Figures Barcelona (2021)

#### 1) Road graph map Barcelona (2021):

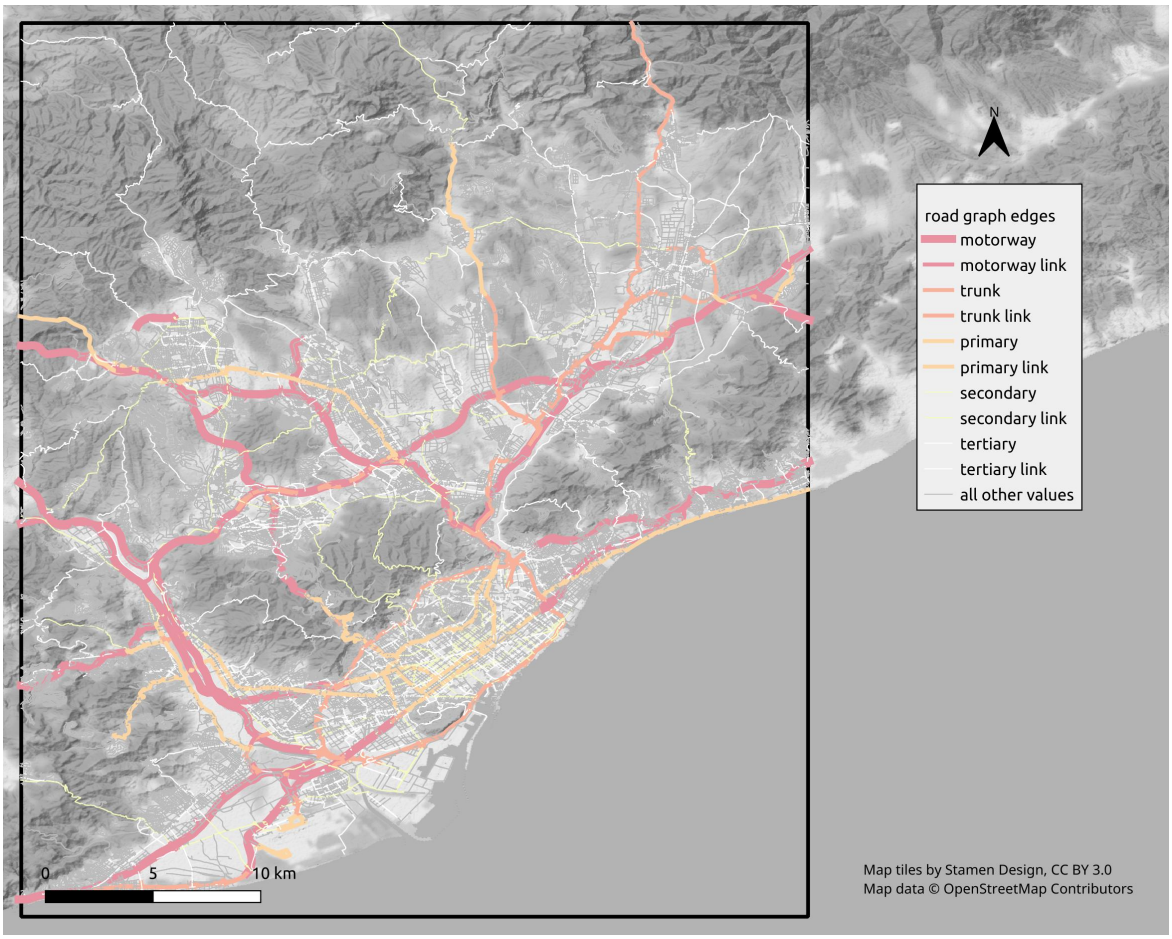



Fig. 22: Road graph Barcelona, OSM color scheme (2021).

#### 2) Static data Barcelona (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 1.925–2.361 / 41.253–41.748 | |
| num_edges | | | | | | 118’813 | |
| motorway | | | | | | 442 | |
| motorway_link | | | | | | 700 | |
| trunk | | | | | | 613 | |
| trunk_link | | | | | | 860 | |
| primary | | | | | | 2126 | |
| primary_link | | | | | | 690 | |
| secondary | | | | | | 5525 | |
| secondary_link | | | | | | 879 | |
| tertiary | | | | | | 14875 | |
| tertiary_link | | | | | | 1250 | |
| unclassified | | | | | | 3840 | |
| residential | | | | | | 87013 | |
| num_nodes | | | | | | 58106 | |
| num_edges_per_cell | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 410’314 | |
| num_intersecting_cells | 3.7 | 4.6 | 3.0 | 1.0 | 18.0 | 118’813 | |
| node_degree | 3.0 | 0.8 | 3.0 | 1.0 | 4.0 | 58’106 | |
| length_meters | 118.5 | 215.0 | 74.0 | 4.5 | 808.4 | 118’813 | 1.4e+07 |
| motorway | 987.6 | 954.8 | 708.9 | 38.7 | 5’246.0 | 442 | 4.4e+05 |
| motorway_link | 315.6 | 295.8 | 262.0 | 12.6 | 1’313.0 | 700 | 2.2e+05 |
| trunk | 456.4 | 428.8 | 355.4 | 13.5 | 2’071.3 | 613 | 2.8e+05 |
| trunk_link | 199.6 | 163.0 | 165.8 | 9.5 | 734.7 | 860 | 1.7e+05 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 122.2 | 227.6 | 63.1 | 3.4 | 1’054.5 | 2’126 | 2.6e+05 |
| primary_link | 81.5 | 106.4 | 45.4 | 4.4 | 450.3 | 690 | 5.6e+04 |
| secondary | 122.6 | 268.5 | 52.9 | 3.7 | 1’083.5 | 5’525 | 6.8e+05 |
| secondary_link | 54.9 | 80.4 | 29.9 | 3.1 | 365.3 | 879 | 4.8e+04 |
| tertiary | 122.3 | 361.2 | 55.2 | 3.1 | 1’192.1 | 14’875 | 1.8e+06 |
| tertiary_link | 46.2 | 60.3 | 27.8 | 3.4 | 301.6 | 1’250 | 5.8e+04 |
| unclassified | 238.8 | 458.7 | 101.7 | 5.1 | 2’086.6 | 3’840 | 9.2e+05 |
| residential | 105.0 | 112.4 | 76.6 | 5.2 | 550.9 | 87’013 | 9.1e+06 |
| speed_kph | 37.2 | 9.4 | 33.9 | 30.0 | 80.0 | 118’813 | |
| motorway | 100.0 | 19.9 | 100.0 | 40.0 | 120.0 | 442 | |
| motorway_link | 63.7 | 13.6 | 63.3 | 40.0 | 120.0 | 700 | |
| trunk | 81.5 | 15.5 | 80.0 | 40.0 | 100.0 | 613 | |
| trunk_link | 58.5 | 10.9 | 58.6 | 30.0 | 100.0 | 860 | |
| primary | 48.0 | 9.6 | 50.0 | 20.0 | 80.0 | 2’126 | |
| primary_link | 46.8 | 7.0 | 50.0 | 20.0 | 60.0 | 690 | |
| secondary | 49.5 | 10.7 | 50.0 | 30.0 | 90.0 | 5’525 | |
| secondary_link | 46.2 | 6.5 | 46.7 | 30.0 | 60.0 | 879 | |
| tertiary | 43.3 | 8.1 | 44.2 | 30.0 | 60.0 | 14’875 | |
| tertiary_link | 38.7 | 6.9 | 38.5 | 30.0 | 50.0 | 1’250 | |
| unclassified | 40.9 | 5.1 | 41.0 | 30.0 | 50.0 | 3’840 | |
| residential | 33.7 | 3.7 | 33.9 | 30.0 | 50.0 | 87’013 | |
| free_flow_kph | 34.5 | 21.6 | 29.6 | 0.0 | 117.4 | 103’177 | |
| motorway | 105.3 | 12.3 | 104.0 | 71.4 | 120.0 | 442 | |
| motorway_link | 94.3 | 22.7 | 99.8 | 35.3 | 120.0 | 699 | |
| trunk | 87.4 | 16.0 | 89.9 | 39.9 | 118.6 | 613 | |
| trunk_link | 81.6 | 20.2 | 86.6 | 24.1 | 119.3 | 858 | |
| primary | 47.1 | 18.6 | 42.8 | 18.5 | 100.7 | 2’126 | |
| primary_link | 52.9 | 21.9 | 49.9 | 14.5 | 109.1 | 686 | |
| secondary | 43.6 | 17.3 | 39.5 | 17.9 | 102.3 | 5’519 | |
| secondary_link | 44.4 | 19.4 | 40.9 | 14.0 | 102.8 | 865 | |
| tertiary | 39.0 | 18.4 | 34.8 | 12.7 | 104.9 | 14’706 | |
| tertiary_link | 42.9 | 22.7 | 36.7 | 10.9 | 120.0 | 1’215 | |
| unclassified | 42.1 | 26.0 | 35.3 | 0.0 | 120.0 | 3’228 | |
| residential | 29.7 | 18.6 | 26.4 | 0.0 | 104.9 | 72’220 | |
| free_flow_kph-speed_kph | -3.1 | 19.4 | -6.6 | -33.9 | 70.0 | 103’177 | |
| motorway | 5.3 | 15.7 | 0.0 | -24.0 | 40.0 | 442 | |
| motorway_link | 30.6 | 22.6 | 35.1 | -27.5 | 70.0 | 699 | |
| trunk | 5.9 | 13.1 | 4.0 | -25.0 | 43.2 | 613 | |
| trunk_link | 23.1 | 21.1 | 28.0 | -34.5 | 61.4 | 858 | |
| primary | -0.9 | 17.5 | -3.9 | -30.7 | 53.6 | 2’126 | |
| primary_link | 6.0 | 22.3 | 0.9 | -33.1 | 58.8 | 686 | |
| secondary | -5.9 | 17.3 | -8.4 | -42.2 | 53.4 | 5’519 | |
| secondary_link | -1.7 | 19.1 | -4.4 | -35.9 | 59.2 | 865 | |
| tertiary | -4.3 | 18.8 | -7.8 | -34.0 | 64.9 | 14’706 | |
| tertiary_link | 4.1 | 23.0 | -1.8 | -30.7 | 80.0 | 1’215 | |
| unclassified | 1.0 | 26.5 | -5.7 | -41.0 | 79.0 | 3’228 | |
| residential | -3.9 | 18.7 | -7.1 | -33.9 | 71.0 | 72’220 | |

TABLE VII: Key figures Barcelona for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Barcelona (2021):*

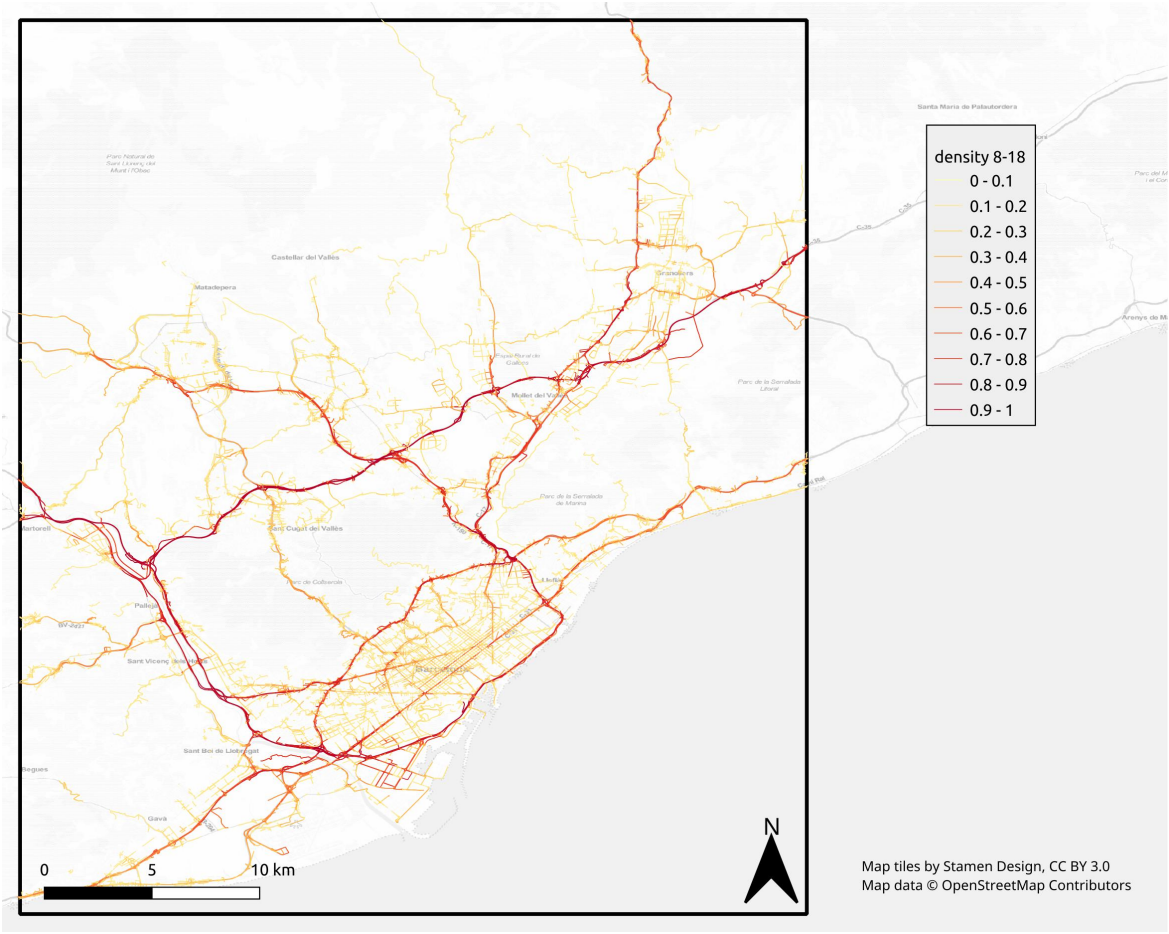



Fig. 23: Segment-wise density 8am–6pm Barcelona from 20 randomly sampled days.

*4) Daily density profile Barcelona (2021) :*

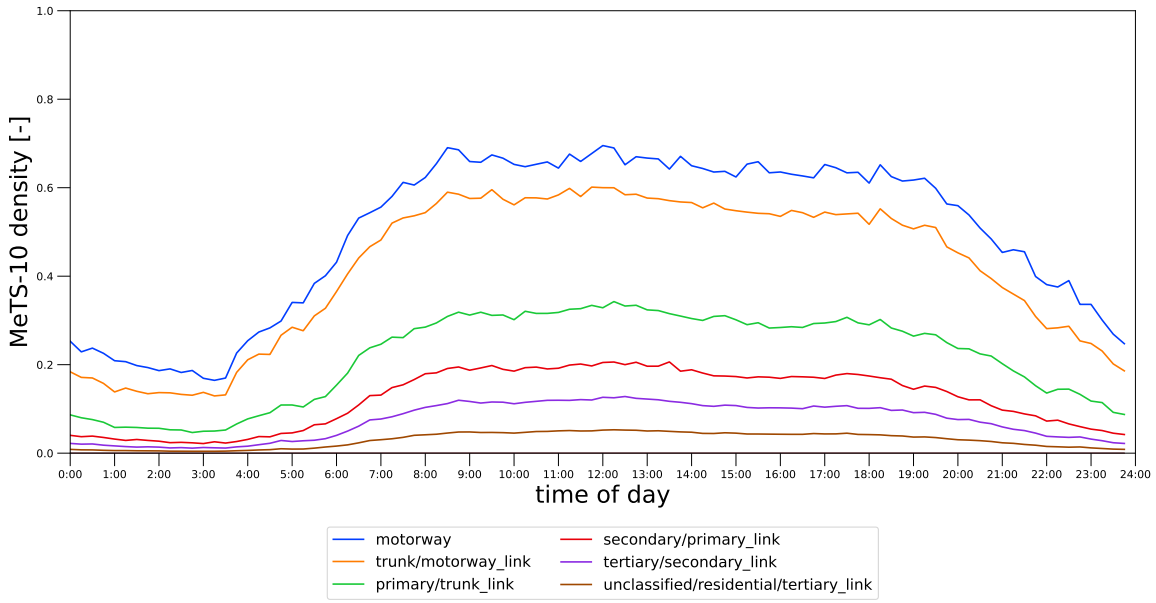



Fig. 24: Daily density profile for different road types for Barcelona . Data from 20 randomly sampled days.

*5) Daily speed profile Barcelona (2021) :*

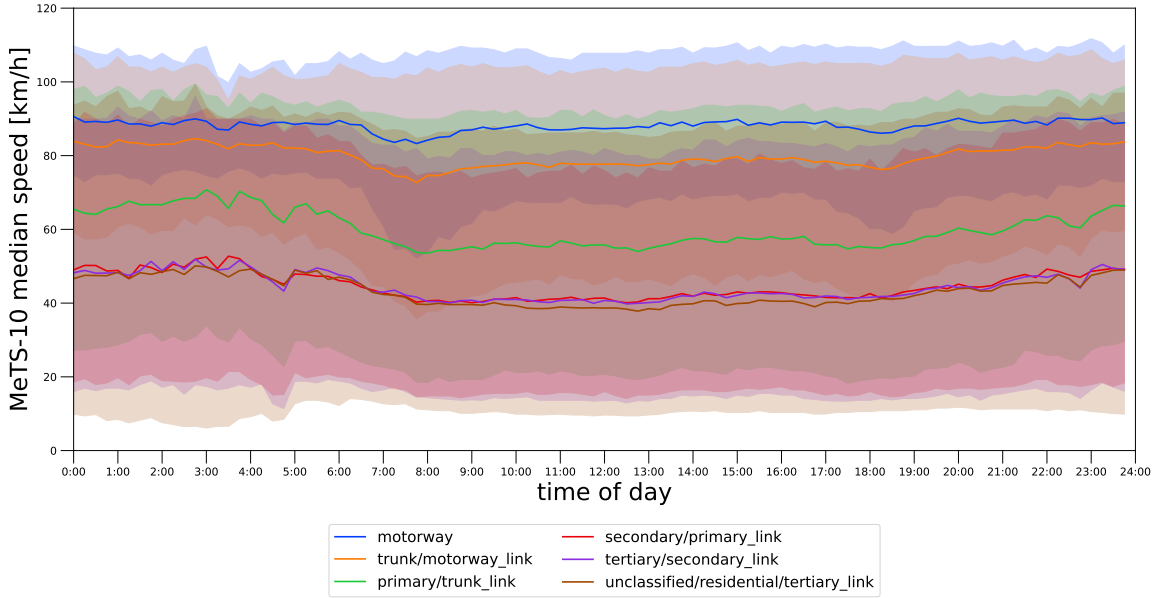



Fig. 25: Daily median 15 min speeds of all intersecting cells profile for different road types for Barcelona . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

### D. Key Figures Berlin (2021)

#### 1) Road graph map Berlin (2021):

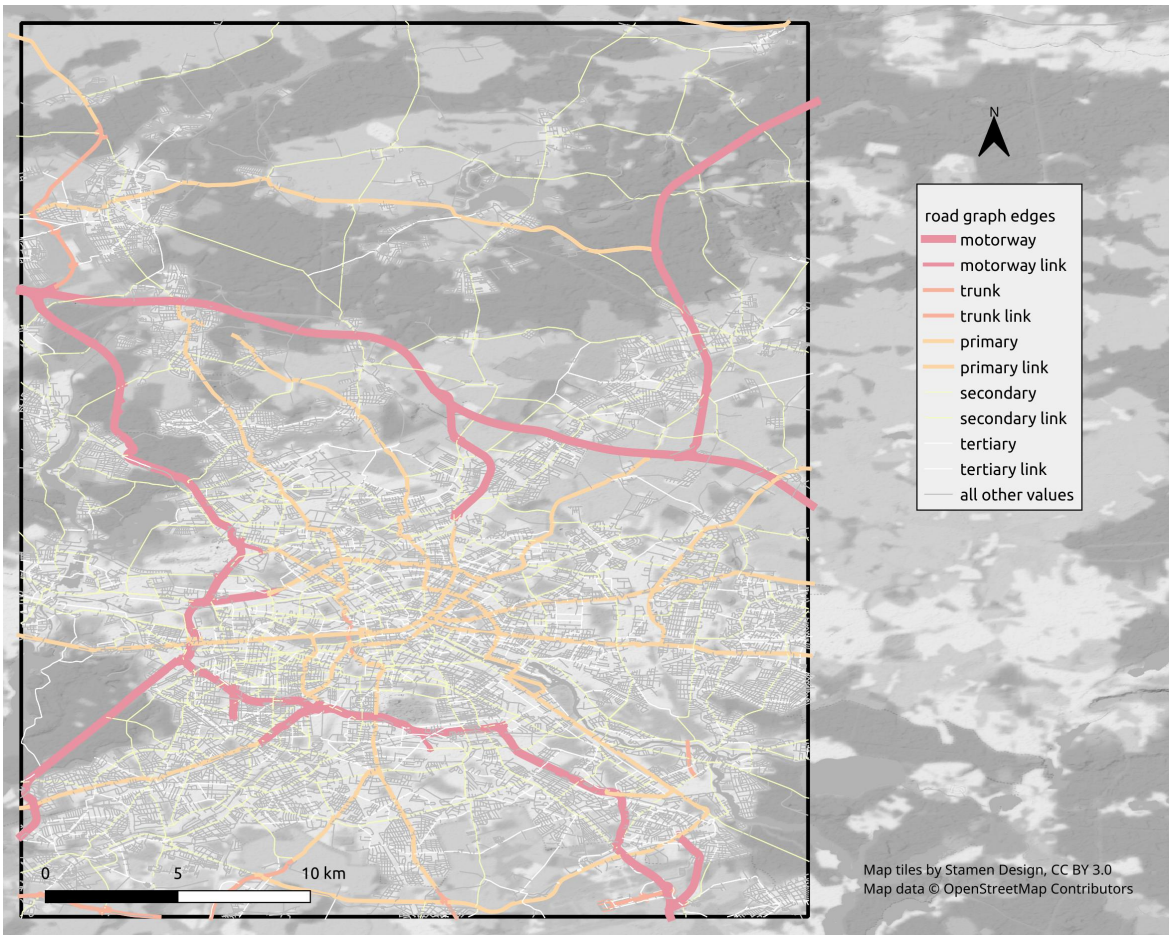



Fig. 26: Road graph Berlin, OSM color scheme (2021).

#### 2) Static data Berlin (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 13.189–13.625 / 52.359–52.854 | |
| num_edges | | | | | | 88’882 | |
| motorway | | | | | | 279 | |
| motorway_link | | | | | | 469 | |
| trunk | | | | | | 75 | |
| trunk_link | | | | | | 77 | |
| primary | | | | | | 2754 | |
| primary_link | | | | | | 150 | |
| secondary | | | | | | 10292 | |
| secondary_link | | | | | | 280 | |
| tertiary | | | | | | 8486 | |
| tertiary_link | | | | | | 61 | |
| unclassified | | | | | | 1766 | |
| residential | | | | | | 64193 | |
| num_nodes | | | | | | 34308 | |
| num_edges_per_cell | 1.0 | 0.2 | 1.0 | 1.0 | 2.0 | 405’500 | |
| num_intersecting_cells | 4.7 | 4.3 | 4.0 | 1.0 | 20.0 | 88’882 | |
| node_degree | 2.9 | 0.9 | 3.0 | 1.0 | 4.0 | 34’308 | |
| length_meters | 158.0 | 202.0 | 119.3 | 8.5 | 784.2 | 88’882 | 1.4e+07 |
| motorway | 1’058.1 | 1’232.4 | 585.3 | 88.1 | 5’875.6 | 279 | 3.0e+05 |
| motorway_link | 256.9 | 257.1 | 216.8 | 14.3 | 1’456.1 | 469 | 1.2e+05 |
| trunk | 846.4 | 959.8 | 516.8 | 44.1 | 5’038.1 | 75 | 6.3e+04 |
| trunk_link | 214.3 | 117.7 | 220.9 | 13.5 | 532.3 | 77 | 1.6e+04 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 191.6 | 292.9 | 119.1 | 7.7 | 1’583.0 | 2’754 | 5.3e+05 |
| primary_link | 52.6 | 73.4 | 18.0 | 7.2 | 302.2 | 150 | 7.9e+03 |
| secondary | 174.3 | 300.9 | 111.5 | 7.6 | 1’554.5 | 10’292 | 1.8e+06 |
| secondary_link | 25.5 | 31.5 | 14.6 | 7.0 | 149.6 | 280 | 7.1e+03 |
| tertiary | 155.1 | 216.5 | 113.0 | 7.3 | 951.6 | 8’486 | 1.3e+06 |
| tertiary_link | 23.3 | 34.8 | 12.9 | 7.2 | 160.2 | 61 | 1.4e+03 |
| unclassified | 310.2 | 439.8 | 171.5 | 9.5 | 2’386.5 | 1’766 | 5.5e+05 |
| residential | 145.6 | 116.1 | 120.1 | 9.0 | 547.1 | 64’193 | 9.3e+06 |
| speed_kph | 35.7 | 10.1 | 30.0 | 30.0 | 60.0 | 88’882 | |
| motorway | 85.4 | 17.1 | 80.0 | 60.0 | 120.0 | 279 | |
| motorway_link | 61.7 | 14.7 | 60.0 | 40.0 | 120.0 | 469 | |
| trunk | 87.5 | 32.5 | 100.0 | 30.0 | 120.0 | 75 | |
| trunk_link | 52.6 | 8.5 | 52.5 | 30.0 | 72.4 | 77 | |
| primary | 49.5 | 8.3 | 50.0 | 30.0 | 80.0 | 2’754 | |
| primary_link | 48.9 | 7.8 | 50.0 | 30.0 | 70.0 | 150 | |
| secondary | 48.7 | 6.5 | 50.0 | 30.0 | 70.0 | 10’292 | |
| secondary_link | 48.2 | 5.2 | 50.0 | 30.0 | 60.0 | 280 | |
| tertiary | 46.4 | 8.5 | 50.0 | 30.0 | 60.0 | 8’486 | |
| tertiary_link | 46.4 | 8.3 | 50.0 | 22.0 | 54.0 | 61 | |
| unclassified | 42.6 | 10.0 | 43.1 | 10.0 | 70.0 | 1’766 | |
| residential | 30.8 | 4.4 | 30.0 | 20.0 | 50.0 | 64’193 | |
| free_flow_kph | 37.4 | 14.1 | 35.3 | 12.0 | 87.5 | 85’074 | |
| motorway | 92.2 | 15.7 | 87.8 | 68.4 | 119.5 | 279 | |
| motorway_link | 78.4 | 20.0 | 80.6 | 31.4 | 119.0 | 469 | |
| trunk | 90.5 | 25.2 | 99.1 | 47.4 | 118.6 | 75 | |
| trunk_link | 83.7 | 26.8 | 82.4 | 18.6 | 118.3 | 77 | |
| primary | 48.8 | 12.1 | 48.5 | 24.0 | 89.8 | 2’754 | |
| primary_link | 44.8 | 18.5 | 41.9 | 13.2 | 96.4 | 150 | |
| secondary | 46.9 | 11.3 | 47.5 | 21.5 | 84.7 | 10’283 | |
| secondary_link | 34.8 | 16.7 | 33.6 | 11.8 | 80.9 | 280 | |
| tertiary | 44.2 | 10.7 | 43.8 | 21.6 | 83.0 | 8’484 | |
| tertiary_link | 32.8 | 15.1 | 33.4 | 11.3 | 61.8 | 59 | |
| unclassified | 43.9 | 17.0 | 42.8 | 16.0 | 105.4 | 1’689 | |
| residential | 33.4 | 11.8 | 32.0 | 10.4 | 73.5 | 60’475 | |
| free_flow_kph-speed_kph | 1.5 | 12.6 | 0.6 | -28.4 | 42.2 | 85’074 | |
| motorway | 6.9 | 16.6 | 6.6 | -48.4 | 37.0 | 279 | |
| motorway_link | 16.7 | 20.9 | 19.2 | -29.0 | 59.1 | 469 | |
| trunk | 3.0 | 13.4 | -0.1 | -35.2 | 34.3 | 75 | |
| trunk_link | 31.1 | 26.1 | 29.8 | -33.9 | 65.8 | 77 | |
| primary | -0.7 | 10.8 | -0.5 | -26.2 | 31.8 | 2’754 | |
| primary_link | -4.1 | 19.6 | -7.2 | -52.1 | 39.7 | 150 | |
| secondary | -1.8 | 11.5 | -1.1 | -29.3 | 33.2 | 10’283 | |
| secondary_link | -13.4 | 17.9 | -15.3 | -42.1 | 30.9 | 280 | |
| tertiary | -2.2 | 11.4 | -2.2 | -28.4 | 31.9 | 8’484 | |
| tertiary_link | -13.5 | 19.6 | -14.6 | -37.8 | 40.4 | 59 | |
| unclassified | 1.3 | 18.1 | -0.3 | -32.1 | 59.7 | 1’689 | |
| residential | 2.5 | 12.3 | 1.3 | -27.2 | 42.9 | 60’475 | |

TABLE VIII: Key figures Berlin for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Berlin (2021):*

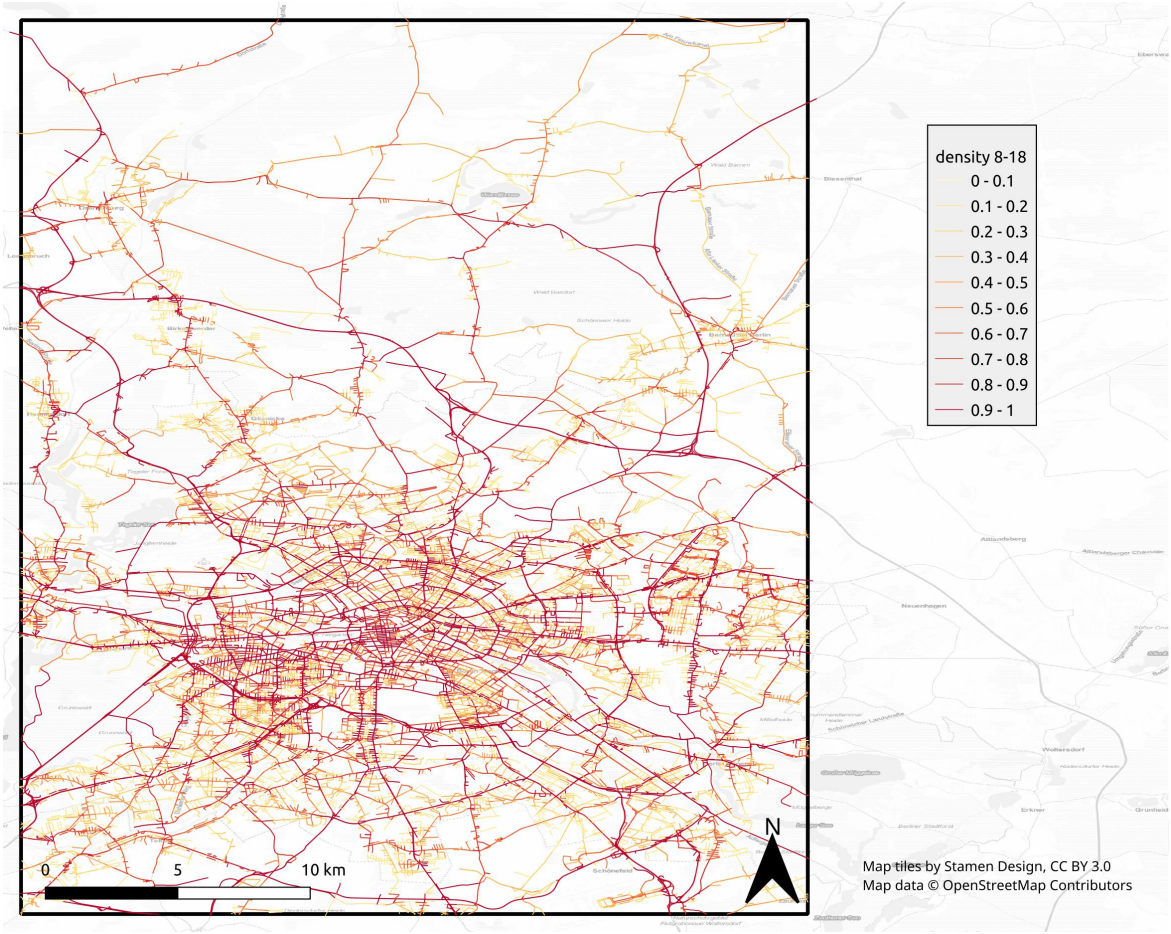



Fig. 27: Segment-wise density 8am–6pm Berlin from 20 randomly sampled days.

*4) Daily density profile Berlin (2021) :*

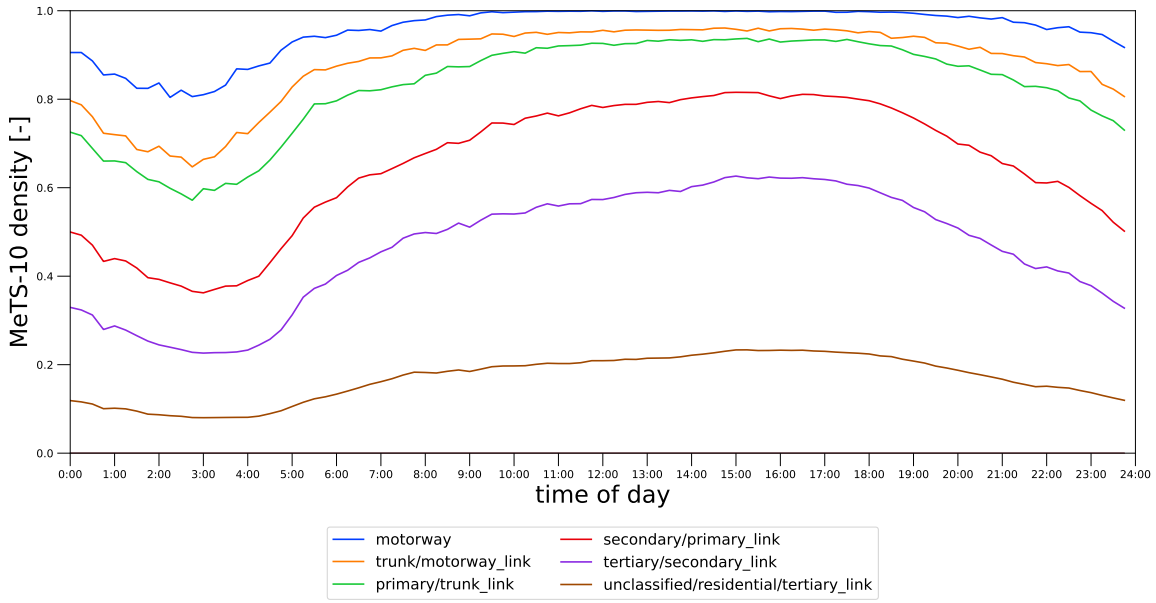



Fig. 28: Daily density profile for different road types for Berlin . Data from 20 randomly sampled days.

*5) Daily speed profile Berlin (2021) :*

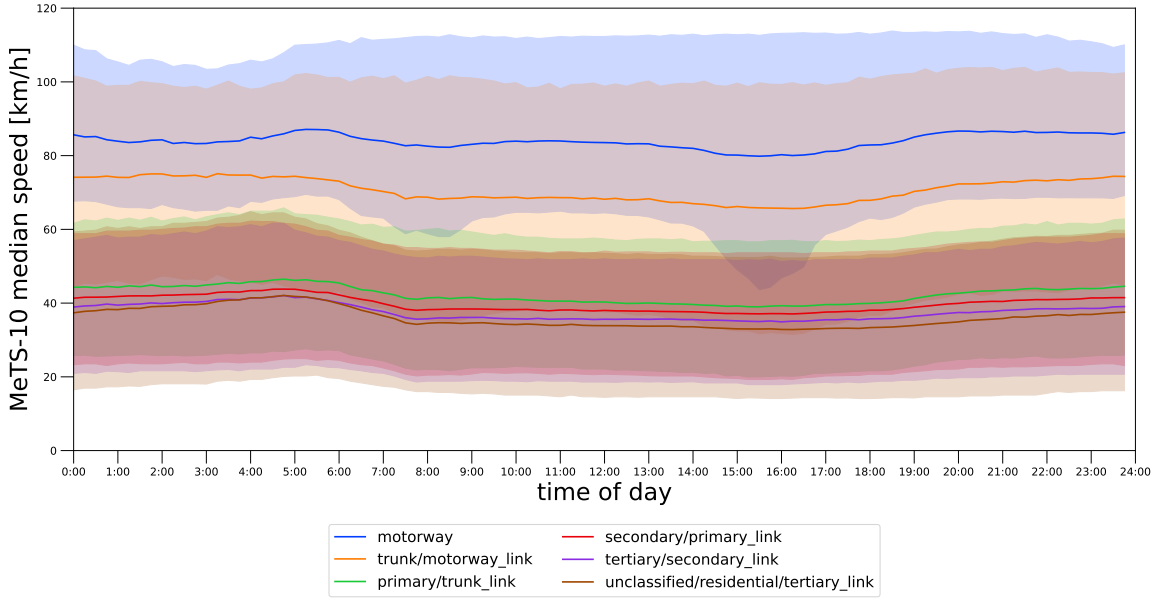



Fig. 29: Daily median 15 min speeds of all intersecting cells profile for different road types for Berlin . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

### E. Key Figures Chicago (2021)

#### 1) Road graph map Chicago (2021):

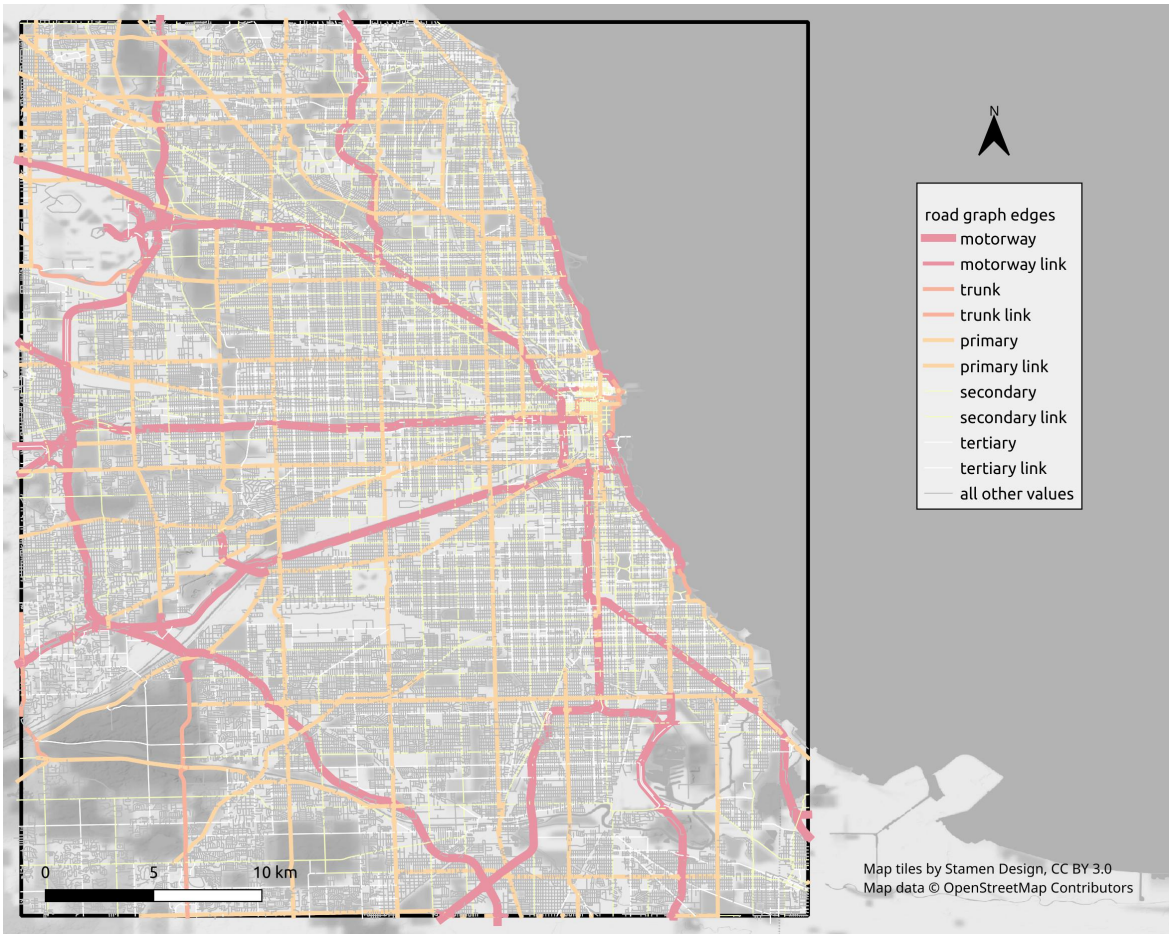



Fig. 30: Road graph Chicago, OSM color scheme (2021).

#### 2) Static data Chicago (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | -87.945—87.509 / 41.601–42.096 | |
| num_edges | | | | | | 187’570 | |
| motorway | | | | | | 822 | |
| motorway_link | | | | | | 1178 | |
| trunk | | | | | | 207 | |
| trunk_link | | | | | | 73 | |
| primary | | | | | | 10439 | |
| primary_link | | | | | | 387 | |
| secondary | | | | | | 22812 | |
| secondary_link | | | | | | 208 | |
| tertiary | | | | | | 16603 | |
| tertiary_link | | | | | | 71 | |
| unclassified | | | | | | 1069 | |
| residential | | | | | | 133701 | |
| num_nodes | | | | | | 68430 | |
| num_edges_per_cell | 1.1 | 0.3 | 1.0 | 1.0 | 3.0 | 966’289 | |
| num_intersecting_cells | 5.5 | 3.3 | 4.0 | 1.0 | 16.0 | 187’570 | |
| node_degree | 3.2 | 0.9 | 3.0 | 1.0 | 4.0 | 68’430 | |
| length_meters | 144.6 | 134.2 | 103.9 | 9.7 | 583.7 | 187’570 | 2.7e+07 |
| motorway | 778.1 | 872.2 | 559.2 | 22.6 | 4’295.7 | 822 | 6.4e+05 |
| motorway_link | 329.9 | 265.3 | 301.3 | 10.2 | 1’229.2 | 1’178 | 3.9e+05 |
| trunk | 370.4 | 431.5 | 262.0 | 7.6 | 1’872.6 | 207 | 7.7e+04 |
| trunk_link | 106.8 | 102.1 | 59.3 | 4.6 | 371.3 | 73 | 7.8e+03 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 141.9 | 158.8 | 102.1 | 6.9 | 797.0 | 10’439 | 1.5e+06 |
| primary_link | 70.4 | 72.8 | 52.5 | 10.2 | 404.8 | 387 | 2.7e+04 |
| secondary | 128.0 | 111.6 | 101.5 | 7.2 | 588.6 | 22’812 | 2.9e+06 |
| secondary_link | 61.2 | 66.2 | 43.8 | 8.7 | 346.1 | 208 | 1.3e+04 |
| tertiary | 140.2 | 148.4 | 102.3 | 8.2 | 674.1 | 16’603 | 2.3e+06 |
| tertiary_link | 40.3 | 31.5 | 30.6 | 6.4 | 131.5 | 71 | 2.9e+03 |
| unclassified | 229.4 | 297.9 | 126.5 | 4.8 | 1’519.1 | 1’069 | 2.5e+05 |
| residential | 142.0 | 95.5 | 106.8 | 10.3 | 452.4 | 133’701 | 1.9e+07 |
| speed_kph | 41.0 | 8.0 | 36.8 | 36.8 | 83.8 | 187’570 | |
| motorway | 87.7 | 6.9 | 88.5 | 72.4 | 112.7 | 822 | |
| motorway_link | 83.7 | 3.0 | 83.8 | 83.8 | 83.8 | 1’178 | |
| trunk | 75.1 | 8.8 | 74.4 | 48.3 | 88.5 | 207 | |
| trunk_link | 57.1 | 0.0 | 57.1 | 57.1 | 57.1 | 73 | |
| primary | 55.6 | 3.4 | 55.8 | 48.3 | 64.4 | 10’439 | |
| primary_link | 57.1 | 0.0 | 57.1 | 57.1 | 57.1 | 387 | |
| secondary | 50.9 | 1.9 | 50.9 | 48.3 | 56.3 | 22’812 | |
| secondary_link | 32.2 | 0.0 | 32.2 | 32.2 | 32.2 | 208 | |
| tertiary | 44.7 | 2.5 | 44.7 | 32.2 | 56.3 | 16’603 | |
| tertiary_link | 48.3 | 0.0 | 48.3 | 48.3 | 48.3 | 71 | |
| unclassified | 56.3 | 2.7 | 56.3 | 56.3 | 56.3 | 1’069 | |
| residential | 36.8 | 0.6 | 36.8 | 36.8 | 36.8 | 133’701 | |
| free_flow_kph | 45.1 | 19.0 | 42.8 | 4.2 | 111.2 | 162’191 | |
| motorway | 99.4 | 12.9 | 98.1 | 52.3 | 118.6 | 822 | |
| motorway_link | 91.4 | 20.9 | 95.5 | 29.6 | 118.9 | 1’178 | |
| trunk | 68.8 | 17.9 | 70.6 | 32.1 | 98.8 | 207 | |
| trunk_link | 67.4 | 17.8 | 76.7 | 26.4 | 91.4 | 73 | |
| primary | 55.2 | 13.6 | 54.1 | 30.1 | 98.4 | 10’427 | |
| primary_link | 52.4 | 17.2 | 51.8 | 12.7 | 96.4 | 384 | |
| secondary | 49.6 | 14.6 | 46.6 | 25.9 | 99.8 | 22’787 | |
| secondary_link | 51.7 | 21.0 | 48.5 | 13.7 | 110.0 | 208 | |
| tertiary | 48.9 | 16.7 | 45.6 | 21.2 | 111.1 | 16’538 | |
| tertiary_link | 48.4 | 20.2 | 46.6 | 19.4 | 110.9 | 69 | |
| unclassified | 47.6 | 24.9 | 46.5 | 3.3 | 118.0 | 988 | |
| residential | 41.5 | 18.5 | 39.2 | 2.7 | 107.3 | 108’510 | |
| free_flow_kph-speed_kph | 3.4 | 17.7 | 0.9 | -33.5 | 64.5 | 162’191 | |
| motorway | 11.8 | 12.8 | 10.6 | -35.5 | 40.4 | 822 | |
| motorway_link | 7.7 | 21.0 | 11.7 | -54.2 | 36.2 | 1’178 | |
| trunk | -6.3 | 14.9 | -3.7 | -44.6 | 18.3 | 207 | |
| trunk_link | 10.3 | 17.8 | 19.6 | -30.7 | 34.3 | 73 | |
| primary | -0.4 | 13.3 | -1.2 | -26.2 | 42.1 | 10’427 | |
| primary_link | -4.7 | 17.2 | -5.3 | -44.4 | 39.3 | 384 | |
| secondary | -1.2 | 14.6 | -4.1 | -25.0 | 48.9 | 22’787 | |
| secondary_link | 19.5 | 21.0 | 16.3 | -18.5 | 77.8 | 208 | |
| tertiary | 4.2 | 16.7 | 1.2 | -23.5 | 66.4 | 16’538 | |
| tertiary_link | 0.1 | 20.2 | -1.7 | -28.9 | 62.6 | 69 | |
| unclassified | -8.7 | 24.8 | -9.7 | -53.0 | 61.7 | 988 | |
| residential | 4.7 | 18.5 | 2.3 | -34.0 | 70.6 | 108’510 | |

TABLE IX: Key figures Chicago for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Chicago (2021):*

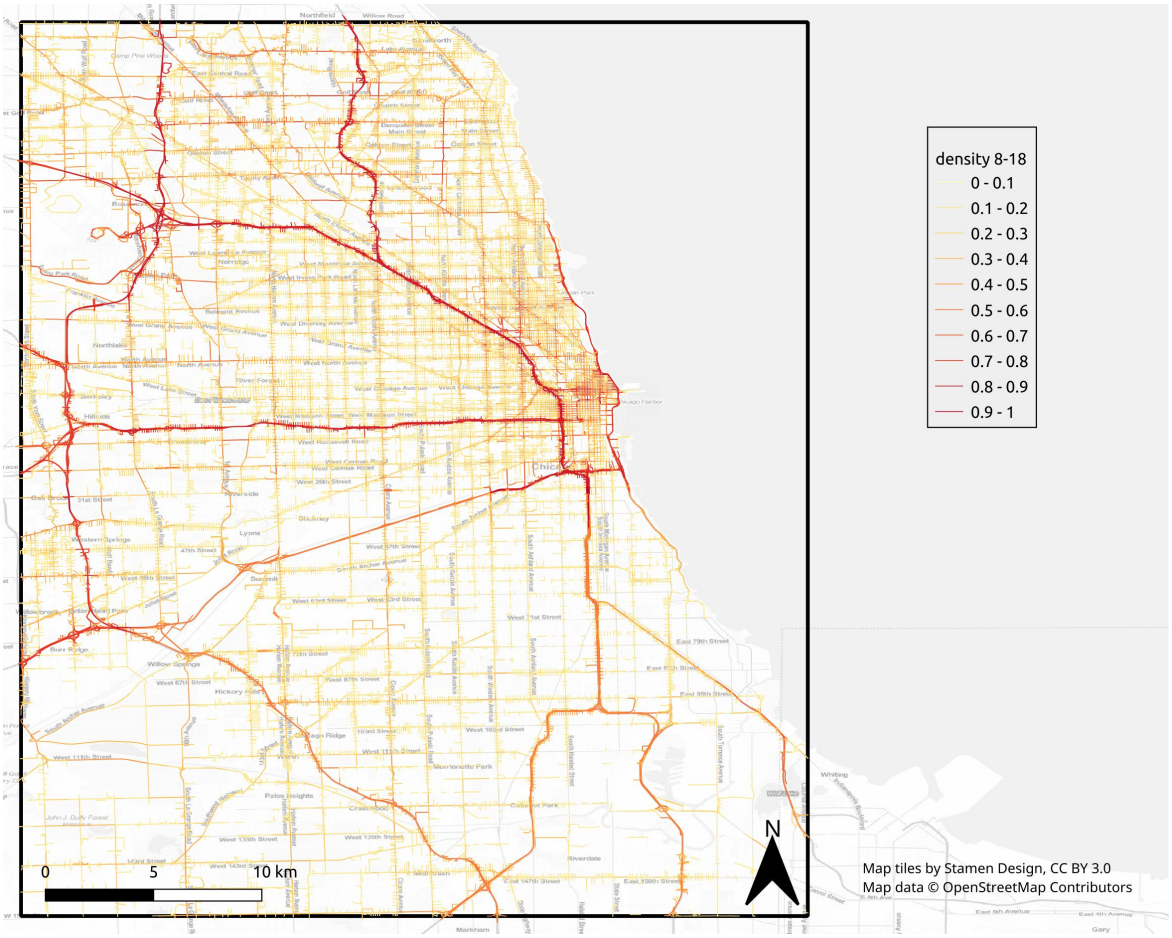



Fig. 31: Segment-wise density 8am–6pm Chicago from 20 randomly sampled days.

*4) Daily density profile Chicago (2021) :*

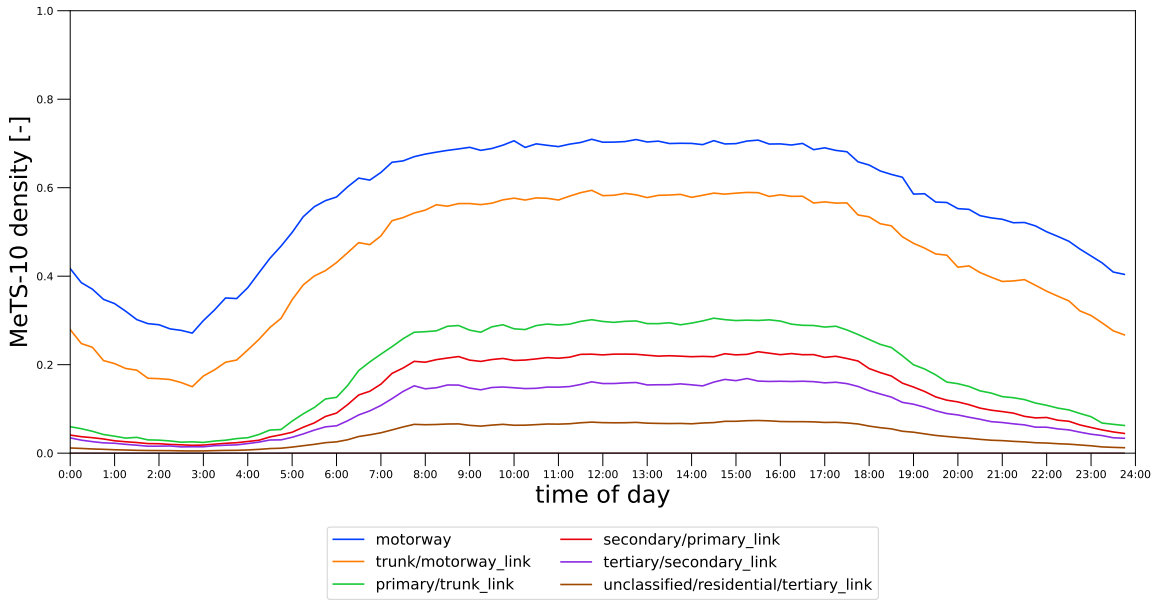



Fig. 32: Daily density profile for different road types for Chicago . Data from 20 randomly sampled days.

*5) Daily speed profile Chicago (2021) :*

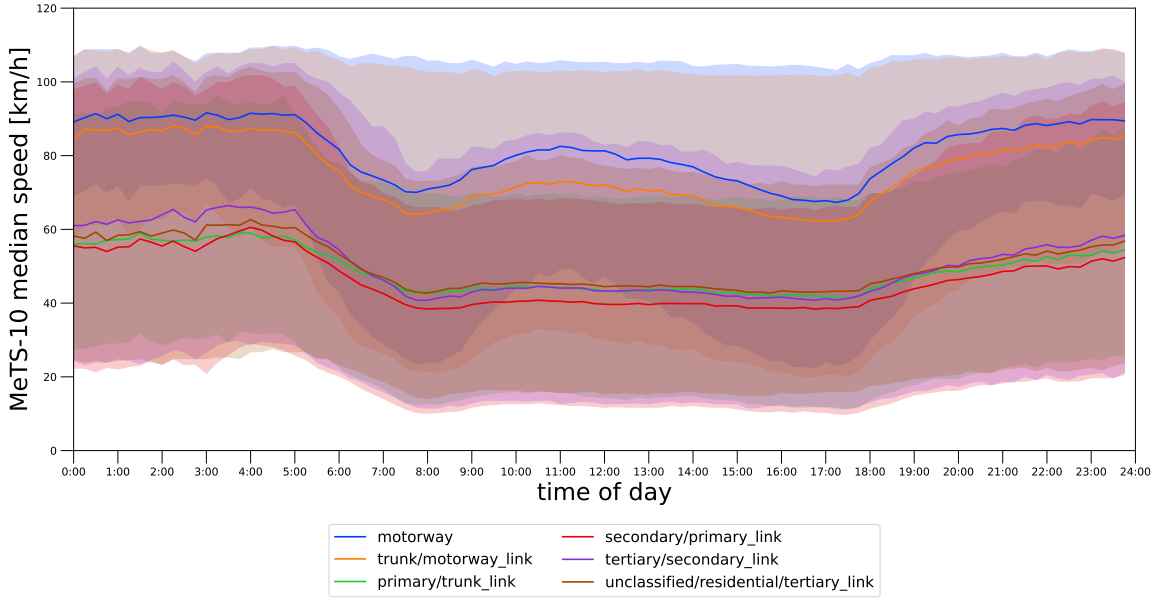



Fig. 33: Daily median 15 min speeds of all intersecting cells profile for different road types for Chicago . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

### F. Key Figures Istanbul (2021)

#### 1) Road graph map Istanbul (2021):

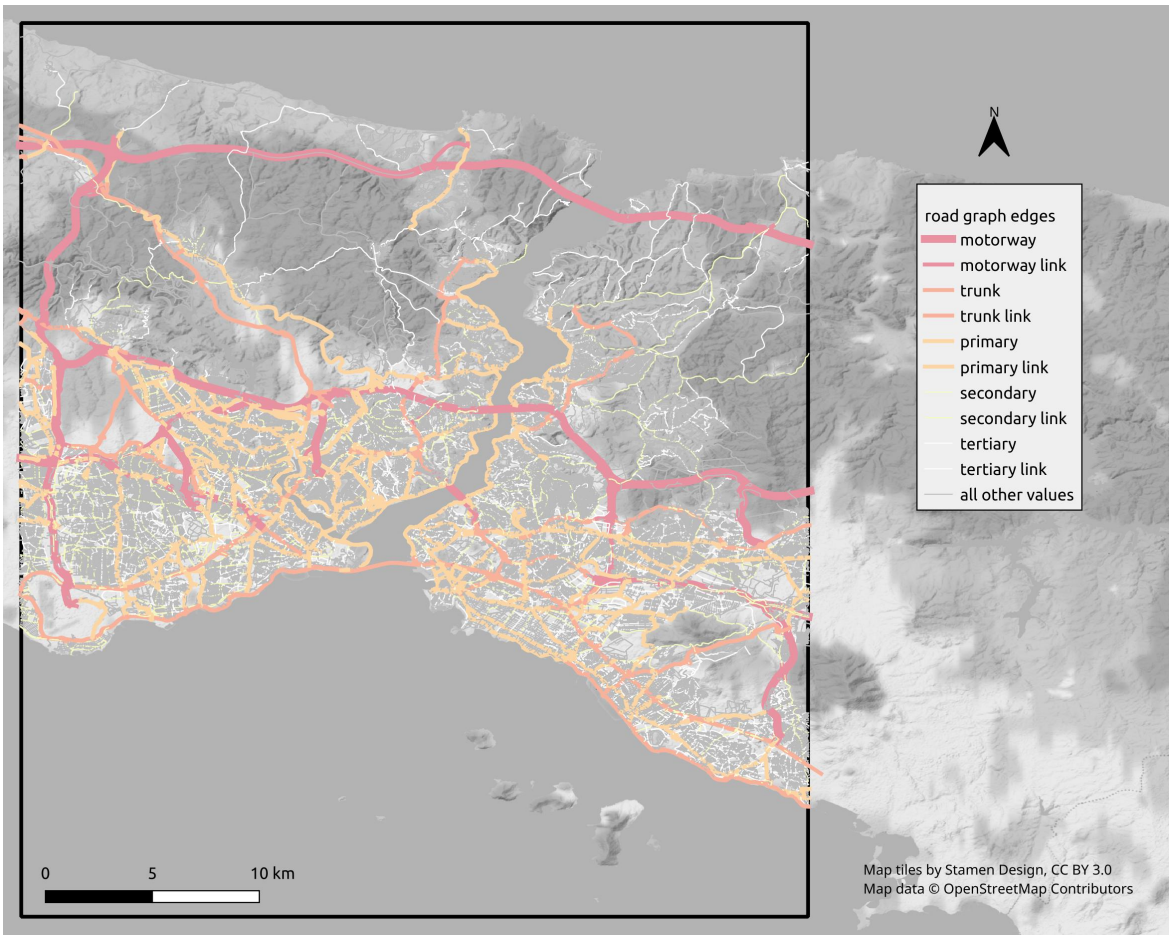



Fig. 34: Road graph Istanbul, OSM color scheme (2021).

#### 2) Static data Istanbul (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 28.794–29.23 / 40.81–41.305 | |
| num_edges | | | | | | 270’109 | |
| motorway | | | | | | 338 | |
| motorway_link | | | | | | 699 | |
| trunk | | | | | | 1156 | |
| trunk_link | | | | | | 1529 | |
| primary | | | | | | 9242 | |
| primary_link | | | | | | 2430 | |
| secondary | | | | | | 17014 | |
| secondary_link | | | | | | 1403 | |
| tertiary | | | | | | 30221 | |
| tertiary_link | | | | | | 625 | |
| unclassified | | | | | | 5422 | |
| residential | | | | | | 200030 | |
| num_nodes | | | | | | 102754 | |
| num_edges_per_cell | 1.1 | 0.6 | 1.0 | 1.0 | 4.0 | 734’722 | |
| num_intersecting_cells | 3.1 | 2.9 | 2.0 | 1.0 | 12.0 | 270’109 | |
| node_degree | 3.0 | 0.8 | 3.0 | 1.0 | 4.0 | 102’754 | |
| length_meters | 81.9 | 135.0 | 53.3 | 5.9 | 479.4 | 270’109 | 2.2e+07 |
| motorway | 1’066.1 | 1’693.6 | 647.9 | 42.4 | 8’557.5 | 338 | 3.6e+05 |
| motorway_link | 361.1 | 312.1 | 277.1 | 11.8 | 1’505.5 | 699 | 2.5e+05 |
| trunk | 394.2 | 522.6 | 216.3 | 9.5 | 2’387.7 | 1’156 | 4.6e+05 |
| trunk_link | 162.4 | 148.9 | 126.8 | 7.7 | 677.8 | 1’529 | 2.5e+05 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 104.8 | 160.3 | 57.2 | 5.6 | 723.8 | 9’242 | 9.7e+05 |
| primary_link | 65.0 | 78.0 | 37.4 | 5.7 | 378.0 | 2’430 | 1.6e+05 |
| secondary | 74.6 | 128.1 | 42.2 | 5.0 | 507.6 | 17’014 | 1.3e+06 |
| secondary_link | 48.6 | 75.7 | 28.1 | 4.6 | 308.9 | 1’403 | 6.8e+04 |
| tertiary | 73.5 | 153.4 | 43.8 | 4.8 | 515.8 | 30’221 | 2.2e+06 |
| tertiary_link | 30.4 | 32.4 | 20.1 | 3.9 | 170.2 | 625 | 1.9e+04 |
| unclassified | 217.9 | 370.2 | 104.7 | 7.1 | 1’861.4 | 5’422 | 1.2e+06 |
| residential | 74.6 | 67.7 | 55.0 | 6.5 | 317.6 | 200’030 | 1.5e+07 |
| speed_kph | 35.4 | 6.2 | 33.2 | 22.3 | 50.0 | 270’109 | |
| motorway | 107.1 | 9.9 | 107.3 | 80.0 | 120.0 | 338 | |
| motorway_link | 47.5 | 8.8 | 46.6 | 30.0 | 90.0 | 699 | |
| trunk | 75.3 | 10.8 | 76.4 | 30.0 | 100.0 | 1’156 | |
| trunk_link | 42.3 | 4.8 | 42.4 | 30.0 | 50.0 | 1’529 | |
| primary | 44.9 | 4.5 | 44.9 | 30.0 | 50.0 | 9’242 | |
| primary_link | 32.4 | 2.8 | 32.4 | 30.0 | 32.4 | 2’430 | |
| secondary | 38.1 | 2.9 | 38.1 | 30.0 | 50.0 | 17’014 | |
| secondary_link | 30.5 | 1.8 | 30.6 | 20.0 | 30.6 | 1’403 | |
| tertiary | 45.1 | 2.2 | 45.2 | 33.2 | 50.0 | 30’221 | |
| tertiary_link | 31.6 | 1.4 | 31.6 | 30.0 | 31.6 | 625 | |
| unclassified | 22.4 | 1.2 | 22.3 | 22.3 | 33.2 | 5’422 | |
| residential | 33.2 | 1.1 | 33.2 | 33.2 | 33.2 | 200’030 | |
| free_flow_kph | 24.7 | 12.4 | 20.9 | 10.4 | 75.8 | 268’548 | |
| motorway | 81.4 | 14.2 | 83.9 | 18.9 | 106.3 | 338 | |
| motorway_link | 69.4 | 16.7 | 71.7 | 24.4 | 98.1 | 698 | |
| trunk | 61.7 | 14.7 | 64.5 | 19.6 | 91.1 | 1’156 | |
| trunk_link | 53.9 | 18.2 | 56.5 | 10.8 | 87.4 | 1’529 | |
| primary | 36.4 | 12.4 | 34.4 | 16.5 | 75.9 | 9’242 | |
| primary_link | 33.6 | 13.9 | 31.5 | 11.3 | 77.1 | 2’430 | |
| secondary | 31.2 | 14.4 | 26.8 | 14.3 | 82.3 | 17’014 | |
| secondary_link | 32.0 | 16.9 | 26.8 | 10.7 | 82.5 | 1’403 | |
| tertiary | 26.1 | 10.2 | 24.0 | 12.7 | 67.8 | 30’195 | |
| tertiary_link | 24.7 | 10.7 | 22.0 | 10.1 | 76.5 | 625 | |
| unclassified | 29.7 | 16.4 | 25.6 | 8.0 | 89.1 | 4’735 | |
| residential | 22.5 | 10.4 | 19.8 | 9.9 | 68.2 | 199’183 | |
| free_flow_kph-speed_kph | -10.7 | 12.1 | -13.7 | -29.5 | 37.7 | 268’548 | |
| motorway | -25.8 | 15.6 | -23.3 | -88.4 | 2.1 | 338 | |
| motorway_link | 21.9 | 17.6 | 24.5 | -26.7 | 53.6 | 698 | |
| trunk | -13.6 | 15.8 | -11.4 | -57.6 | 25.1 | 1’156 | |
| trunk_link | 11.6 | 18.0 | 14.5 | -31.6 | 44.6 | 1’529 | |
| primary | -8.5 | 12.6 | -10.3 | -30.3 | 29.7 | 9’242 | |
| primary_link | 1.2 | 14.1 | -0.6 | -22.2 | 43.6 | 2’430 | |
| secondary | -6.9 | 14.6 | -11.3 | -25.2 | 44.4 | 17’014 | |
| secondary_link | 1.5 | 16.9 | -3.5 | -19.9 | 51.9 | 1’403 | |
| tertiary | -18.9 | 10.4 | -21.0 | -33.0 | 22.1 | 30’195 | |
| tertiary_link | -6.9 | 10.8 | -9.6 | -22.5 | 44.9 | 625 | |
| unclassified | 7.3 | 16.5 | 3.3 | -15.9 | 66.8 | 4’735 | |
| residential | -10.8 | 10.4 | -13.4 | -23.3 | 35.0 | 199’183 | |

TABLE X: Key figures Istanbul for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Istanbul (2021):*

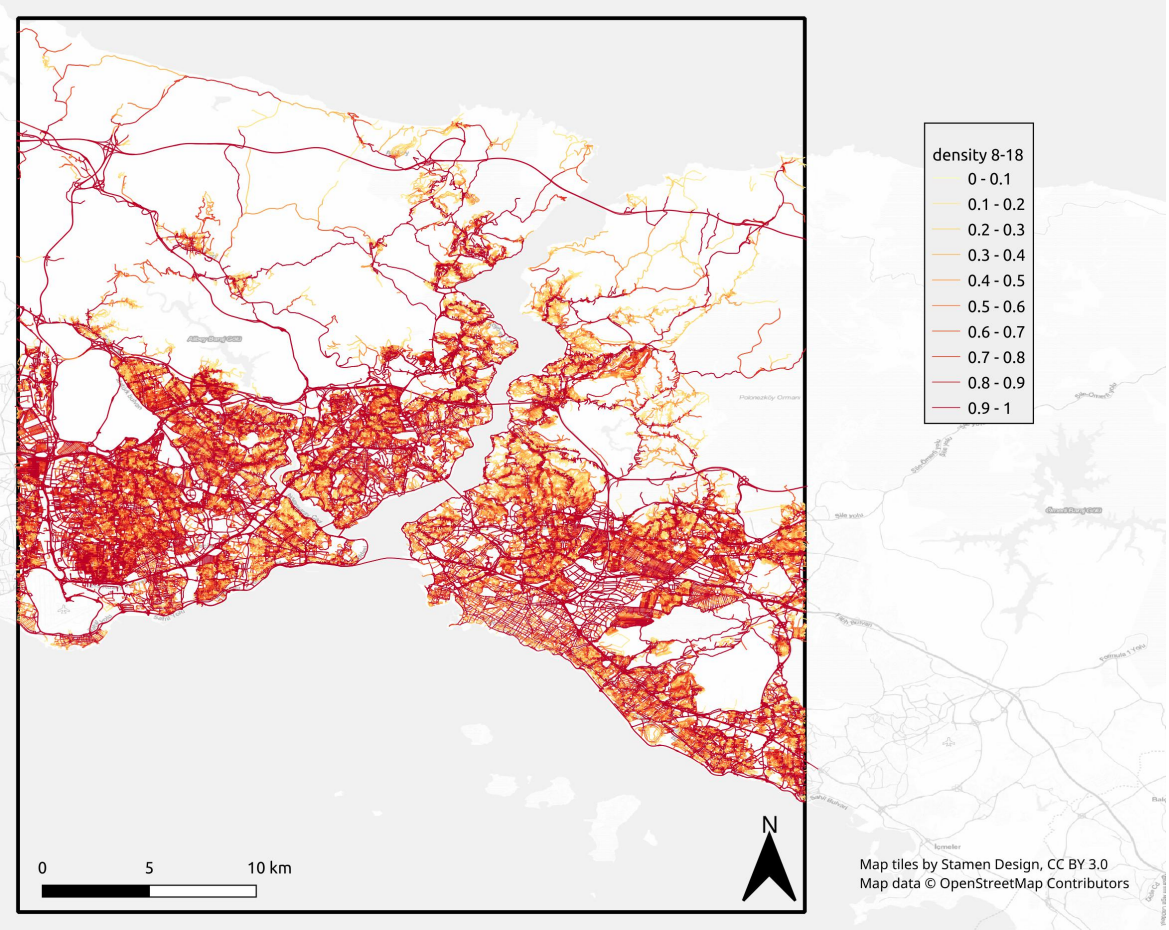



Fig. 35: Segment-wise density 8am–6pm Istanbul from 20 randomly sampled days.

*4) Daily density profile Istanbul (2021) :*

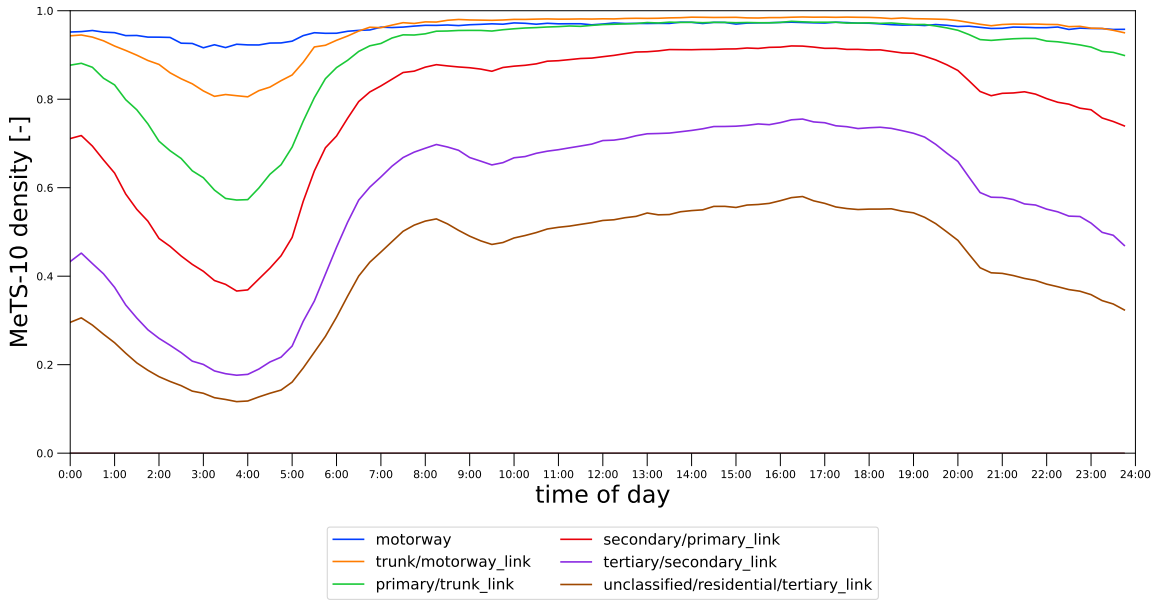



Fig. 36: Daily density profile for different road types for Istanbul . Data from 20 randomly sampled days.

*5) Daily speed profile Istanbul (2021) :*

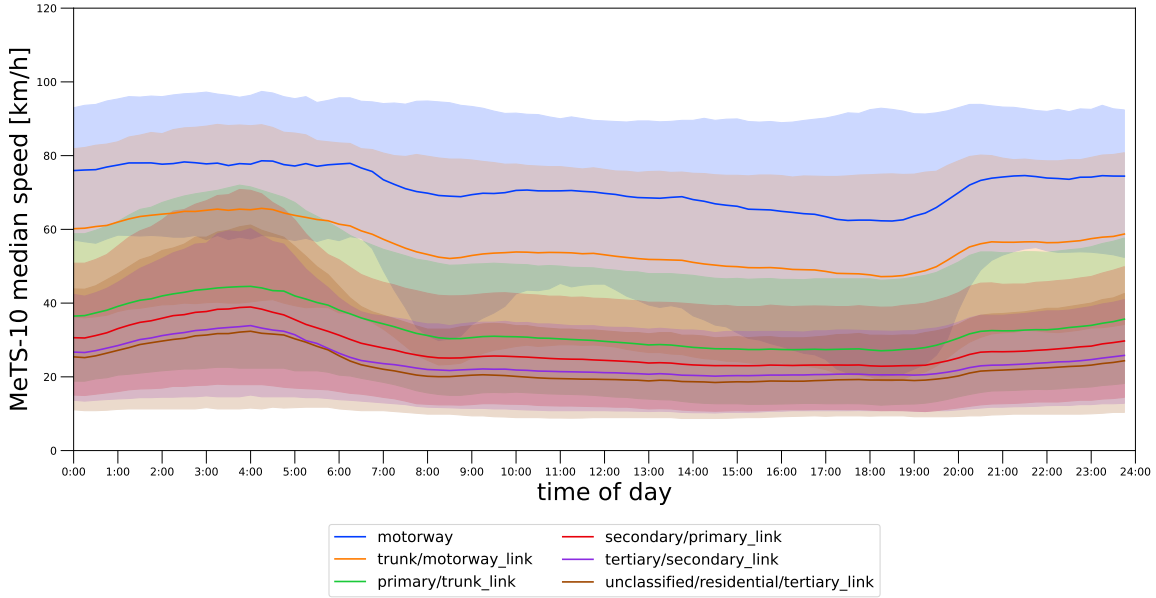



Fig. 37: Daily median 15 min speeds of all intersecting cells profile for different road types for Istanbul . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

### G. Key Figures Melbourne (2021)

#### 1) Road graph map Melbourne (2021):

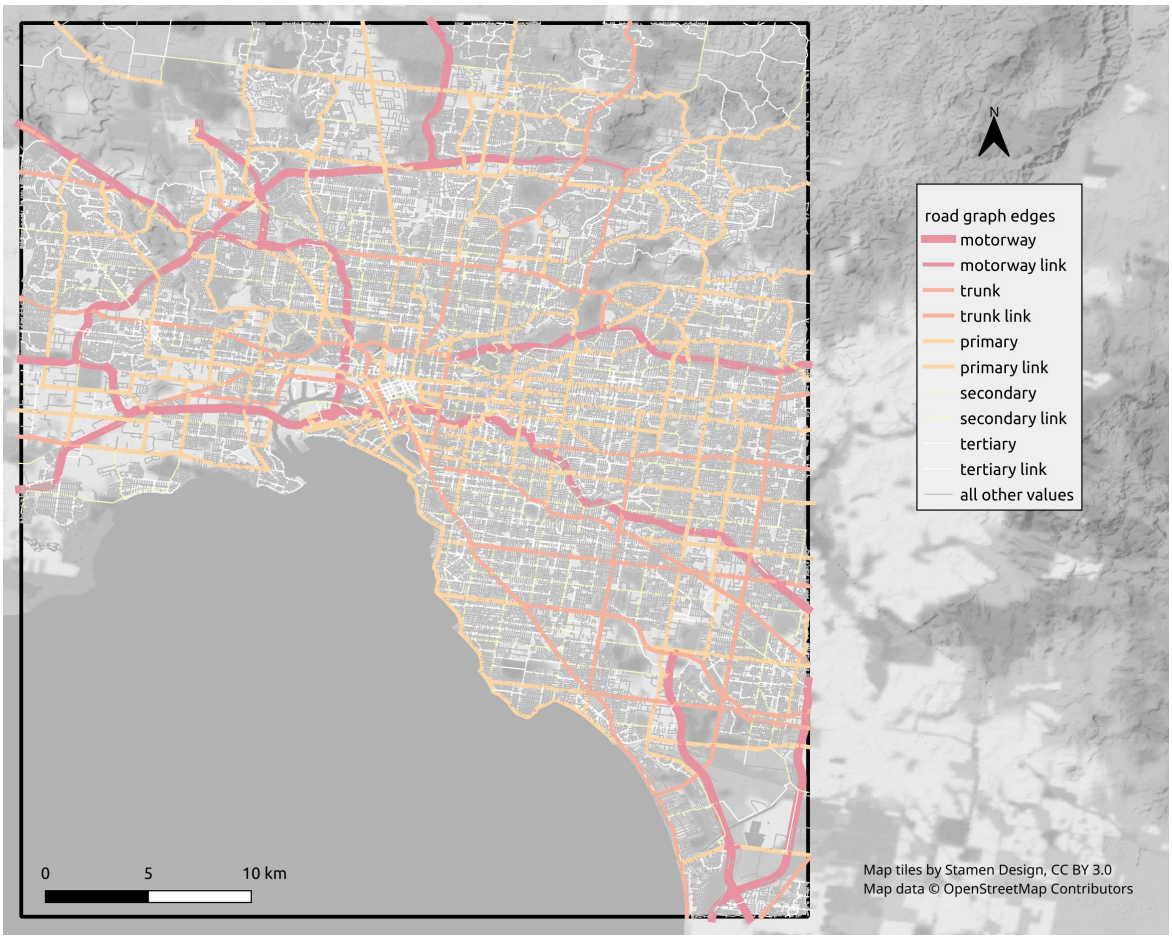



Fig. 38: Road graph Melbourne, OSM color scheme (2021).

#### 2) Static data Melbourne (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 144.757–145.193 / -38.106—37.611 | |
| num_edges | | | | | | 230’654 | |
| motorway | | | | | | 354 | |
| motorway_link | | | | | | 891 | |
| trunk | | | | | | 5383 | |
| trunk_link | | | | | | 766 | |
| primary | | | | | | 13917 | |
| primary_link | | | | | | 1574 | |
| secondary | | | | | | 10342 | |
| secondary_link | | | | | | 394 | |
| tertiary | | | | | | 30552 | |
| tertiary_link | | | | | | 1007 | |
| unclassified | | | | | | 7301 | |
| residential | | | | | | 158173 | |
| num_nodes | | | | | | 103062 | |
| num_edges_per_cell | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 891’475 | |
| num_intersecting_cells | 4.2 | 3.1 | 4.0 | 1.0 | 14.0 | 230’654 | |
| node_degree | 2.8 | 0.8 | 3.0 | 1.0 | 4.0 | 103’062 | |
| length_meters | 105.3 | 123.1 | 81.5 | 2.7 | 497.8 | 230’654 | 2.4e+07 |
| motorway | 1’102.6 | 774.5 | 976.5 | 26.1 | 4’090.9 | 354 | 3.9e+05 |
| motorway_link | 261.5 | 319.2 | 102.2 | 10.1 | 1’525.0 | 891 | 2.3e+05 |
| trunk | 105.4 | 139.8 | 68.1 | 3.9 | 657.1 | 5’383 | 5.7e+05 |
| trunk_link | 36.2 | 39.8 | 22.9 | 7.8 | 182.2 | 766 | 2.8e+04 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 99.4 | 115.9 | 69.4 | 3.0 | 565.5 | 13’917 | 1.4e+06 |
| primary_link | 30.5 | 34.3 | 17.0 | 6.2 | 146.5 | 1’574 | 4.8e+04 |
| secondary | 86.5 | 104.6 | 64.2 | 2.3 | 457.6 | 10’342 | 9.0e+05 |
| secondary_link | 40.3 | 28.6 | 37.1 | 5.1 | 124.3 | 394 | 1.6e+04 |
| tertiary | 78.5 | 111.2 | 54.4 | 1.6 | 421.8 | 30’552 | 2.4e+06 |
| tertiary_link | 23.2 | 25.0 | 12.7 | 2.0 | 117.5 | 1’007 | 2.3e+04 |
| unclassified | 153.4 | 235.0 | 89.3 | 3.7 | 1’066.3 | 7’301 | 1.1e+06 |
| residential | 108.6 | 99.5 | 87.7 | 3.1 | 444.9 | 158’173 | 1.7e+07 |
| speed_kph | 51.1 | 6.8 | 48.7 | 40.0 | 80.0 | 230’654 | |
| motorway | 93.6 | 9.5 | 100.0 | 80.0 | 100.0 | 354 | |
| motorway_link | 77.2 | 11.0 | 78.9 | 50.0 | 100.0 | 891 | |
| trunk | 68.6 | 9.5 | 70.0 | 40.0 | 80.0 | 5’383 | |
| trunk_link | 65.2 | 5.0 | 65.4 | 50.0 | 80.0 | 766 | |
| primary | 62.5 | 8.3 | 60.0 | 40.0 | 80.0 | 13’917 | |
| primary_link | 57.1 | 3.3 | 57.0 | 40.0 | 70.0 | 1’574 | |
| secondary | 58.8 | 5.9 | 60.0 | 40.0 | 80.0 | 10’342 | |
| secondary_link | 59.4 | 2.5 | 59.6 | 50.0 | 70.0 | 394 | |
| tertiary | 51.4 | 5.8 | 51.4 | 40.0 | 70.0 | 30’552 | |
| tertiary_link | 54.4 | 3.0 | 54.6 | 40.0 | 60.0 | 1’007 | |
| unclassified | 49.1 | 4.8 | 49.0 | 20.0 | 60.0 | 7’301 | |
| residential | 48.7 | 2.4 | 48.7 | 40.0 | 50.0 | 158’173 | |
| free_flow_kph | 40.6 | 18.7 | 39.5 | 0.0 | 96.7 | 187’487 | |
| motorway | 91.4 | 10.0 | 96.0 | 65.0 | 100.7 | 348 | |
| motorway_link | 76.9 | 22.7 | 82.6 | 24.2 | 99.8 | 879 | |
| trunk | 56.4 | 13.4 | 56.9 | 26.8 | 80.8 | 5’380 | |
| trunk_link | 47.2 | 19.8 | 49.9 | 4.3 | 85.6 | 747 | |
| primary | 51.0 | 13.1 | 52.7 | 23.1 | 82.8 | 13’913 | |
| primary_link | 46.4 | 19.6 | 47.4 | 3.8 | 94.4 | 1’516 | |
| secondary | 49.5 | 13.3 | 51.1 | 20.8 | 94.6 | 10’301 | |
| secondary_link | 43.1 | 15.7 | 41.2 | 7.7 | 93.9 | 387 | |
| tertiary | 42.1 | 13.0 | 41.6 | 16.9 | 84.7 | 29’619 | |
| tertiary_link | 39.8 | 16.4 | 38.6 | 6.6 | 76.2 | 941 | |
| unclassified | 37.9 | 18.5 | 33.9 | 3.3 | 94.6 | 6’868 | |
| residential | 37.1 | 19.4 | 35.8 | 0.0 | 96.9 | 116’588 | |
| free_flow_kph-speed_kph | -11.0 | 17.6 | -11.2 | -48.7 | 44.5 | 187’487 | |
| motorway | -2.1 | 9.0 | -2.1 | -30.0 | 17.2 | 348 | |
| motorway_link | -0.3 | 22.8 | 0.4 | -54.7 | 38.8 | 879 | |
| trunk | -12.3 | 12.2 | -9.2 | -45.6 | 12.7 | 5’380 | |
| trunk_link | -18.0 | 20.0 | -15.4 | -61.1 | 19.7 | 747 | |
| primary | -11.5 | 12.5 | -8.5 | -44.0 | 19.5 | 13’913 | |
| primary_link | -10.7 | 19.8 | -9.1 | -53.2 | 36.5 | 1’516 | |
| secondary | -9.3 | 13.1 | -7.8 | -38.6 | 36.9 | 10’301 | |
| secondary_link | -16.4 | 16.0 | -18.7 | -51.9 | 34.3 | 387 | |
| tertiary | -9.3 | 12.7 | -9.5 | -35.4 | 32.8 | 29’619 | |
| tertiary_link | -14.6 | 16.4 | -15.8 | -50.0 | 21.6 | 941 | |
| unclassified | -11.2 | 18.8 | -15.1 | -47.1 | 44.6 | 6’868 | |
| residential | -11.5 | 19.5 | -12.8 | -48.7 | 47.8 | 116’588 | |

TABLE XI: Key figures Melbourne for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Melbourne (2021):*

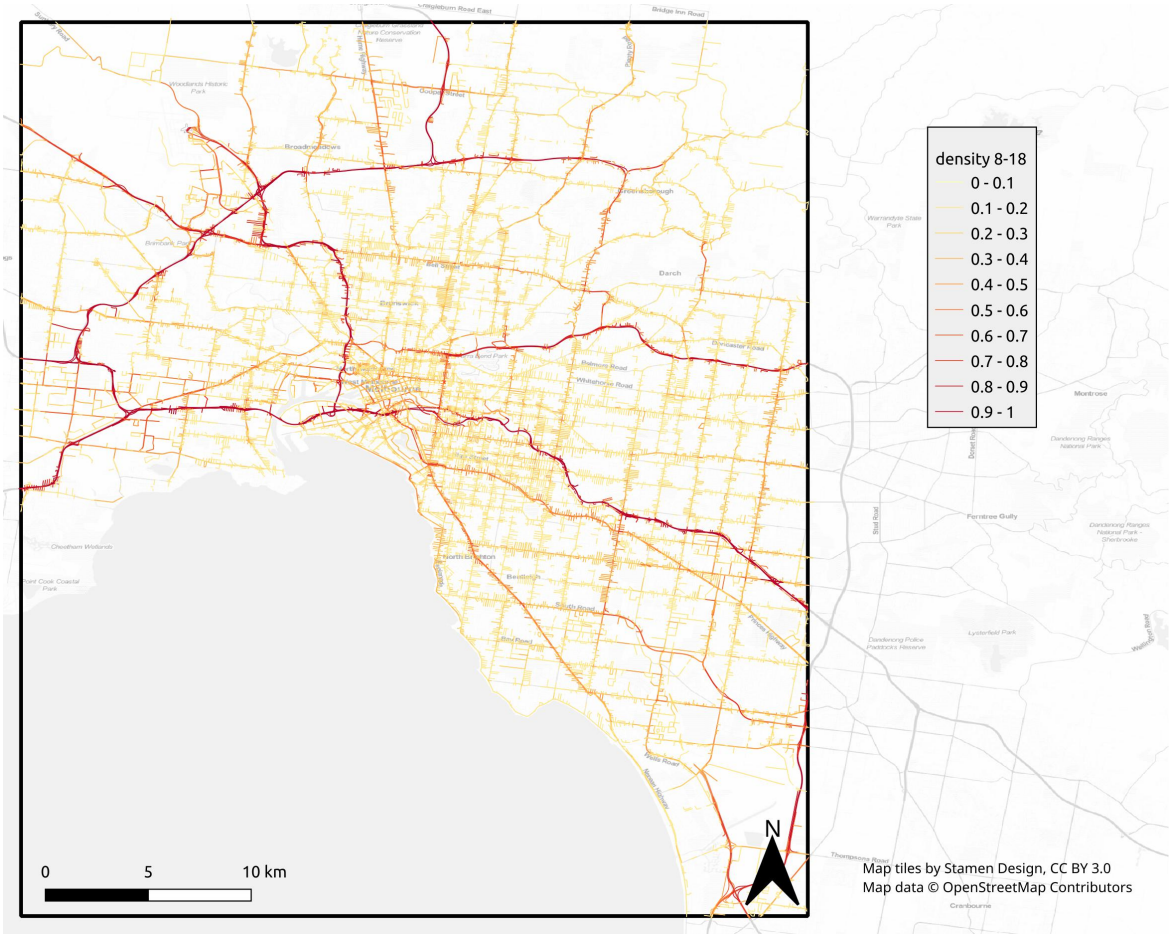



Fig. 39: Segment-wise density 8am–6pm Melbourne from 20 randomly sampled days.

*4) Daily density profile Melbourne (2021) :*

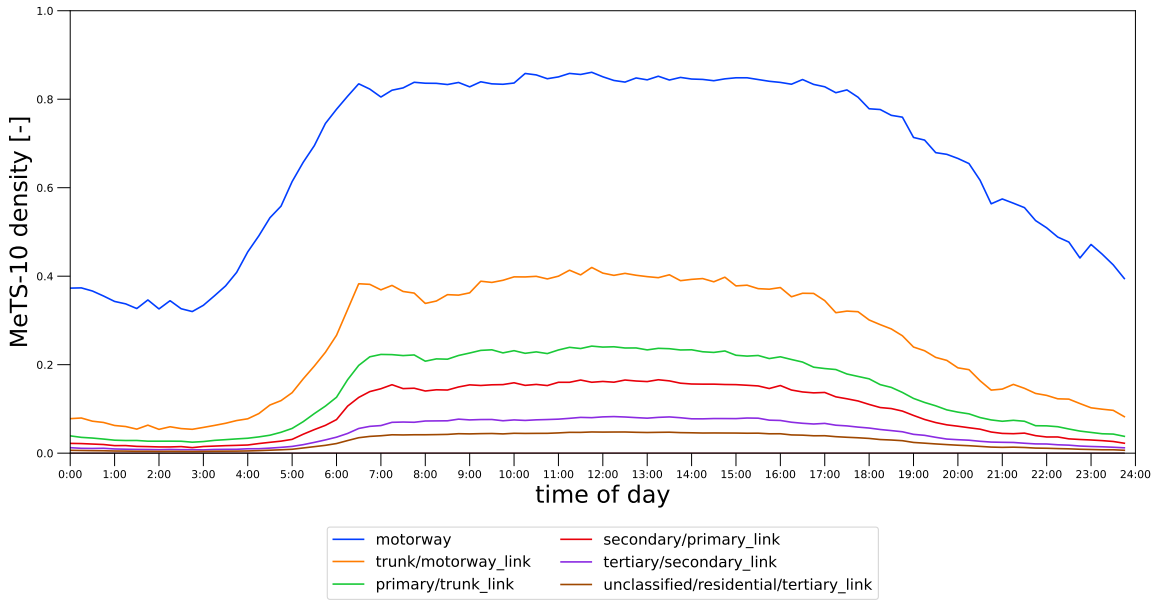



Fig. 40: Daily density profile for different road types for Melbourne . Data from 20 randomly sampled days.

*5) Daily speed profile Melbourne (2021) :*

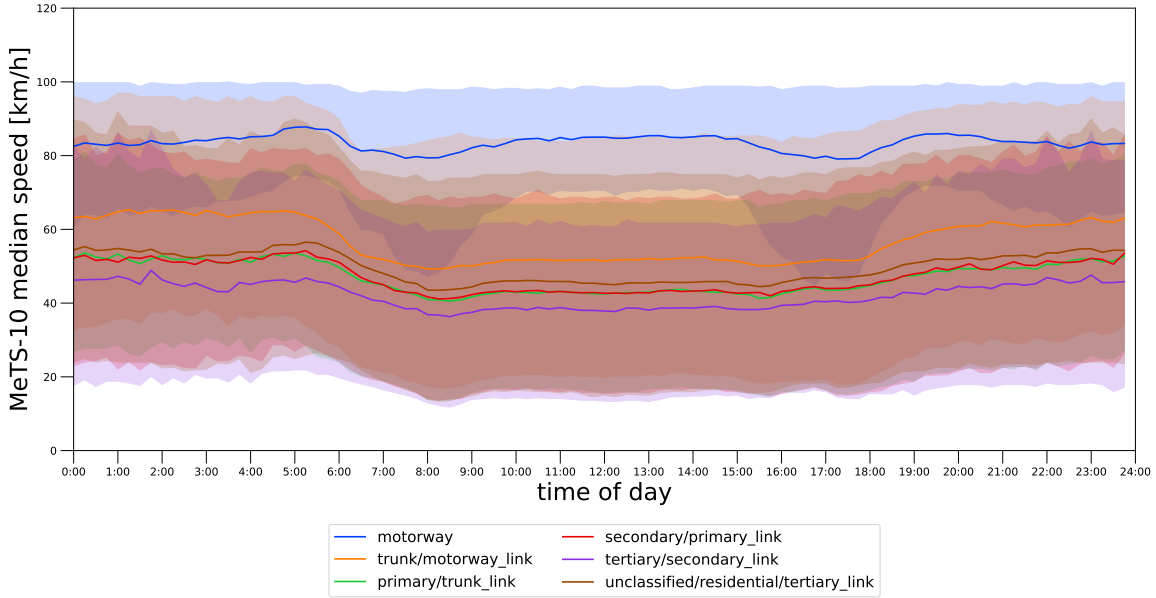



Fig. 41: Daily median 15 min speeds of all intersecting cells profile for different road types for Melbourne . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

### H. Key Figures Moscow (2021)

#### 1) Road graph map Moscow (2021):

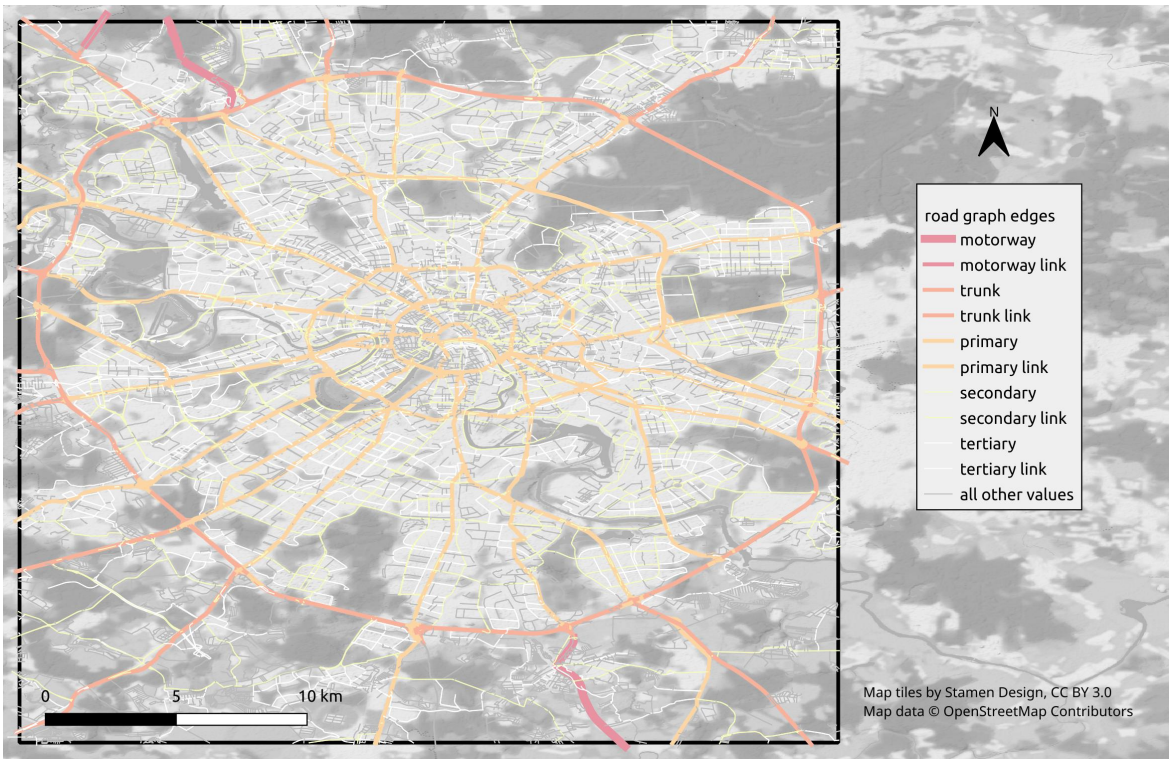



Fig. 42: Road graph Moscow, OSM color scheme (2021).

#### 2) Static data Moscow (2021) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 37.358–37.853 / 55.506–55.942 | |
| num_edges | | | | | | 47'877 | |
| motorway | | | | | | 14 | |
| trunk | | | | | | 653 | |
| trunk_link | | | | | | 150 | |
| primary | | | | | | 2766 | |
| primary_link | | | | | | 575 | |
| secondary | | | | | | 9406 | |
| secondary_link | | | | | | 1461 | |
| tertiary | | | | | | 11198 | |
| tertiary_link | | | | | | 806 | |
| unclassified | | | | | | 6407 | |
| residential | | | | | | 14441 | |
| num_nodes | | | | | | 22627 | |
| num_edges_per_cell | 1.0 | 0.2 | 1.0 | 1.0 | 2.0 | 293'771 | |
| num_intersecting_cells | 6.3 | 6.2 | 4.0 | 1.0 | 30.0 | 47'877 | |
| node_degree | 2.9 | 0.8 | 3.0 | 1.0 | 4.0 | 22'627 | |
| length_meters | 227.8 | 280.2 | 140.5 | 7.6 | 1'272.5 | 47'877 | 1.1e+07 |
| motorway | 1'970.2 | 1'889.5 | 869.5 | 175.3 | 4'800.2 | 14 | 2.8e+04 |
| trunk | 561.1 | 840.2 | 293.3 | 18.5 | 3'519.5 | 653 | 3.7e+05 |
| trunk_link | 363.9 | 332.4 | 268.5 | 15.6 | 1'560.7 | 150 | 5.5e+04 |
| primary | 294.2 | 371.6 | 174.6 | 8.3 | 1'723.0 | 2'766 | 8.1e+05 |
| primary_link | 238.1 | 242.6 | 164.0 | 9.4 | 1'165.3 | 575 | 1.4e+05 |
| secondary | 209.8 | 255.6 | 115.8 | 6.2 | 1'204.2 | 9'406 | 2.0e+06 |
| secondary_link | 138.4 | 165.0 | 75.8 | 9.2 | 810.4 | 1'461 | 2.0e+05 |
| tertiary | 231.5 | 270.7 | 134.7 | 7.8 | 1'276.1 | 11'198 | 2.6e+06 |
| tertiary_link | 97.5 | 123.9 | 54.8 | 8.5 | 619.4 | 806 | 7.9e+04 |
| unclassified | 220.6 | 277.7 | 131.1 | 6.5 | 1'348.2 | 6'407 | 1.4e+06 |
| residential | 224.9 | 217.1 | 161.8 | 8.8 | 1'070.7 | 14'441 | 3.2e+06 |
| speed_kph | 48.6 | 11.3 | 49.0 | 20.0 | 94.7 | 47'877 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| motorway | 71.1 | 16.4 | 73.2 | 40.0 | 105.2 | 14 |
| trunk | 94.1 | 12.0 | 100.0 | 50.0 | 110.0 | 653 |
| trunk_link | 54.1 | 5.6 | 54.5 | 30.0 | 60.0 | 150 |
| primary | 73.8 | 6.5 | 74.1 | 50.0 | 90.0 | 2’766 |
| primary_link | 45.2 | 4.7 | 45.1 | 27.4 | 60.0 | 575 |
| secondary | 53.5 | 5.5 | 53.5 | 30.0 | 60.0 | 9’406 |
| secondary_link | 50.6 | 3.8 | 50.4 | 40.0 | 60.0 | 1’461 |
| tertiary | 49.6 | 5.3 | 49.0 | 30.0 | 60.0 | 11’198 |
| tertiary_link | 52.6 | 3.2 | 52.4 | 40.0 | 60.0 | 806 |
| unclassified | 36.9 | 5.3 | 36.6 | 20.0 | 60.0 | 6’407 |
| residential | 42.5 | 4.5 | 42.6 | 20.0 | 60.0 | 14’441 |
| free_flow_kph | 35.4 | 15.8 | 32.5 | 8.9 | 79.8 | 47’501 |
| motorway | 93.0 | 9.7 | 92.0 | 76.9 | 105.9 | 14 |
| trunk | 73.8 | 10.7 | 76.5 | 43.5 | 92.4 | 653 |
| trunk_link | 63.0 | 11.7 | 62.4 | 37.2 | 85.0 | 150 |
| primary | 51.6 | 12.5 | 51.8 | 23.4 | 77.2 | 2’766 |
| primary_link | 53.4 | 13.3 | 53.9 | 22.1 | 82.1 | 575 |
| secondary | 41.5 | 12.5 | 40.5 | 19.6 | 72.9 | 9’406 |
| secondary_link | 47.1 | 15.3 | 47.4 | 14.6 | 81.8 | 1’461 |
| tertiary | 35.9 | 11.9 | 34.0 | 16.5 | 73.2 | 11’198 |
| tertiary_link | 44.3 | 18.0 | 42.8 | 11.8 | 83.3 | 806 |
| unclassified | 29.4 | 14.1 | 26.4 | 7.1 | 73.8 | 6’363 |
| residential | 25.7 | 12.3 | 23.3 | 6.6 | 68.2 | 14’109 |
| free_flow_kph-speed_kph | -13.3 | 14.2 | -15.6 | -40.4 | 28.8 | 47’501 |
| motorway | 21.9 | 22.0 | 18.6 | -12.9 | 65.9 | 14 |
| trunk | -20.3 | 12.1 | -20.9 | -47.6 | 11.5 | 653 |
| trunk_link | 8.9 | 12.9 | 7.7 | -19.7 | 37.0 | 150 |
| primary | -22.2 | 12.1 | -21.0 | -50.8 | 1.8 | 2’766 |
| primary_link | 8.2 | 14.0 | 8.7 | -25.1 | 37.2 | 575 |
| secondary | -12.0 | 13.2 | -13.0 | -36.3 | 20.9 | 9’406 |
| secondary_link | -3.5 | 15.5 | -3.3 | -35.8 | 33.8 | 1’461 |
| tertiary | -13.7 | 12.6 | -15.4 | -36.7 | 24.4 | 11’198 |
| tertiary_link | -8.4 | 18.0 | -9.6 | -40.6 | 31.0 | 806 |
| unclassified | -7.5 | 14.5 | -10.2 | -35.1 | 36.8 | 6’363 |
| residential | -16.8 | 13.0 | -19.5 | -38.3 | 26.3 | 14’109 |

TABLE XII: Key figures Moscow for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Moscow (2021):*


Fig. 43: Segment-wise density 8am–6pm Moscow from 20 randomly sampled days.

*4) Daily density profile Moscow (2021) :*

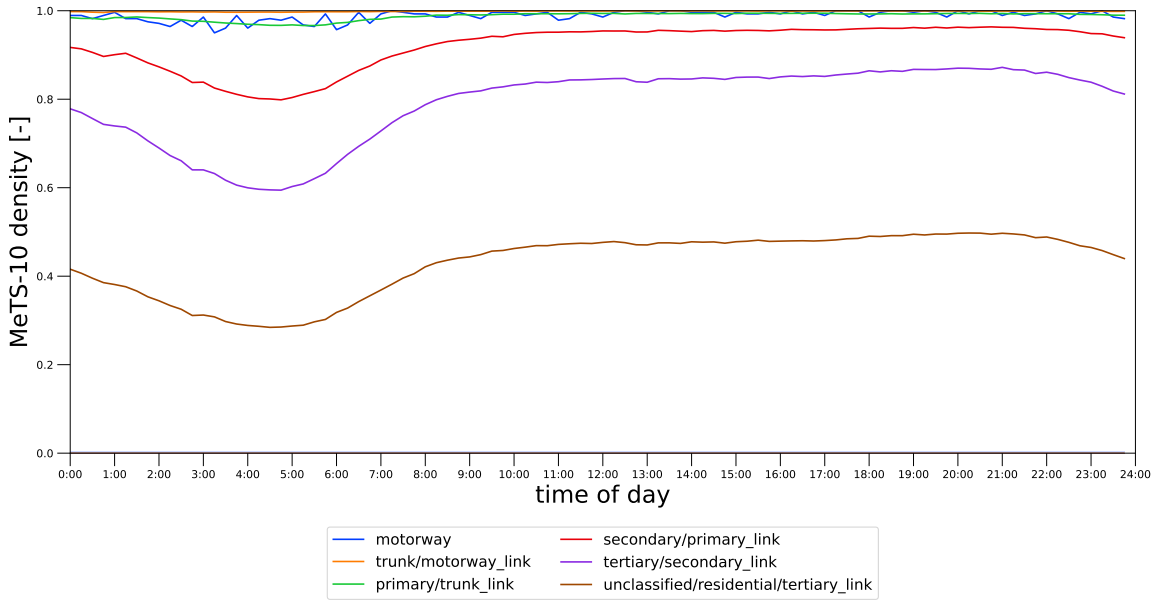



Fig. 44: Daily density profile for different road types for Moscow . Data from 20 randomly sampled days.

*5) Daily speed profile Moscow (2021) :*

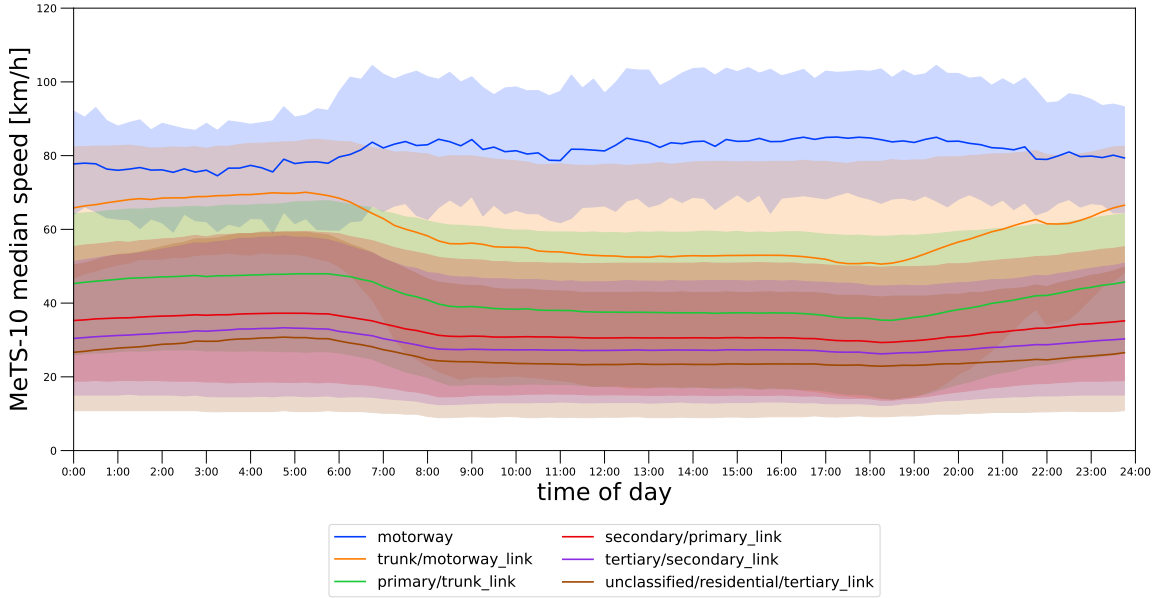



Fig. 45: Daily median 15 min speeds of all intersecting cells profile for different road types for Moscow . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

## I. Key Figures London (2022)

### 1) Road graph map London (2022):

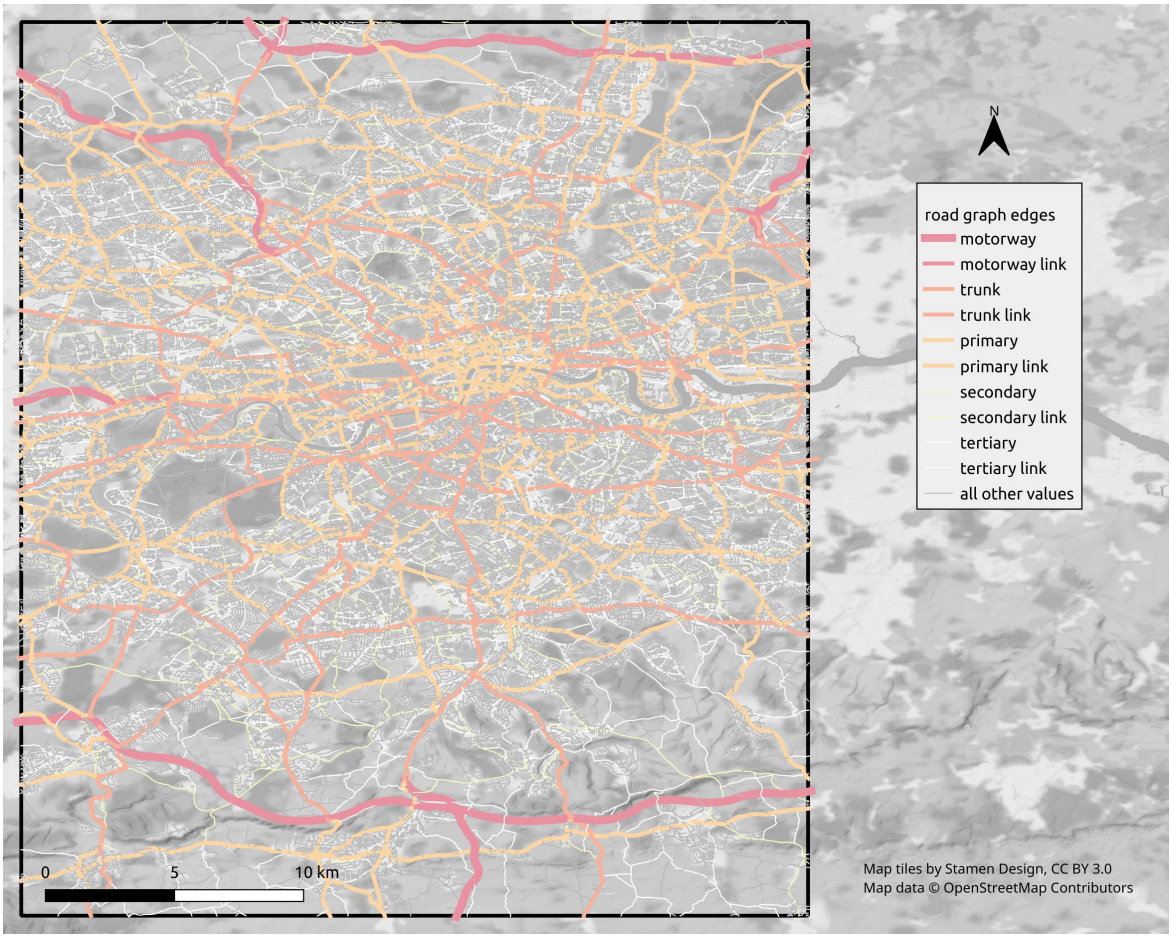



Fig. 46: Road graph London, OSM color scheme (2022).

### 2) Static data London (2022) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | -0.369–0.067 / 51.205–51.7 | |
| num_edges | | | | | | 271’075 | |
| motorway | | | | | | 79 | |
| motorway_link | | | | | | 82 | |
| trunk | | | | | | 8629 | |
| trunk_link | | | | | | 686 | |
| primary | | | | | | 25189 | |
| primary_link | | | | | | 411 | |
| secondary | | | | | | 11275 | |
| secondary_link | | | | | | 110 | |
| tertiary | | | | | | 23878 | |
| tertiary_link | | | | | | 124 | |
| unclassified | | | | | | 16513 | |
| residential | | | | | | 184099 | |
| num_nodes | | | | | | 116304 | |
| num_edges_per_cell | 1.1 | 0.3 | 1.0 | 1.0 | 3.0 | 912’914 | |
| num_intersecting_cells | 3.6 | 3.0 | 3.0 | 1.0 | 13.0 | 271’075 | |
| node_degree | 2.5 | 0.9 | 3.0 | 1.0 | 4.0 | 116’304 | |
| length_meters | 98.6 | 127.4 | 69.4 | 5.2 | 496.3 | 271’075 | 2.7e+07 |
| motorway | 2’516.4 | 2’181.2 | 1’699.3 | 332.5 | 10’264.8 | 79 | 2.0e+05 |
| motorway_link | 520.9 | 373.5 | 463.0 | 28.6 | 1’615.7 | 82 | 4.3e+04 |
| trunk | 114.3 | 205.3 | 57.4 | 3.7 | 1’001.6 | 8’629 | 9.9e+05 |
| trunk_link | 124.8 | 135.0 | 56.8 | 6.6 | 521.9 | 686 | 8.6e+04 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 83.2 | 116.4 | 56.4 | 3.6 | 505.1 | 25’189 | 2.1e+06 |
| primary_link | 40.8 | 48.2 | 28.1 | 6.2 | 242.2 | 411 | 1.7e+04 |
| secondary | 96.8 | 131.4 | 66.5 | 3.9 | 597.7 | 11’275 | 1.1e+06 |
| secondary_link | 28.3 | 21.2 | 24.9 | 7.2 | 119.8 | 110 | 3.1e+03 |
| tertiary | 112.9 | 166.6 | 73.2 | 5.0 | 835.6 | 23’878 | 2.7e+06 |
| tertiary_link | 40.4 | 34.5 | 29.9 | 8.1 | 189.0 | 124 | 5.0e+03 |
| unclassified | 117.2 | 188.0 | 68.2 | 5.1 | 943.9 | 16’513 | 1.9e+06 |
| residential | 95.5 | 85.8 | 71.6 | 6.1 | 402.9 | 184’099 | 1.8e+07 |
| speed_kph | 36.8 | 7.9 | 32.2 | 32.2 | 64.4 | 271’075 | |
| motorway | 106.2 | 15.6 | 112.7 | 60.9 | 112.7 | 79 | |
| motorway_link | 104.4 | 16.6 | 112.7 | 48.3 | 112.7 | 82 | |
| trunk | 51.1 | 12.4 | 48.3 | 32.2 | 96.6 | 8’629 | |
| trunk_link | 57.0 | 14.3 | 48.3 | 32.2 | 112.7 | 686 | |
| primary | 42.0 | 9.6 | 48.3 | 32.2 | 64.4 | 25’189 | |
| primary_link | 44.2 | 8.1 | 48.3 | 32.2 | 64.4 | 411 | |
| secondary | 38.9 | 8.5 | 32.2 | 32.2 | 64.4 | 11’275 | |
| secondary_link | 39.4 | 8.5 | 40.0 | 32.2 | 64.4 | 110 | |
| tertiary | 38.5 | 8.4 | 32.2 | 32.2 | 64.4 | 23’878 | |
| tertiary_link | 46.1 | 11.9 | 47.0 | 32.2 | 96.6 | 124 | |
| unclassified | 35.4 | 6.9 | 32.2 | 24.1 | 64.4 | 16’513 | |
| residential | 35.1 | 5.5 | 32.2 | 32.2 | 48.3 | 184’099 | |
| free_flow_kph | 30.0 | 11.8 | 28.7 | 6.8 | 68.7 | 263’309 | |
| motorway | 104.3 | 14.4 | 110.4 | 60.6 | 118.3 | 79 | |
| motorway_link | 92.3 | 20.2 | 99.0 | 36.6 | 117.6 | 82 | |
| trunk | 39.5 | 12.9 | 36.2 | 19.2 | 81.8 | 8’629 | |
| trunk_link | 53.5 | 20.7 | 57.9 | 13.6 | 85.9 | 682 | |
| primary | 35.3 | 9.6 | 32.9 | 17.9 | 64.9 | 25’189 | |
| primary_link | 31.6 | 14.3 | 28.7 | 8.9 | 76.6 | 411 | |
| secondary | 34.9 | 9.7 | 32.9 | 17.9 | 65.9 | 11’275 | |
| secondary_link | 27.4 | 9.4 | 26.8 | 4.7 | 50.3 | 110 | |
| tertiary | 35.0 | 10.2 | 32.9 | 17.9 | 67.3 | 23’872 | |
| tertiary_link | 34.7 | 14.0 | 30.2 | 18.0 | 76.7 | 124 | |
| unclassified | 28.0 | 13.0 | 26.4 | 6.1 | 72.0 | 16’213 | |
| residential | 27.8 | 11.1 | 26.8 | 5.6 | 63.1 | 176’643 | |
| free_flow_kph-speed_kph | -6.9 | 11.5 | -6.4 | -33.7 | 27.5 | 263’309 | |
| motorway | -1.9 | 12.5 | -1.6 | -33.7 | 35.9 | 79 | |
| motorway_link | -12.1 | 17.4 | -11.1 | -68.8 | 13.2 | 82 | |
| trunk | -11.6 | 10.6 | -11.4 | -45.7 | 10.9 | 8’629 | |
| trunk_link | -3.5 | 18.8 | -3.6 | -45.6 | 32.6 | 682 | |
| primary | -6.7 | 10.0 | -5.5 | -30.5 | 16.5 | 25’189 | |
| primary_link | -12.5 | 14.2 | -15.6 | -36.0 | 28.4 | 411 | |
| secondary | -4.0 | 9.5 | -3.5 | -27.6 | 20.4 | 11’275 | |
| secondary_link | -12.1 | 10.5 | -11.0 | -35.3 | 10.6 | 110 | |
| tertiary | -3.5 | 9.6 | -3.5 | -26.7 | 23.8 | 23’872 | |
| tertiary_link | -11.4 | 16.8 | -12.3 | -69.8 | 28.5 | 124 | |
| unclassified | -7.3 | 12.8 | -8.2 | -33.7 | 33.0 | 16’213 | |
| residential | -7.2 | 11.7 | -7.3 | -33.7 | 28.5 | 176’643 | |

TABLE XIII: Key figures London for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map London (2022):*

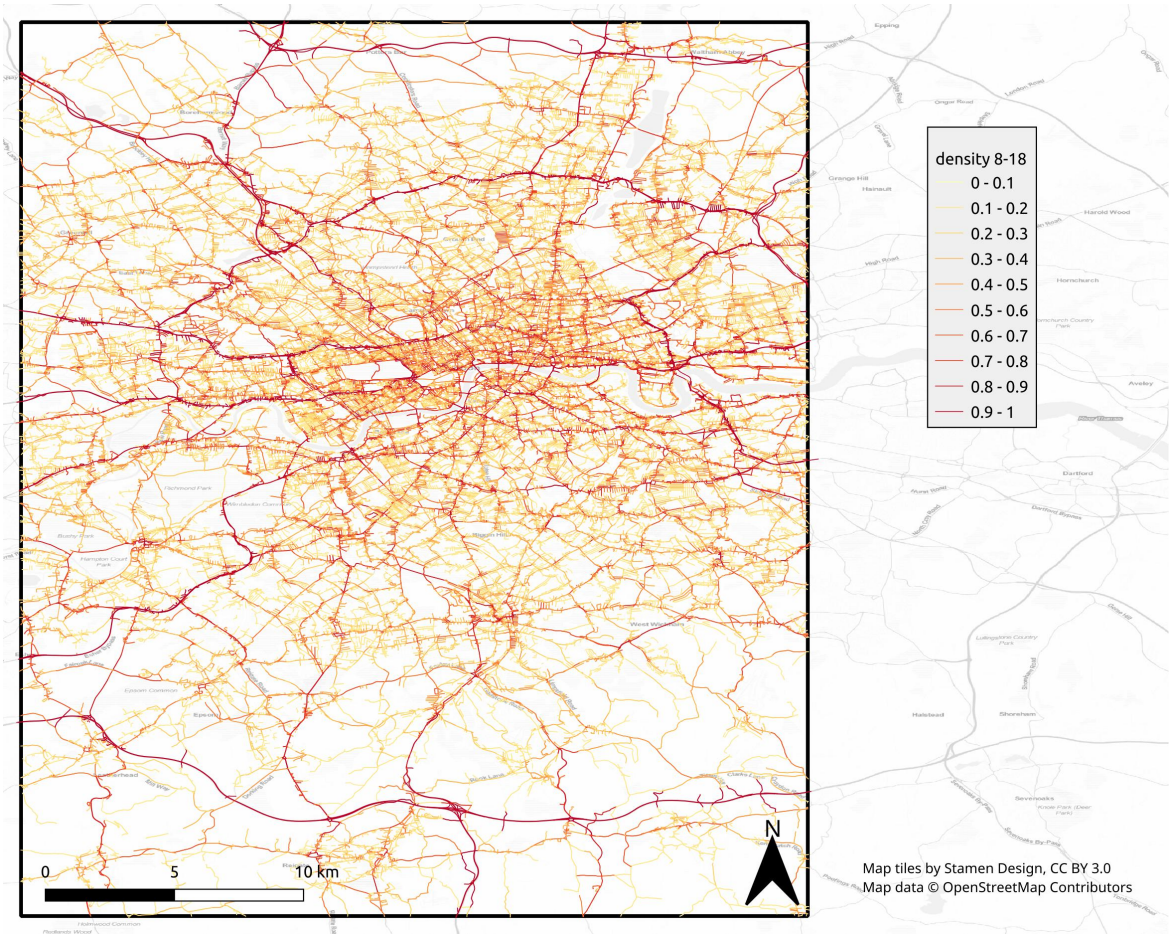



Fig. 47: Segment-wise density 8am–6pm London from 20 randomly sampled days.

*4) Daily density profile London (2022) :*

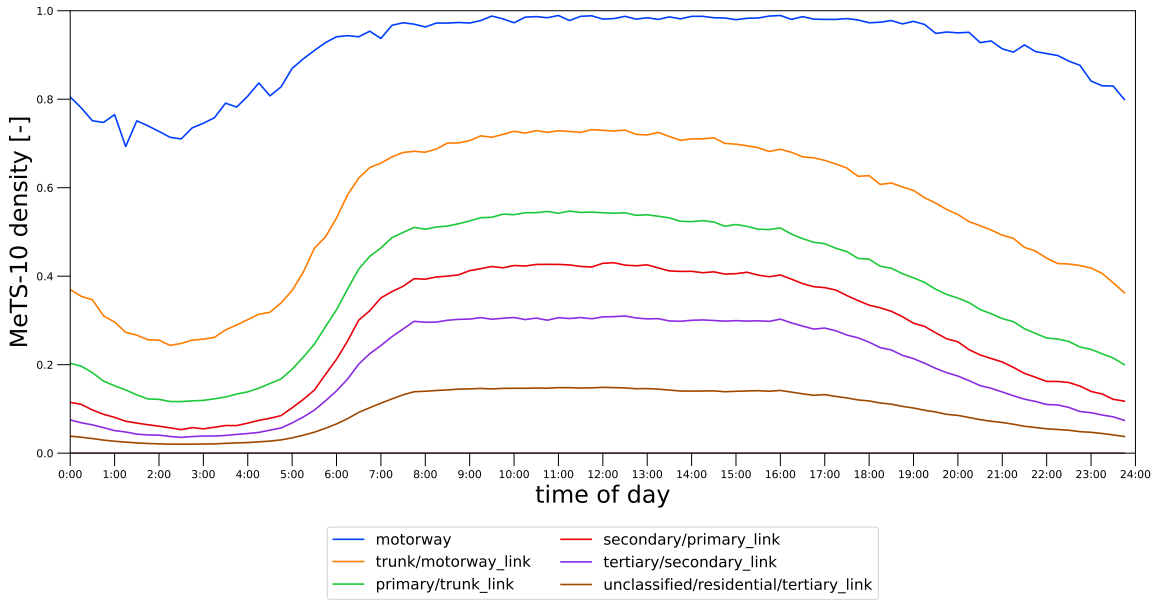



Fig. 48: Daily density profile for different road types for London . Data from 20 randomly sampled days.

*5) Daily speed profile London (2022) :*

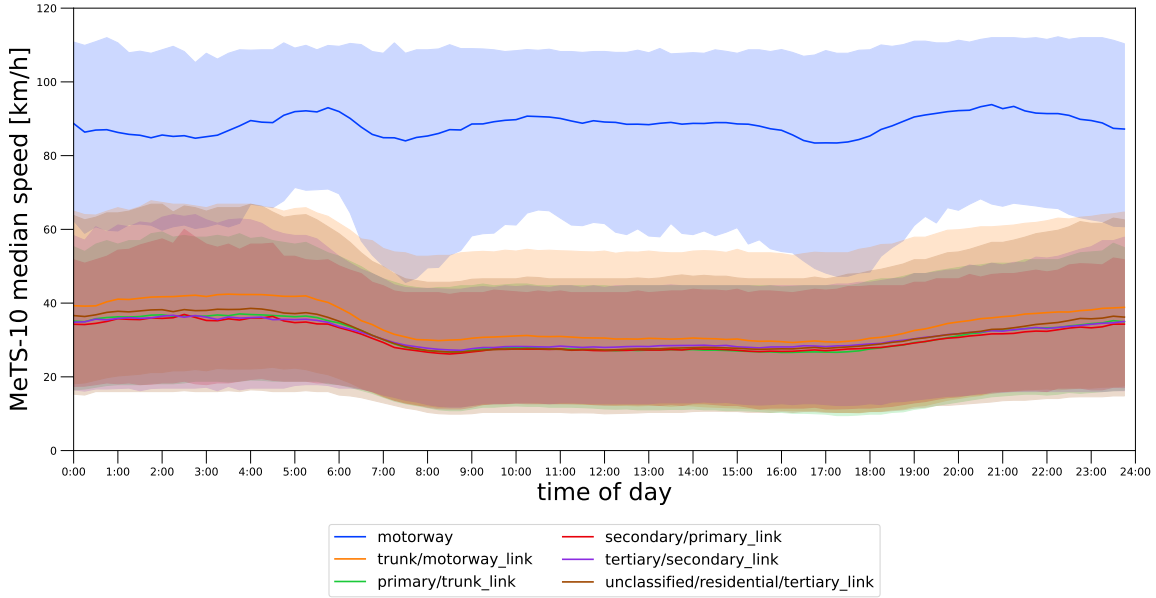



Fig. 49: Daily median 15 min speeds of all intersecting cells profile for different road types for London . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

## J. Key Figures Madrid (2022)

### 1) Road graph map Madrid (2022):


Fig. 50: Road graph Madrid, OSM color scheme (2022).

### 2) Static data Madrid (2022) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | -3.927—3.491 / 40.177–40.672 | |
| num_edges | | | | | | 143’402 | |
| motorway | | | | | | 1277 | |
| motorway_link | | | | | | 2647 | |
| trunk | | | | | | 1017 | |
| trunk_link | | | | | | 373 | |
| primary | | | | | | 6265 | |
| primary_link | | | | | | 475 | |
| secondary | | | | | | 6855 | |
| secondary_link | | | | | | 276 | |
| tertiary | | | | | | 16147 | |
| tertiary_link | | | | | | 310 | |
| unclassified | | | | | | 5669 | |
| residential | | | | | | 102091 | |
| num_nodes | | | | | | 71757 | |
| num_edges_per_cell | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 467’013 | |
| num_intersecting_cells | 3.5 | 3.7 | 3.0 | 1.0 | 16.0 | 143’402 | |
| node_degree | 3.0 | 0.7 | 3.0 | 1.0 | 4.0 | 71’757 | |
| length_meters | 110.2 | 193.2 | 66.0 | 4.7 | 776.8 | 143’402 | 1.6e+07 |
| motorway | 878.7 | 842.8 | 660.3 | 13.2 | 4’440.7 | 1’277 | 1.1e+06 |
| motorway_link | 343.5 | 287.4 | 286.5 | 15.6 | 1’344.9 | 2’647 | 9.1e+05 |
| trunk | 254.4 | 483.3 | 60.4 | 4.9 | 2’285.9 | 1’017 | 2.6e+05 |
| trunk_link | 227.4 | 235.6 | 175.3 | 12.4 | 923.6 | 373 | 8.5e+04 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 130.1 | 335.0 | 44.6 | 3.3 | 1’346.9 | 6’265 | 8.1e+05 |
| primary_link | 132.5 | 135.1 | 85.7 | 8.1 | 654.7 | 475 | 6.3e+04 |
| secondary | 94.2 | 247.8 | 41.0 | 3.2 | 686.8 | 6’855 | 6.5e+05 |
| secondary_link | 73.9 | 94.8 | 38.2 | 6.0 | 420.4 | 276 | 2.0e+04 |
| tertiary | 88.6 | 147.2 | 45.6 | 3.2 | 602.5 | 16’147 | 1.4e+06 |
| tertiary_link | 77.3 | 112.8 | 35.7 | 6.5 | 581.5 | 310 | 2.4e+04 |
| unclassified | 169.9 | 331.4 | 76.3 | 5.6 | 1’687.0 | 5’669 | 9.6e+05 |
| residential | 92.7 | 92.4 | 68.0 | 5.2 | 452.5 | 102’091 | 9.5e+06 |
| speed_kph | 68.6 | 1’334.2 | 76.6 | 20.0 | 151.3 | 143’402 | |
| motorway | 98.1 | 15.5 | 100.0 | 50.0 | 120.0 | 1’277 | |
| motorway_link | 60.4 | 13.0 | 59.2 | 40.0 | 100.0 | 2’647 | |
| trunk | 63.8 | 19.1 | 71.2 | 30.0 | 100.0 | 1’017 | |
| trunk_link | 52.8 | 9.2 | 52.1 | 40.0 | 82.8 | 373 | |
| primary | 87.7 | 50.7 | 50.0 | 30.0 | 151.3 | 6’265 | |
| primary_link | 48.9 | 6.8 | 49.0 | 40.0 | 90.0 | 475 | |
| secondary | 56.5 | 120.6 | 61.3 | 30.0 | 70.0 | 6’855 | |
| secondary_link | 45.1 | 4.7 | 45.3 | 30.0 | 60.0 | 276 | |
| tertiary | 44.6 | 5.8 | 44.8 | 20.0 | 50.0 | 16’147 | |
| tertiary_link | 41.7 | 5.7 | 41.8 | 20.0 | 60.0 | 310 | |
| unclassified | 40.6 | 4.2 | 40.5 | 20.0 | 60.0 | 5’669 | |
| residential | 73.8 | 1’580.9 | 76.6 | 20.0 | 76.6 | 102’091 | |
| free_flow_kph | 34.8 | 17.9 | 30.6 | 9.9 | 101.2 | 141’365 | |
| motorway | 93.3 | 15.4 | 95.2 | 51.2 | 120.0 | 1’277 | |
| motorway_link | 86.7 | 18.0 | 90.4 | 32.1 | 120.0 | 2’645 | |
| trunk | 57.1 | 24.0 | 49.4 | 24.0 | 102.7 | 1’017 | |
| trunk_link | 76.8 | 18.3 | 81.4 | 28.7 | 105.7 | 373 | |
| primary | 42.2 | 15.9 | 38.6 | 17.9 | 95.2 | 6’261 | |
| primary_link | 61.4 | 24.2 | 61.6 | 10.7 | 101.0 | 474 | |
| secondary | 37.9 | 13.3 | 35.3 | 18.4 | 88.8 | 6’855 | |
| secondary_link | 49.6 | 20.1 | 46.6 | 9.1 | 87.9 | 272 | |
| tertiary | 36.2 | 13.6 | 33.9 | 16.9 | 91.9 | 16’144 | |
| tertiary_link | 47.3 | 22.0 | 41.9 | 11.7 | 101.6 | 307 | |
| unclassified | 43.9 | 25.0 | 34.8 | 8.9 | 107.0 | 5’448 | |
| residential | 30.8 | 13.5 | 28.7 | 8.9 | 89.9 | 100’292 | |
| free_flow_kph-speed_kph | -33.7 | 1’343.9 | -36.6 | -108.0 | 46.4 | 141’365 | |
| motorway | -4.8 | 14.1 | -4.6 | -46.5 | 26.0 | 1’277 | |
| motorway_link | 26.3 | 19.5 | 29.3 | -26.3 | 60.8 | 2’645 | |
| trunk | -6.7 | 20.4 | -3.3 | -44.4 | 40.5 | 1’017 | |
| trunk_link | 24.1 | 19.3 | 27.2 | -30.5 | 60.7 | 373 | |
| primary | -45.5 | 50.0 | -18.0 | -129.7 | 23.6 | 6’261 | |
| primary_link | 12.6 | 24.7 | 12.6 | -41.7 | 53.0 | 474 | |
| secondary | -18.6 | 120.7 | -17.5 | -41.9 | 28.3 | 6’855 | |
| secondary_link | 4.5 | 20.0 | 2.3 | -36.8 | 42.4 | 272 | |
| tertiary | -8.3 | 14.5 | -10.9 | -31.2 | 48.1 | 16’144 | |
| tertiary_link | 5.6 | 22.3 | -0.6 | -31.2 | 59.8 | 307 | |
| unclassified | 3.2 | 24.7 | -5.7 | -31.6 | 67.3 | 5’448 | |
| residential | -43.0 | 1’595.0 | -44.6 | -67.0 | 22.7 | 100’292 | |

TABLE XIV: Key figures Madrid for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Madrid (2022):*


Fig. 51: Segment-wise density 8am–6pm Madrid from 20 randomly sampled days.

*4) Daily density profile Madrid (2022) :*

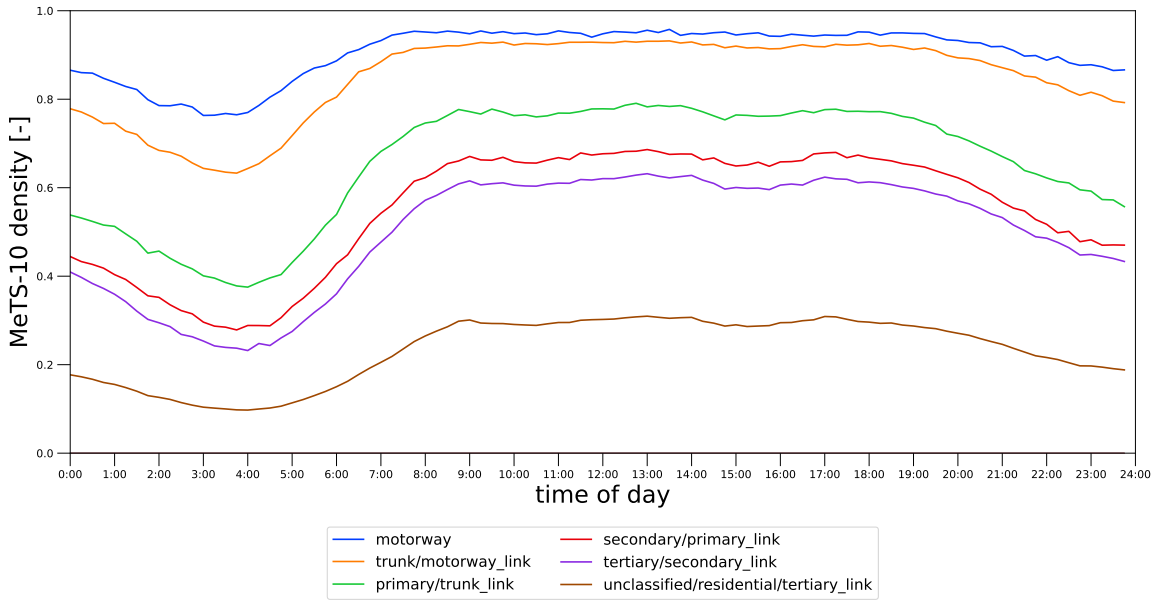



Fig. 52: Daily density profile for different road types for Madrid . Data from 20 randomly sampled days.

*5) Daily speed profile Madrid (2022) :*

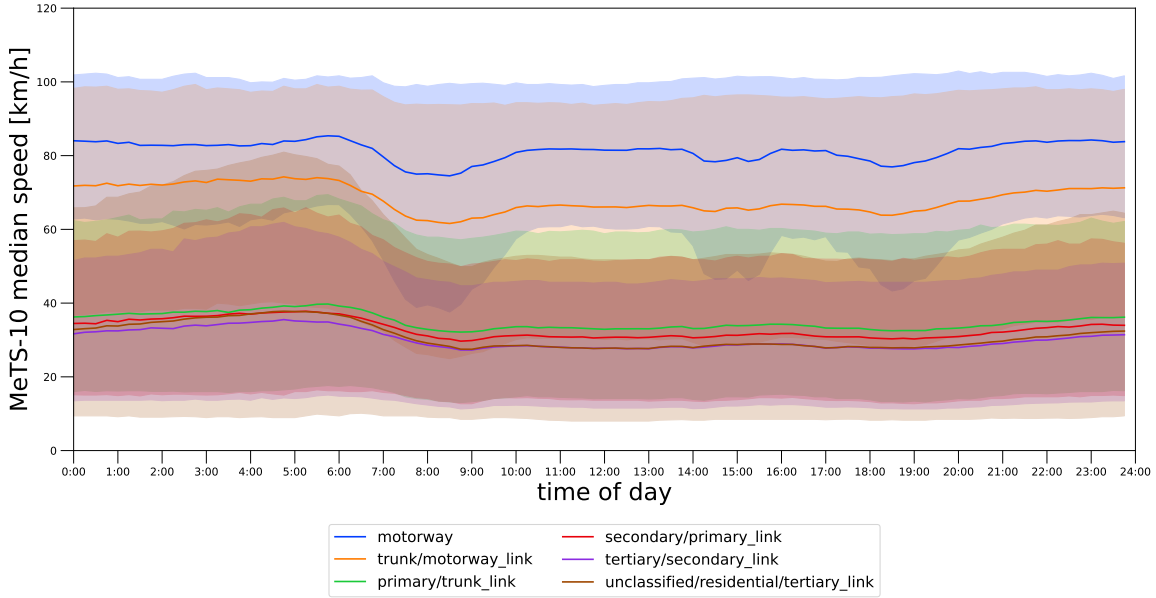



Fig. 53: Daily median 15 min speeds of all intersecting cells profile for different road types for Madrid . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

## K. Key Figures Melbourne (2022)

### 1) Road graph map Melbourne (2022):

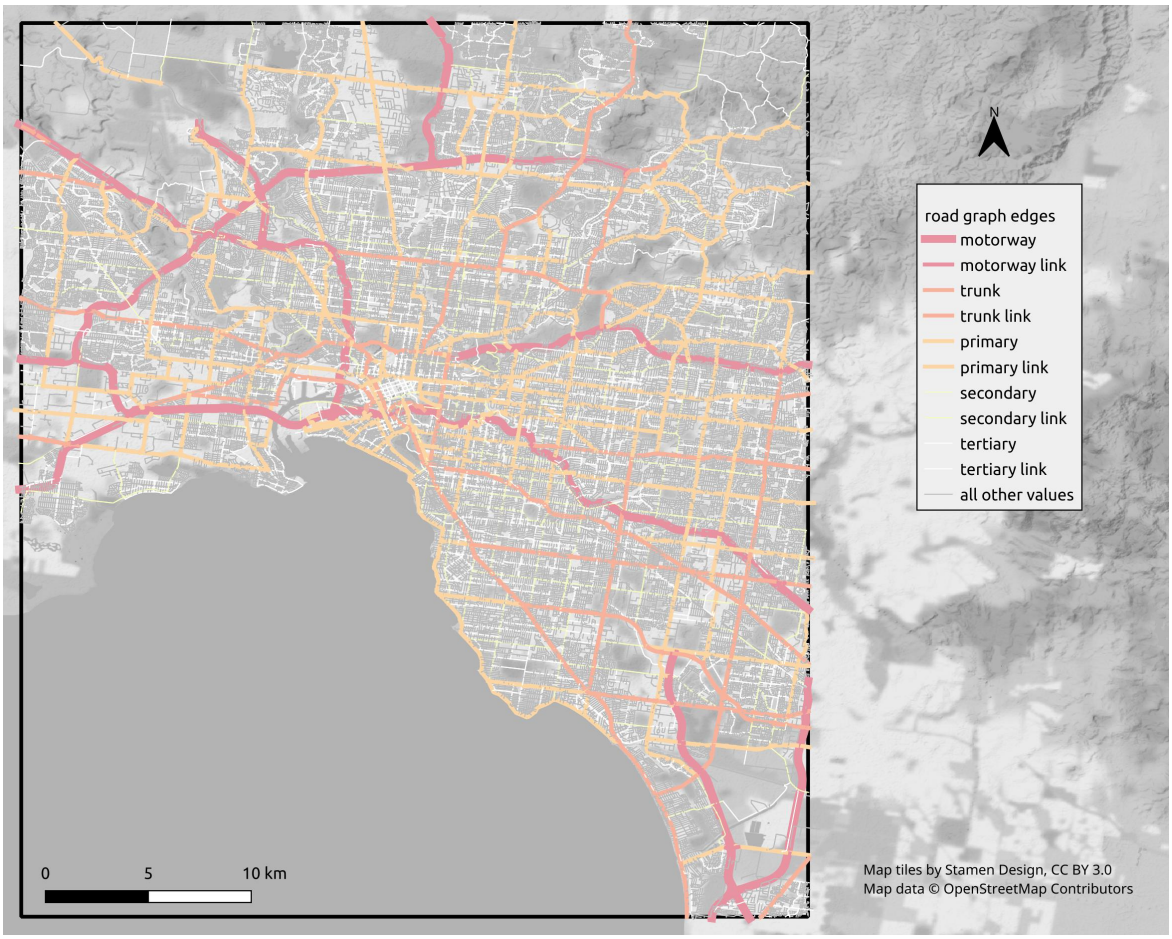



Fig. 54: Road graph Melbourne, OSM color scheme (2022).

### 2) Static data Melbourne (2022) :

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box | | | | | | 144.757–145.193 / -38.106—37.611 | |
| num_edges | | | | | | 230’654 | |
| motorway | | | | | | 354 | |
| motorway_link | | | | | | 896 | |
| trunk | | | | | | 5382 | |
| trunk_link | | | | | | 762 | |
| primary | | | | | | 13913 | |
| primary_link | | | | | | 1574 | |
| secondary | | | | | | 10342 | |
| secondary_link | | | | | | 394 | |
| tertiary | | | | | | 30557 | |
| tertiary_link | | | | | | 1001 | |
| unclassified | | | | | | 7381 | |
| residential | | | | | | 158098 | |
| num_nodes | | | | | | 103062 | |
| num_edges_per_cell | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 891’475 | |
| num_intersecting_cells | 4.2 | 3.1 | 4.0 | 1.0 | 14.0 | 230’654 | |
| node_degree | 2.8 | 0.8 | 3.0 | 1.0 | 4.0 | 103’062 | |
| length_meters | 105.3 | 123.1 | 81.5 | 2.7 | 497.8 | 230’654 | 2.4e+07 |
| motorway | 1’102.6 | 774.5 | 976.5 | 26.1 | 4’090.9 | 354 | 3.9e+05 |
| motorway_link | 260.7 | 318.6 | 102.0 | 10.2 | 1’524.8 | 896 | 2.3e+05 |
| trunk | 105.4 | 139.8 | 68.1 | 3.9 | 657.1 | 5’382 | 5.7e+05 |
| trunk_link | 36.0 | 39.8 | 22.8 | 7.8 | 182.3 | 762 | 2.7e+04 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| primary | 99.3 | 115.6 | 69.4 | 3.0 | 564.1 | 13’913 | 1.4e+06 |
| primary_link | 30.5 | 34.3 | 17.0 | 6.2 | 146.5 | 1’574 | 4.8e+04 |
| secondary | 86.5 | 104.6 | 64.2 | 2.3 | 457.6 | 10’342 | 9.0e+05 |
| secondary_link | 40.3 | 28.6 | 37.1 | 5.1 | 124.3 | 394 | 1.6e+04 |
| tertiary | 78.5 | 111.2 | 54.4 | 1.6 | 421.8 | 30’557 | 2.4e+06 |
| tertiary_link | 22.9 | 24.5 | 12.7 | 2.0 | 105.6 | 1’001 | 2.3e+04 |
| unclassified | 155.5 | 235.7 | 91.0 | 3.7 | 1’068.5 | 7’381 | 1.1e+06 |
| residential | 108.5 | 99.3 | 87.6 | 3.1 | 443.9 | 158’098 | 1.7e+07 |
| speed_kph | 51.1 | 6.8 | 48.7 | 40.0 | 80.0 | 230’654 | |
| motorway | 93.6 | 9.5 | 100.0 | 80.0 | 100.0 | 354 | |
| motorway_link | 77.2 | 11.0 | 78.9 | 50.0 | 100.0 | 896 | |
| trunk | 68.6 | 9.5 | 70.0 | 40.0 | 80.0 | 5’382 | |
| trunk_link | 65.2 | 5.0 | 65.4 | 50.0 | 80.0 | 762 | |
| primary | 62.5 | 8.3 | 60.0 | 40.0 | 80.0 | 13’913 | |
| primary_link | 57.1 | 3.3 | 57.0 | 40.0 | 70.0 | 1’574 | |
| secondary | 58.8 | 5.9 | 60.0 | 40.0 | 80.0 | 10’342 | |
| secondary_link | 59.4 | 2.5 | 59.6 | 50.0 | 70.0 | 394 | |
| tertiary | 51.4 | 5.8 | 51.4 | 40.0 | 70.0 | 30’557 | |
| tertiary_link | 54.4 | 3.0 | 54.6 | 40.0 | 60.0 | 1’001 | |
| unclassified | 49.1 | 4.8 | 49.0 | 20.0 | 60.0 | 7’381 | |
| residential | 48.7 | 2.4 | 48.7 | 40.0 | 50.0 | 158’098 | |
| free_flow_kph | 37.7 | 18.3 | 37.2 | 0.0 | 82.8 | 190’471 | |
| motorway | 87.6 | 15.0 | 94.0 | 16.7 | 99.8 | 354 | |
| motorway_link | 73.0 | 23.1 | 80.0 | 16.9 | 98.8 | 894 | |
| trunk | 54.9 | 13.1 | 56.0 | 25.3 | 77.9 | 5’381 | |
| trunk_link | 44.8 | 20.3 | 46.2 | 0.0 | 80.5 | 748 | |
| primary | 49.8 | 12.9 | 51.8 | 24.0 | 80.0 | 13’906 | |
| primary_link | 45.2 | 19.1 | 44.7 | 1.1 | 92.5 | 1’527 | |
| secondary | 47.6 | 12.6 | 49.9 | 19.6 | 85.6 | 10’326 | |
| secondary_link | 41.7 | 14.5 | 40.9 | 12.3 | 82.6 | 385 | |
| tertiary | 39.5 | 12.2 | 39.1 | 10.1 | 73.9 | 29’809 | |
| tertiary_link | 37.6 | 15.4 | 36.7 | 0.0 | 74.6 | 930 | |
| unclassified | 36.0 | 18.6 | 32.2 | 0.0 | 92.2 | 7’035 | |
| residential | 33.7 | 18.6 | 32.9 | 0.0 | 80.0 | 119’176 | |
| free_flow_kph-speed_kph | -13.9 | 17.0 | -13.8 | -50.0 | 29.9 | 190’471 | |
| motorway | -6.0 | 14.9 | -2.1 | -80.1 | 17.1 | 354 | |
| motorway_link | -4.1 | 23.3 | -1.2 | -62.0 | 37.9 | 894 | |
| trunk | -13.7 | 12.1 | -10.4 | -47.4 | 6.4 | 5’381 | |
| trunk_link | -20.4 | 20.5 | -18.8 | -65.4 | 22.9 | 748 | |
| primary | -12.6 | 12.3 | -9.6 | -43.9 | 18.6 | 13’906 | |
| primary_link | -11.9 | 19.1 | -11.5 | -55.9 | 31.3 | 1’527 | |
| secondary | -11.2 | 12.4 | -9.2 | -39.5 | 30.6 | 10’326 | |
| secondary_link | -17.8 | 14.8 | -18.7 | -49.4 | 23.0 | 385 | |
| tertiary | -11.9 | 11.7 | -11.9 | -42.5 | 19.2 | 29’809 | |
| tertiary_link | -16.8 | 15.3 | -17.5 | -54.6 | 20.2 | 930 | |
| unclassified | -13.1 | 18.9 | -16.5 | -49.0 | 42.7 | 7’035 | |
| residential | -14.8 | 18.7 | -15.5 | -50.0 | 31.9 | 119’176 | |

TABLE XV: Key figures Melbourne for the generated data from 20 randomly sampled days. **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Segment density map Melbourne (2022):*

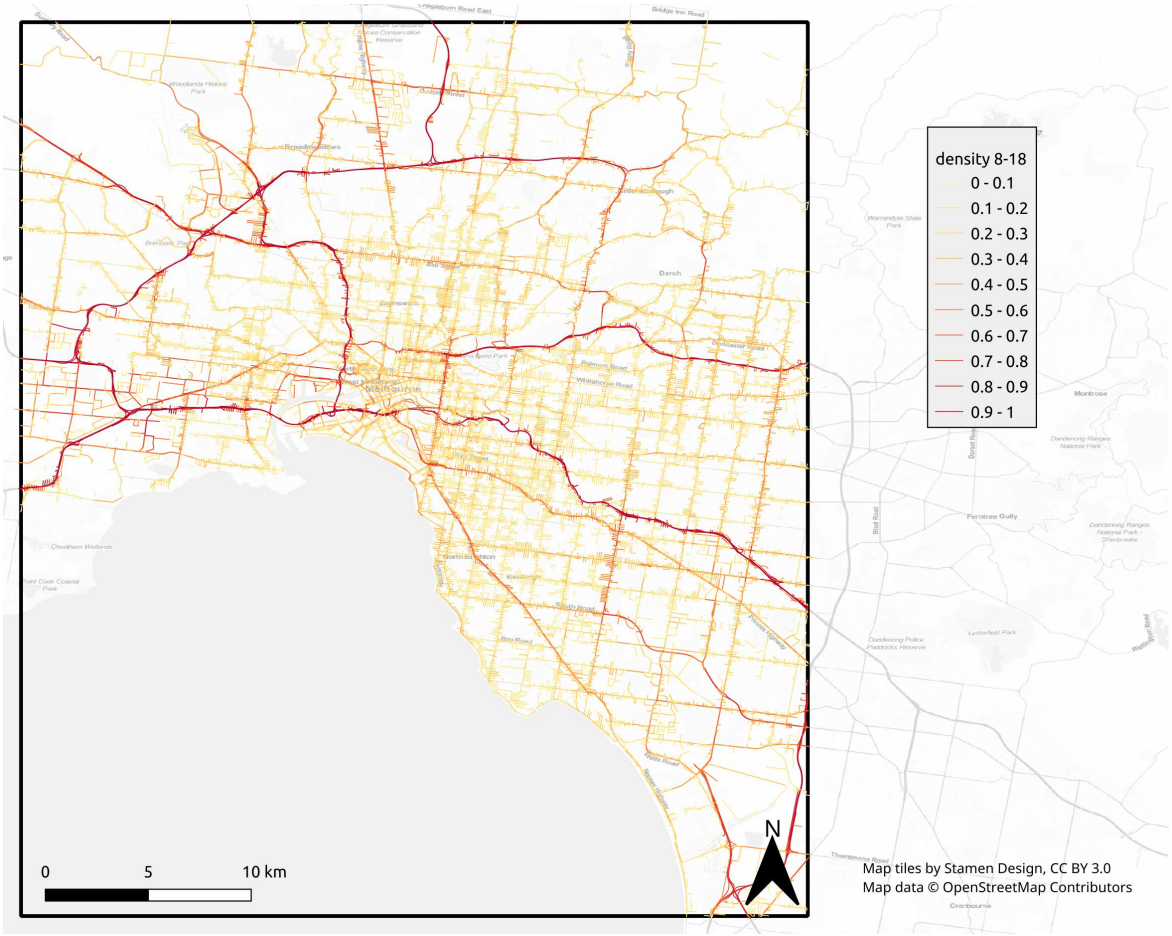



Fig. 55: Segment-wise density 8am–6pm Melbourne from 20 randomly sampled days.

*4) Daily density profile Melbourne (2022) :*

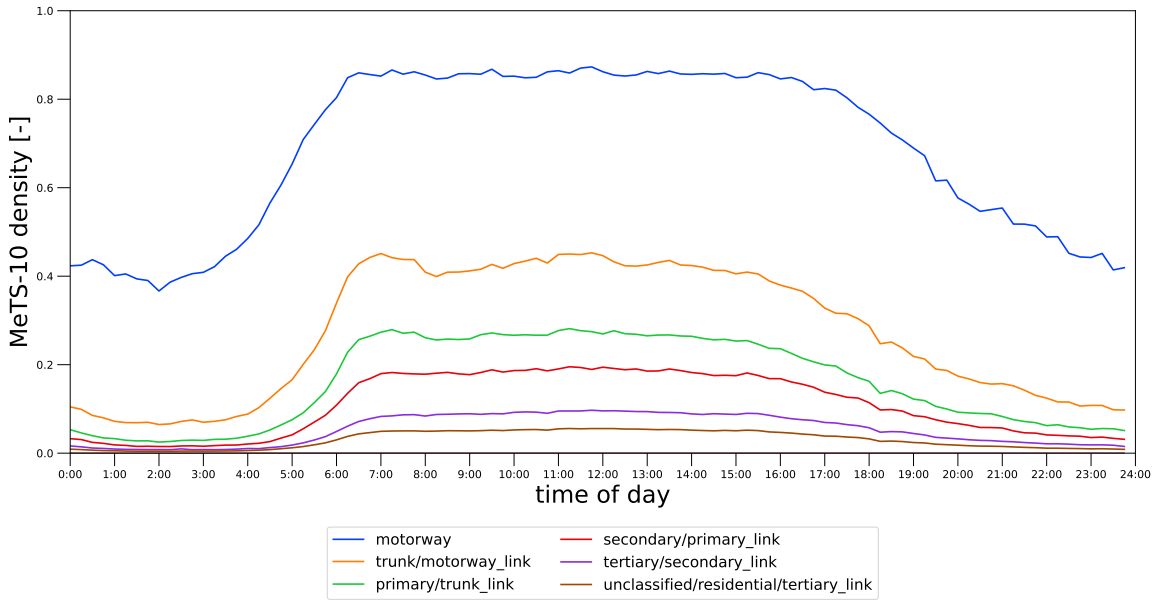



Fig. 56: Daily density profile for different road types for Melbourne . Data from 20 randomly sampled days.

*5) Daily speed profile Melbourne (2022) :*

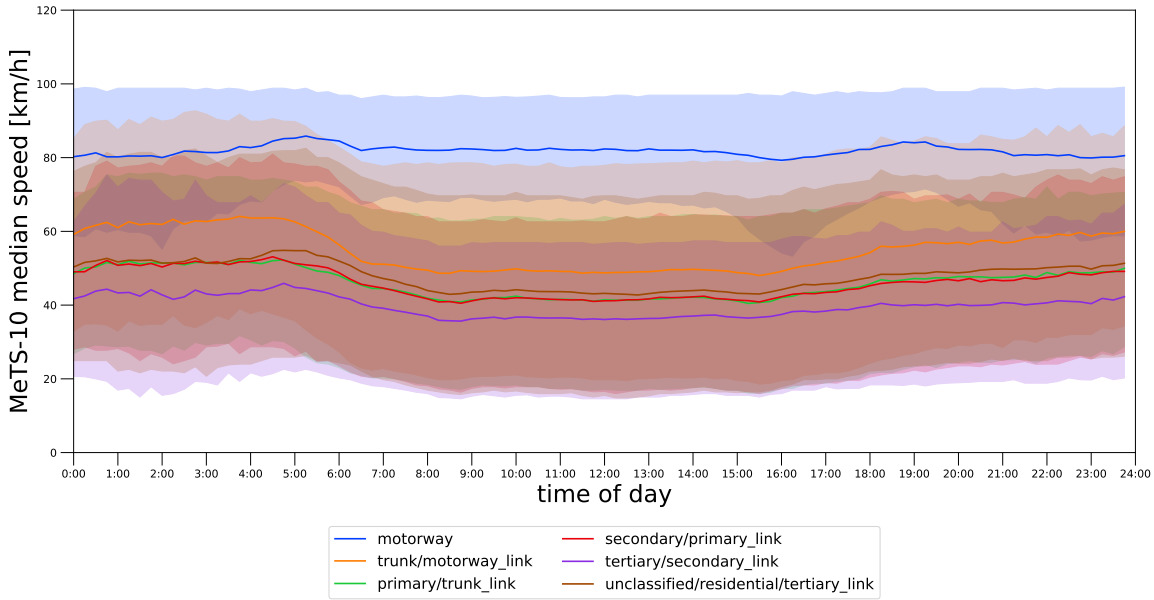



Fig. 57: Daily median 15 min speeds of all intersecting cells profile for different road types for Melbourne . The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

# SUPPLEMENT G
# KEY FIGURES UBER VALIDATION HISTORIC ROAD GRAPH

## A. Key Figures London

### 1) Road graph map London:

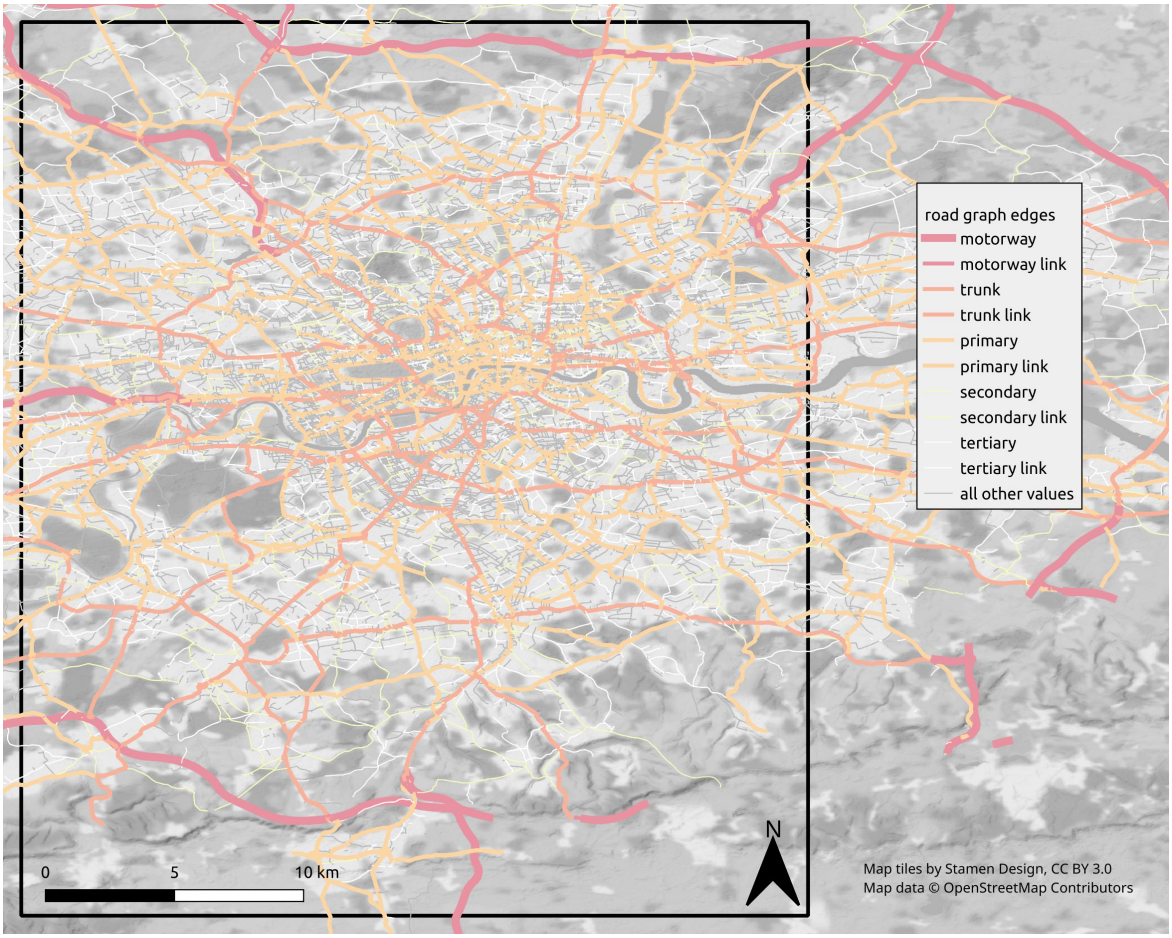



Fig. 58: Road graph London, OSM color scheme.

### 2) Static data London (full historic road graph):

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box (full historic road graph) | | | | | | -0.369–0.067 / 51.205–51.7 | |
| num_edges (full historic road graph) | | | | | | 234'308 | |
| motorway | | | | | | 1520 | |
| motorway_link | | | | | | 894 | |
| trunk | | | | | | 17347 | |
| trunk_link | | | | | | 1600 | |
| primary | | | | | | 62005 | |
| primary_link | | | | | | 907 | |
| secondary | | | | | | 28003 | |
| secondary_link | | | | | | 135 | |
| tertiary | | | | | | 59977 | |
| tertiary_link | | | | | | 257 | |
| unclassified | | | | | | 12447 | |
| residential | | | | | | 49110 | |
| living_street | | | | | | 58 | |
| service | | | | | | 44 | |
| cycleway | | | | | | 1 | |
| road | | | | | | 2 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| construction | | | | | | 1 | |
| num_nodes (full historic road graph) | | | | | | 140412 | |
| num_edges_per_cell (full historic road graph) | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 355’950 | |
| num_intersecting_cells (full historic road graph) | 1.7 | 2.2 | 1.0 | 0.0 | 9.0 | 234’308 | |
| node_degree (full historic road graph) | 2.2 | 0.6 | 2.0 | 1.0 | 4.0 | 140’412 | |
| length_meters (full historic road graph) | 108.2 | 172.9 | 65.6 | 4.7 | 748.0 | 234’308 | 2.5e+07 |
| motorway | 691.1 | 1’030.4 | 286.2 | 19.1 | 4’846.2 | 1’520 | 1.1e+06 |
| motorway_link | 293.3 | 308.7 | 182.6 | 14.3 | 1’437.8 | 894 | 2.6e+05 |
| trunk | 144.1 | 271.7 | 63.2 | 5.0 | 1’332.8 | 17’347 | 2.5e+06 |
| trunk_link | 178.8 | 198.2 | 97.1 | 8.9 | 834.9 | 1’600 | 2.9e+05 |
| primary | 91.0 | 129.0 | 55.0 | 4.3 | 620.1 | 62’005 | 5.6e+06 |
| primary_link | 84.0 | 104.8 | 48.8 | 5.2 | 572.8 | 907 | 7.6e+04 |
| secondary | 104.5 | 143.8 | 63.2 | 4.6 | 721.5 | 28’003 | 2.9e+06 |
| secondary_link | 54.7 | 60.9 | 33.6 | 6.3 | 294.2 | 135 | 7.4e+03 |
| tertiary | 104.9 | 129.4 | 68.5 | 4.8 | 628.2 | 59’977 | 6.3e+06 |
| tertiary_link | 77.3 | 91.4 | 47.6 | 4.1 | 426.4 | 257 | 2.0e+04 |
| unclassified | 104.1 | 152.4 | 60.9 | 4.4 | 776.5 | 12’447 | 1.3e+06 |
| residential | 101.6 | 94.8 | 76.6 | 5.0 | 469.3 | 49’110 | 5.0e+06 |
| living_street | 68.2 | 52.7 | 49.7 | 4.8 | 207.9 | 58 | 4.0e+03 |
| service | 66.6 | 83.8 | 30.0 | 4.7 | 337.7 | 44 | 2.9e+03 |
| cycleway | 31.0 | nan | 31.0 | 31.0 | 31.0 | 1 | 3.1e+01 |
| road | 45.8 | 1.8 | 45.8 | 44.6 | 47.1 | 2 | 9.2e+01 |
| construction | 14.8 | nan | 14.8 | 14.8 | 14.8 | 1 | 1.5e+01 |
| speed_kph (full historic road graph) | 47.3 | 16.1 | 48.3 | 32.2 | 112.7 | 234’308 | |
| motorway | 110.6 | 8.3 | 112.7 | 64.4 | 112.7 | 1’520 | |
| motorway_link | 106.0 | 14.2 | 112.7 | 64.4 | 112.7 | 894 | |
| trunk | 62.1 | 21.5 | 48.3 | 32.2 | 112.7 | 17’347 | |
| trunk_link | 72.9 | 21.6 | 72.8 | 32.2 | 112.7 | 1’600 | |
| primary | 50.4 | 13.5 | 48.3 | 32.2 | 96.6 | 62’005 | |
| primary_link | 54.2 | 13.9 | 48.3 | 32.2 | 96.6 | 907 | |
| secondary | 48.5 | 14.2 | 48.3 | 32.2 | 96.6 | 28’003 | |
| secondary_link | 47.9 | 14.2 | 48.3 | 32.2 | 91.1 | 135 | |
| tertiary | 46.2 | 12.9 | 46.2 | 32.2 | 96.6 | 59’977 | |
| tertiary_link | 52.2 | 12.7 | 52.0 | 32.2 | 96.6 | 257 | |
| unclassified | 40.4 | 10.3 | 40.4 | 32.2 | 96.6 | 12’447 | |
| residential | 36.3 | 6.1 | 32.2 | 32.2 | 48.3 | 49’110 | |
| living_street | 33.1 | 3.6 | 32.2 | 32.2 | 48.3 | 58 | |
| service | 33.8 | 3.3 | 33.6 | 32.2 | 48.3 | 44 | |
| cycleway | 32.2 | nan | 32.2 | 32.2 | 32.2 | 1 | |
| road | 52.8 | 0.0 | 52.8 | 52.8 | 52.8 | 2 | |
| construction | 32.2 | nan | 32.2 | 32.2 | 32.2 | 1 | |
| free_flow_kph (full historic road graph) | 34.0 | 11.8 | 32.0 | 15.3 | 77.2 | 136’149 | |
| motorway | 103.2 | 14.4 | 109.2 | 59.8 | 117.6 | 311 | |
| motorway_link | 89.0 | 21.2 | 94.8 | 41.5 | 117.5 | 125 | |
| trunk | 41.2 | 14.2 | 38.1 | 20.2 | 85.6 | 11’928 | |
| trunk_link | 54.7 | 19.7 | 57.9 | 18.7 | 102.0 | 779 | |
| primary | 35.8 | 10.0 | 32.9 | 18.4 | 67.4 | 33’921 | |
| primary_link | 44.0 | 19.0 | 38.6 | 17.9 | 80.4 | 511 | |
| secondary | 35.1 | 10.0 | 32.9 | 17.9 | 67.8 | 14’742 | |
| secondary_link | 32.2 | 14.7 | 28.7 | 17.8 | 78.1 | 88 | |
| tertiary | 34.6 | 10.2 | 32.5 | 17.9 | 67.8 | 28’749 | |
| tertiary_link | 48.9 | 20.0 | 46.6 | 19.8 | 78.6 | 134 | |
| unclassified | 28.9 | 11.7 | 27.1 | 11.8 | 75.8 | 7’505 | |
| residential | 28.8 | 8.4 | 27.8 | 12.7 | 54.6 | 37’281 | |
| living_street | 23.1 | 4.3 | 24.9 | 12.9 | 28.6 | 53 | |
| service | 28.0 | 18.2 | 19.8 | 13.4 | 76.8 | 19 | |
| road | 26.4 | 0.7 | 26.4 | 25.9 | 26.8 | 2 | |
| construction | 14.1 | nan | 14.1 | 14.1 | 14.1 | 1 | |
| free_flow_kph-speed_kph (full historic road graph) | -7.6 | 10.1 | -6.3 | -31.4 | 18.6 | 136’149 | |
| motorway | -4.4 | 12.0 | -2.6 | -46.4 | 23.9 | 311 | |
| motorway_link | -12.9 | 19.1 | -7.8 | -64.9 | 12.7 | 125 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| trunk | -11.5 | 9.9 | -11.3 | -39.2 | 10.0 | 11’928 |
| trunk_link | -6.4 | 18.2 | -5.5 | -48.2 | 32.5 | 779 |
| primary | -9.2 | 10.1 | -7.8 | -30.9 | 13.6 | 33’921 |
| primary_link | -5.8 | 16.7 | -5.8 | -37.6 | 29.8 | 511 |
| secondary | -7.1 | 10.1 | -5.4 | -31.5 | 14.4 | 14’742 |
| secondary_link | -10.2 | 14.5 | -10.3 | -30.4 | 29.5 | 88 |
| tertiary | -6.0 | 10.2 | -4.5 | -29.5 | 20.9 | 28’749 |
| tertiary_link | -0.3 | 19.6 | -3.5 | -31.1 | 36.8 | 134 |
| unclassified | -7.9 | 11.5 | -8.2 | -32.8 | 31.5 | 7’505 |
| residential | -6.3 | 8.8 | -5.8 | -29.7 | 17.5 | 37’281 |
| living_street | -10.1 | 5.2 | -8.0 | -21.9 | -3.6 | 53 |
| service | -4.5 | 18.1 | -12.4 | -19.6 | 44.6 | 19 |
| road | -26.4 | 0.7 | -26.4 | -26.9 | -26.0 | 2 |
| construction | -18.1 | nan | -18.1 | -18.1 | -18.1 | 1 |

TABLE XVI: Key figures London for the generated data from 20 randomly sampled days (full historic road graph). **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Static data London (MeTS-10 extent (bounding box)):*

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box (MeTS-10 extent (bounding box)) | | | | | | -0.369–0.067 / 51.205–51.7 | |
| num_edges (MeTS-10 extent (bounding box)) | | | | | | 136’138 | |
| motorway | | | | | | 311 | |
| motorway_link | | | | | | 125 | |
| trunk | | | | | | 11928 | |
| trunk_link | | | | | | 779 | |
| primary | | | | | | 33917 | |
| primary_link | | | | | | 511 | |
| secondary | | | | | | 14738 | |
| secondary_link | | | | | | 88 | |
| tertiary | | | | | | 28749 | |
| tertiary_link | | | | | | 134 | |
| unclassified | | | | | | 7506 | |
| residential | | | | | | 37277 | |
| living_street | | | | | | 53 | |
| service | | | | | | 19 | |
| road | | | | | | 2 | |
| construction | | | | | | 1 | |
| num_nodes (MeTS-10 extent (bounding box)) | | | | | | 77427 | |
| num_edges_per_cell (MeTS-10 extent (bounding box)) | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 355’931 | |
| num_intersecting_cells (MeTS-10 extent (bounding box)) | 2.9 | 2.2 | 2.0 | 1.0 | 10.0 | 136’138 | |
| node_degree (MeTS-10 extent (bounding box)) | 2.2 | 0.6 | 2.0 | 1.0 | 4.0 | 77’427 | |
| length_meters (MeTS-10 extent (bounding box)) | 92.4 | 124.6 | 62.4 | 4.6 | 521.7 | 136’138 | 1.3e+07 |
| motorway | 829.7 | 1’142.2 | 358.1 | 39.0 | 5’045.8 | 311 | 2.6e+05 |
| motorway_link | 429.7 | 421.9 | 343.9 | 30.6 | 1’768.6 | 125 | 5.4e+04 |
| trunk | 102.9 | 162.1 | 57.2 | 4.8 | 764.9 | 11’928 | 1.2e+06 |
| trunk_link | 112.9 | 132.8 | 57.8 | 6.9 | 628.9 | 779 | 8.8e+04 |
| primary | 74.2 | 88.6 | 50.7 | 4.2 | 435.2 | 33’917 | 2.5e+06 |
| primary_link | 71.0 | 86.0 | 42.9 | 7.1 | 408.4 | 511 | 3.6e+04 |
| secondary | 86.7 | 104.9 | 58.8 | 4.5 | 473.7 | 14’738 | 1.3e+06 |
| secondary_link | 44.3 | 49.9 | 29.6 | 5.9 | 244.1 | 88 | 3.9e+03 |
| tertiary | 95.4 | 105.3 | 66.8 | 5.1 | 515.2 | 28’749 | 2.7e+06 |
| tertiary_link | 75.5 | 89.4 | 46.0 | 4.6 | 443.7 | 134 | 1.0e+04 |
| unclassified | 85.6 | 110.3 | 56.2 | 4.2 | 540.6 | 7’506 | 6.4e+05 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| residential | 99.7 | 92.2 | 75.2 | 4.9 | 461.4 | 37’277 | 3.7e+06 |
| living_street | 69.9 | 54.1 | 51.9 | 4.8 | 209.1 | 53 | 3.7e+03 |
| service | 46.9 | 62.2 | 19.6 | 5.1 | 210.4 | 19 | 8.9e+02 |
| road | 45.8 | 1.8 | 45.8 | 44.6 | 47.1 | 2 | 9.2e+01 |
| construction | 14.8 | nan | 14.8 | 14.8 | 14.8 | 1 | 1.5e+01 |
| speed_kph (MeTS-10 extent (bounding box)) | 41.6 | 10.9 | 40.4 | 32.2 | 80.5 | 136’138 | |
| motorway | 107.6 | 13.2 | 112.7 | 64.4 | 112.7 | 311 | |
| motorway_link | 101.9 | 18.0 | 112.7 | 48.3 | 112.7 | 125 | |
| trunk | 52.7 | 12.4 | 48.3 | 32.2 | 96.6 | 11’928 | |
| trunk_link | 61.1 | 14.9 | 64.4 | 32.2 | 112.7 | 779 | |
| primary | 45.0 | 9.2 | 48.3 | 32.2 | 64.4 | 33’917 | |
| primary_link | 49.8 | 11.4 | 48.3 | 32.2 | 80.5 | 511 | |
| secondary | 42.1 | 9.8 | 48.3 | 32.2 | 64.4 | 14’738 | |
| secondary_link | 42.4 | 9.5 | 48.1 | 32.2 | 66.5 | 88 | |
| tertiary | 40.6 | 9.2 | 46.2 | 32.2 | 64.4 | 28’749 | |
| tertiary_link | 49.1 | 11.5 | 48.3 | 32.2 | 80.5 | 134 | |
| unclassified | 36.8 | 7.3 | 32.2 | 24.1 | 48.3 | 7’506 | |
| residential | 35.2 | 5.3 | 32.2 | 32.2 | 48.3 | 37’277 | |
| living_street | 33.2 | 3.7 | 32.2 | 32.2 | 48.3 | 53 | |
| service | 32.6 | 0.6 | 32.2 | 32.2 | 33.6 | 19 | |
| road | 52.8 | 0.0 | 52.8 | 52.8 | 52.8 | 2 | |
| construction | 32.2 | nan | 32.2 | 32.2 | 32.2 | 1 | |
| free_flow_kph (MeTS-10 extent (bounding box)) | 34.0 | 11.8 | 32.0 | 15.3 | 77.2 | 136’137 | |
| motorway | 103.2 | 14.4 | 109.2 | 59.8 | 117.6 | 311 | |
| motorway_link | 89.0 | 21.2 | 94.8 | 41.5 | 117.5 | 125 | |
| trunk | 41.2 | 14.2 | 38.1 | 20.2 | 85.6 | 11’928 | |
| trunk_link | 54.7 | 19.7 | 57.9 | 18.7 | 102.0 | 779 | |
| primary | 35.8 | 10.0 | 32.9 | 18.4 | 67.4 | 33’917 | |
| primary_link | 44.0 | 19.0 | 38.6 | 17.9 | 80.4 | 511 | |
| secondary | 35.1 | 10.0 | 32.9 | 17.9 | 67.8 | 14’738 | |
| secondary_link | 32.2 | 14.7 | 28.7 | 17.8 | 78.1 | 88 | |
| tertiary | 34.6 | 10.2 | 32.5 | 17.9 | 67.8 | 28’749 | |
| tertiary_link | 48.9 | 20.0 | 46.6 | 19.8 | 78.6 | 134 | |
| unclassified | 28.9 | 11.7 | 27.1 | 11.8 | 75.8 | 7’505 | |
| residential | 28.8 | 8.4 | 27.8 | 12.7 | 54.6 | 37’277 | |
| living_street | 23.1 | 4.3 | 24.9 | 12.9 | 28.6 | 53 | |
| service | 28.0 | 18.2 | 19.8 | 13.4 | 76.8 | 19 | |
| road | 26.4 | 0.7 | 26.4 | 25.9 | 26.8 | 2 | |
| construction | 14.1 | nan | 14.1 | 14.1 | 14.1 | 1 | |
| free_flow_kph-speed_kph (MeTS-10 extent (bounding box)) | -7.6 | 10.1 | -6.3 | -31.4 | 18.6 | 136’137 | |
| motorway | -4.4 | 12.0 | -2.6 | -46.4 | 23.9 | 311 | |
| motorway_link | -12.9 | 19.1 | -7.8 | -64.9 | 12.7 | 125 | |
| trunk | -11.5 | 9.9 | -11.3 | -39.2 | 10.0 | 11’928 | |
| trunk_link | -6.4 | 18.2 | -5.5 | -48.2 | 32.5 | 779 | |
| primary | -9.2 | 10.1 | -7.8 | -30.9 | 13.6 | 33’917 | |
| primary_link | -5.8 | 16.7 | -5.8 | -37.6 | 29.8 | 511 | |
| secondary | -7.1 | 10.1 | -5.4 | -31.4 | 14.4 | 14’738 | |
| secondary_link | -10.2 | 14.5 | -10.3 | -30.4 | 29.5 | 88 | |
| tertiary | -6.0 | 10.2 | -4.5 | -29.5 | 20.9 | 28’749 | |
| tertiary_link | -0.3 | 19.6 | -3.5 | -31.1 | 36.8 | 134 | |
| unclassified | -7.9 | 11.5 | -8.2 | -32.8 | 31.5 | 7’505 | |
| residential | -6.3 | 8.8 | -5.8 | -29.7 | 17.5 | 37’277 | |
| living_street | -10.1 | 5.2 | -8.0 | -21.9 | -3.6 | 53 | |
| service | -4.5 | 18.1 | -12.4 | -19.6 | 44.6 | 19 | |
| road | -26.4 | 0.7 | -26.4 | -26.9 | -26.0 | 2 | |
| construction | -18.1 | nan | -18.1 | -18.1 | -18.1 | 1 | |

TABLE XVII: Key figures London for the generated data from 20 randomly sampled days (MeTS-10 extent (bounding box)). **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*4) Segment density map London:*

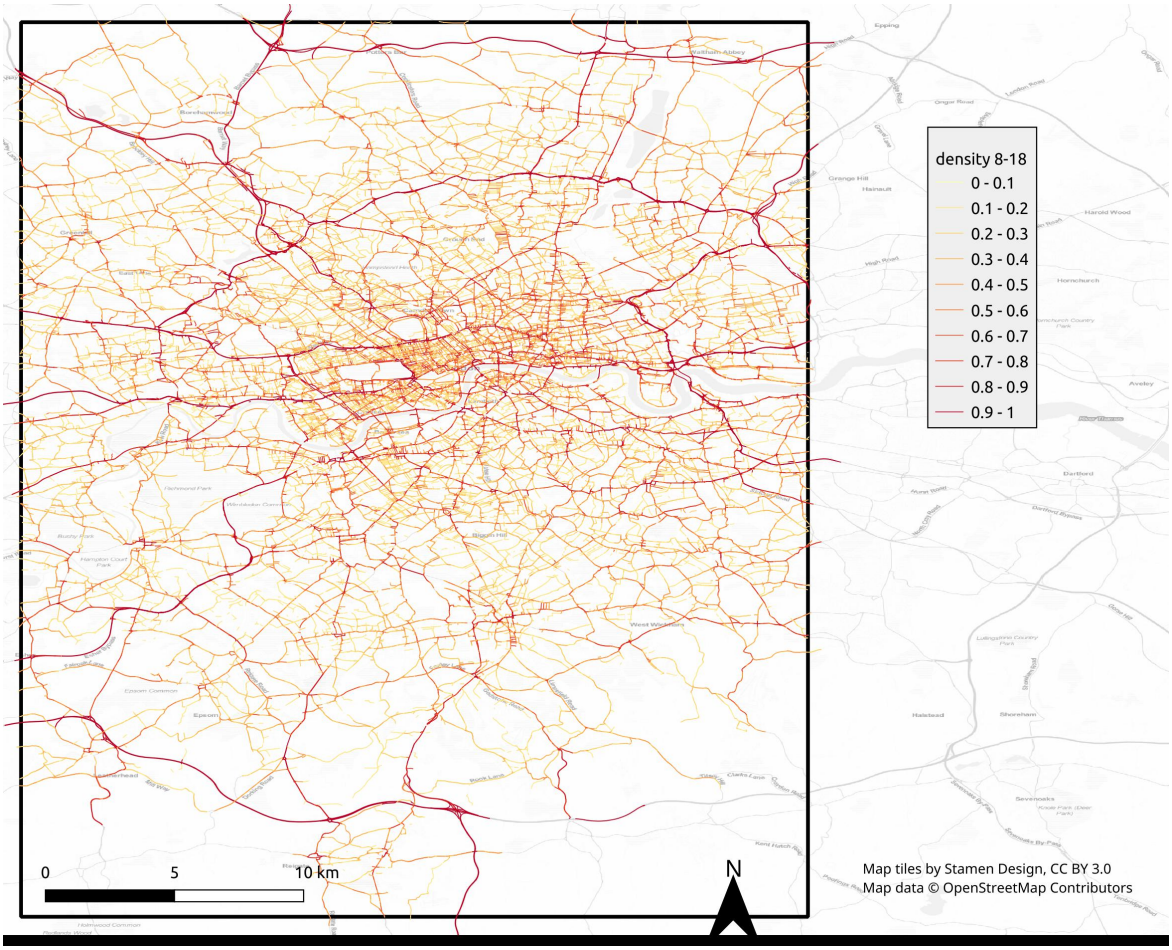



Fig. 59: Segment-wise density 8am–6pm London from 20 randomly sampled days.

*5) Daily density profile London (full historic road graph):*

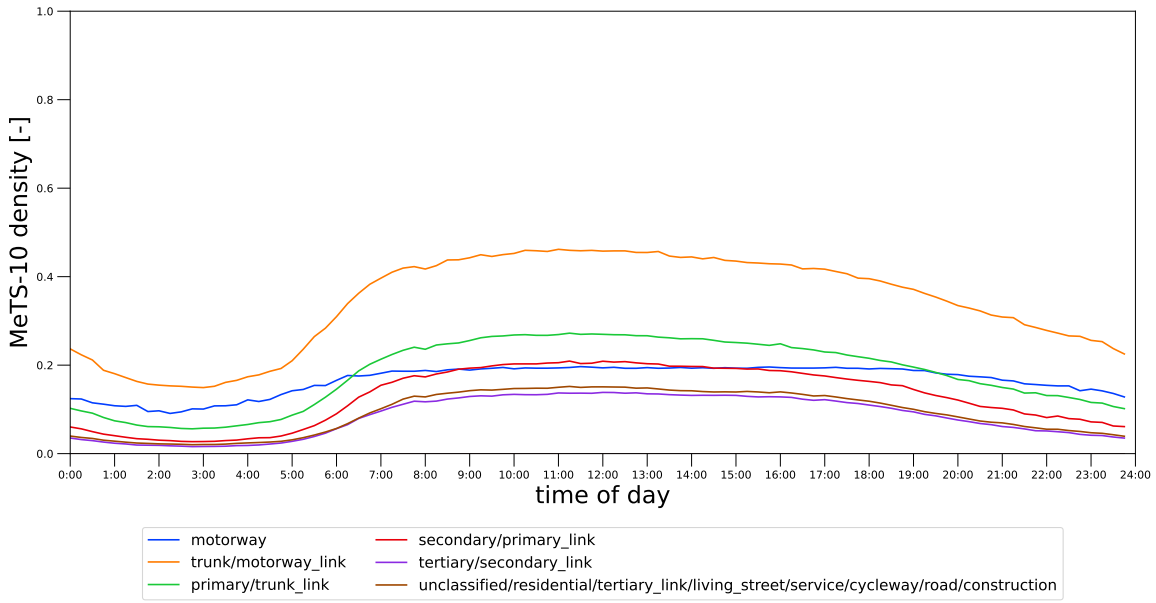



Fig. 60: Daily density profile for different road types for London (full historic road graph). Data from 20 randomly sampled days.

*6) Daily speed profile London (full historic road graph):*

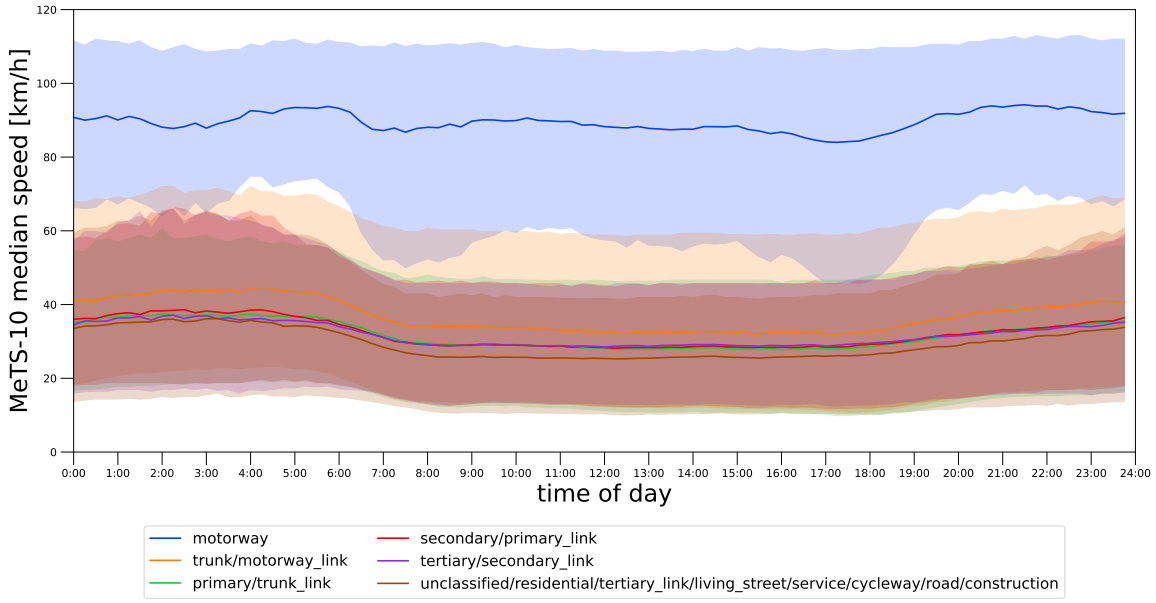



Fig. 61: Daily median 15 min speeds of all intersecting cells profile for different road types for London (full historic road graph). The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

*7) Daily density profile London (MeTS-10 extent (bounding box)):*

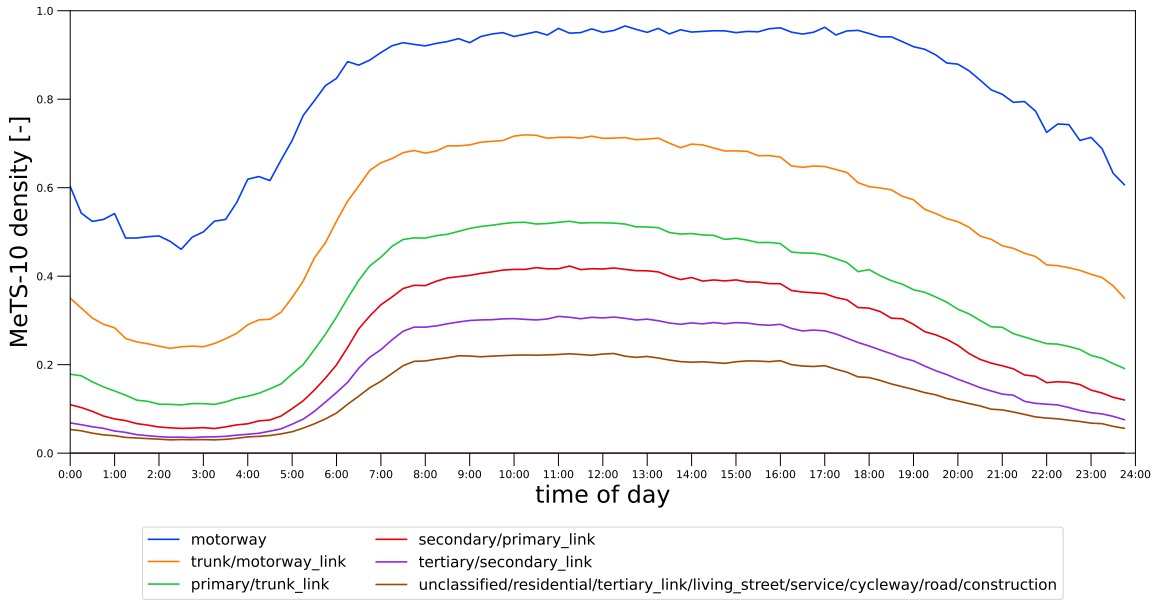



Fig. 62: Daily density profile for different road types for London (MeTS-10 extent (bounding box)). Data from 20 randomly sampled days.

*8) Daily speed profile London (MeTS-10 extent (bounding box)):*

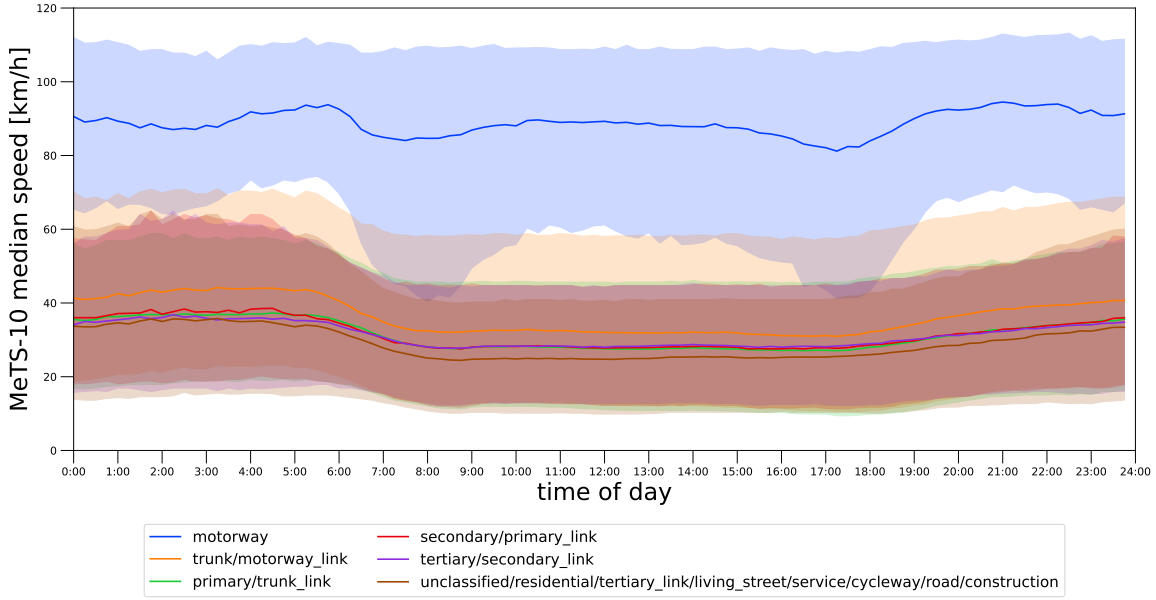



Fig. 63: Daily median 15 min speeds of all intersecting cells profile for different road types for London (MeTS-10 extent (bounding box)). The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

## B. Key Figures Berlin

### 1) Road graph map Berlin:

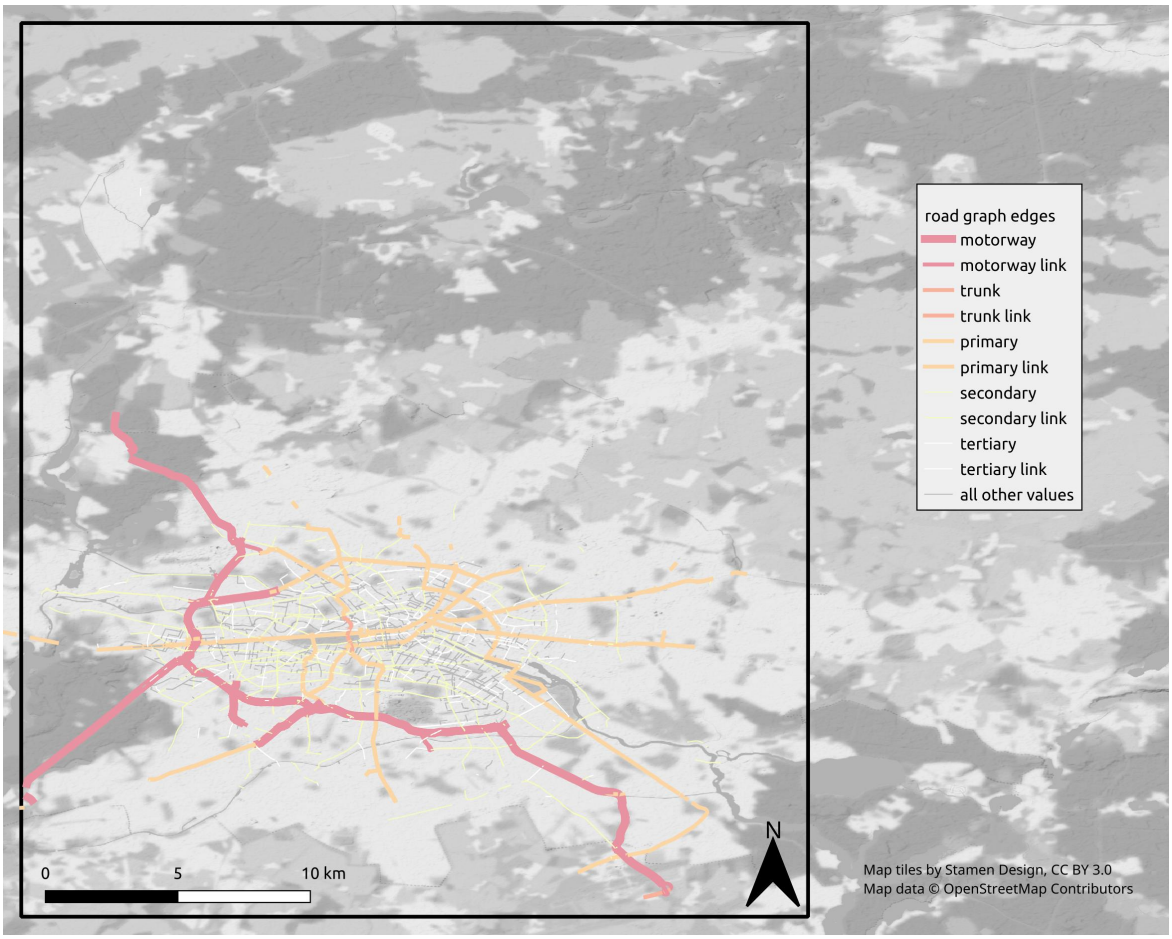



Fig. 64: Road graph Berlin, OSM color scheme.

### 2) Static data Berlin (full historic road graph):

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box (full historic road graph) | | | | | | 13.189–13.625 / 52.359–52.854 | |
| num_edges (full historic road graph) | | | | | | 16’279 | |
| motorway | | | | | | 515 | |
| motorway_link | | | | | | 384 | |
| trunk | | | | | | 72 | |
| trunk_link | | | | | | 4 | |
| primary | | | | | | 2937 | |
| primary_link | | | | | | 15 | |
| secondary | | | | | | 6464 | |
| secondary_link | | | | | | 21 | |
| tertiary | | | | | | 2782 | |
| tertiary_link | | | | | | 2 | |
| unclassified | | | | | | 56 | |
| residential | | | | | | 2934 | |
| living_street | | | | | | 91 | |
| construction | | | | | | 2 | |
| num_nodes (full historic road graph) | | | | | | 12655 | |
| num_edges_per_cell (full historic road graph) | 1.1 | 0.3 | 1.0 | 1.0 | 3.0 | 46’509 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| num_intersecting_cells (full historic road graph) | 3.1 | 2.2 | 2.0 | 1.0 | 12.0 | 16’279 | |
| node_degree (full historic road graph) | 2.2 | 0.7 | 2.0 | 1.0 | 4.0 | 12’655 | |
| length_meters (full historic road graph) | 103.4 | 120.9 | 71.8 | 5.2 | 536.7 | 16’279 | 1.7e+06 |
| motorway | 269.5 | 322.6 | 166.2 | 13.9 | 1’670.6 | 515 | 1.4e+05 |
| motorway_link | 144.0 | 118.0 | 116.4 | 13.2 | 531.2 | 384 | 5.5e+04 |
| trunk | 337.4 | 572.4 | 162.9 | 3.7 | 2’542.3 | 72 | 2.4e+04 |
| trunk_link | 87.3 | 97.4 | 54.2 | 12.1 | 224.5 | 4 | 3.5e+02 |
| primary | 105.3 | 116.2 | 72.0 | 5.6 | 603.9 | 2’937 | 3.1e+05 |
| primary_link | 36.3 | 32.9 | 23.3 | 10.7 | 122.0 | 15 | 5.4e+02 |
| secondary | 91.4 | 89.8 | 66.2 | 5.5 | 413.8 | 6’464 | 5.9e+05 |
| secondary_link | 50.7 | 47.3 | 27.3 | 15.4 | 148.3 | 21 | 1.1e+03 |
| tertiary | 90.2 | 85.8 | 65.8 | 4.9 | 378.2 | 2’782 | 2.5e+05 |
| tertiary_link | 19.2 | 0.0 | 19.2 | 19.2 | 19.2 | 2 | 3.8e+01 |
| unclassified | 75.9 | 80.8 | 46.1 | 4.3 | 351.9 | 56 | 4.2e+03 |
| residential | 101.2 | 86.4 | 77.1 | 4.2 | 373.4 | 2’934 | 3.0e+05 |
| living_street | 111.4 | 96.5 | 88.3 | 6.9 | 369.8 | 91 | 1.0e+04 |
| construction | 36.7 | 0.0 | 36.7 | 36.7 | 36.7 | 2 | 7.3e+01 |
| speed_kph (full historic road graph) | 46.6 | 11.2 | 50.0 | 30.0 | 80.0 | 16’279 | |
| motorway | 77.3 | 11.8 | 80.0 | 40.0 | 120.0 | 515 | |
| motorway_link | 60.1 | 10.0 | 60.0 | 40.0 | 80.0 | 384 | |
| trunk | 70.6 | 22.0 | 65.0 | 50.0 | 100.0 | 72 | |
| trunk_link | 30.0 | 0.0 | 30.0 | 30.0 | 30.0 | 4 | |
| primary | 48.8 | 6.0 | 50.0 | 30.0 | 60.0 | 2’937 | |
| primary_link | 48.0 | 7.7 | 50.0 | 30.0 | 58.6 | 15 | |
| secondary | 48.8 | 5.3 | 50.0 | 30.0 | 60.0 | 6’464 | |
| secondary_link | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 21 | |
| tertiary | 45.7 | 8.1 | 50.0 | 30.0 | 50.0 | 2’782 | |
| tertiary_link | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 2 | |
| unclassified | 37.7 | 10.3 | 30.0 | 20.0 | 50.0 | 56 | |
| residential | 32.5 | 7.7 | 30.0 | 10.0 | 50.0 | 2’934 | |
| living_street | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 91 | |
| construction | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 2 | |
| free_flow_kph (full historic road graph) | 45.1 | 13.5 | 43.5 | 22.1 | 89.9 | 16’229 | |
| motorway | 84.3 | 10.5 | 85.2 | 56.8 | 115.1 | 515 | |
| motorway_link | 77.6 | 14.2 | 81.5 | 36.7 | 114.7 | 384 | |
| trunk | 59.5 | 19.6 | 52.9 | 33.2 | 96.0 | 46 | |
| primary | 47.1 | 8.8 | 47.1 | 28.7 | 70.8 | 2’919 | |
| primary_link | 42.9 | 11.7 | 41.1 | 25.9 | 64.8 | 15 | |
| secondary | 45.9 | 9.2 | 45.6 | 26.5 | 80.3 | 6’464 | |
| secondary_link | 41.6 | 14.0 | 39.8 | 20.2 | 77.2 | 21 | |
| tertiary | 41.4 | 8.8 | 40.9 | 23.4 | 75.6 | 2’780 | |
| tertiary_link | 38.8 | 0.0 | 38.8 | 38.8 | 38.8 | 2 | |
| unclassified | 44.8 | 7.8 | 46.1 | 21.8 | 54.3 | 56 | |
| residential | 34.2 | 7.7 | 33.9 | 18.8 | 55.9 | 2’934 | |
| living_street | 26.0 | 6.1 | 24.9 | 16.5 | 37.9 | 91 | |
| construction | 42.4 | 0.0 | 42.4 | 42.4 | 42.4 | 2 | |
| free_flow_kph-speed_kph (full historic road graph) | -1.4 | 10.8 | -1.3 | -26.0 | 30.2 | 16’229 | |
| motorway | 7.0 | 7.5 | 6.9 | -9.6 | 29.0 | 515 | |
| motorway_link | 17.5 | 13.1 | 20.6 | -15.5 | 38.7 | 384 | |
| trunk | 2.9 | 10.1 | 2.9 | -16.8 | 26.0 | 46 | |
| primary | -1.6 | 8.2 | -1.1 | -20.5 | 19.2 | 2’919 | |
| primary_link | -5.1 | 16.7 | -8.9 | -24.1 | 34.2 | 15 | |
| secondary | -2.9 | 9.9 | -3.4 | -23.4 | 31.5 | 6’464 | |
| secondary_link | -8.4 | 14.0 | -10.2 | -29.8 | 27.2 | 21 | |
| tertiary | -4.4 | 10.8 | -5.3 | -26.0 | 25.6 | 2’780 | |
| tertiary_link | -11.2 | 0.0 | -11.2 | -11.2 | -11.2 | 2 | |
| unclassified | 7.1 | 13.6 | 12.4 | -28.2 | 23.3 | 56 | |
| residential | 1.6 | 10.6 | 2.5 | -29.6 | 26.2 | 2’934 | |
| living_street | -24.0 | 6.1 | -25.1 | -33.5 | -12.1 | 91 | |
| construction | -7.6 | 0.0 | -7.6 | -7.6 | -7.6 | 2 | |

TABLE XVIII: Key figures Berlin for the generated data from 20 randomly sampled days (full historic road graph). **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge's intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Static data Berlin (MeTS-10 extent (bounding box)):*

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box (MeTS-10 extent (bounding box)) | | | | | | 13.189–13.625 / 52.359–52.854 | |
| num_edges (MeTS-10 extent (bounding box)) | | | | | | 16'229 | |
| motorway | | | | | | 515 | |
| motorway_link | | | | | | 384 | |
| trunk | | | | | | 46 | |
| primary | | | | | | 2919 | |
| primary_link | | | | | | 15 | |
| secondary | | | | | | 6464 | |
| secondary_link | | | | | | 21 | |
| tertiary | | | | | | 2780 | |
| tertiary_link | | | | | | 2 | |
| unclassified | | | | | | 56 | |
| residential | | | | | | 2934 | |
| living_street | | | | | | 91 | |
| construction | | | | | | 2 | |
| num_nodes (MeTS-10 extent (bounding box)) | | | | | | 12603 | |
| num_edges_per_cell (MeTS-10 extent (bounding box)) | 1.1 | 0.3 | 1.0 | 1.0 | 3.0 | 46'509 | |
| num_intersecting_cells (MeTS-10 extent (bounding box)) | 3.1 | 2.2 | 2.0 | 1.0 | 12.0 | 16'229 | |
| node_degree (MeTS-10 extent (bounding box)) | 2.2 | 0.7 | 2.0 | 1.0 | 4.0 | 12'603 | |
| length_meters (MeTS-10 extent (bounding box)) | 102.6 | 114.6 | 71.7 | 5.2 | 531.4 | 16'229 | 1.7e+06 |
| motorway | 269.5 | 322.6 | 166.2 | 13.9 | 1'670.6 | 515 | 1.4e+05 |
| motorway_link | 144.0 | 118.0 | 116.4 | 13.2 | 531.2 | 384 | 5.5e+04 |
| trunk | 191.8 | 209.7 | 114.0 | 3.6 | 835.0 | 46 | 8.8e+03 |
| primary | 105.4 | 116.5 | 72.0 | 5.6 | 605.4 | 2'919 | 3.1e+05 |
| primary_link | 36.3 | 32.9 | 23.3 | 10.7 | 122.0 | 15 | 5.4e+02 |
| secondary | 91.4 | 89.8 | 66.2 | 5.5 | 413.8 | 6'464 | 5.9e+05 |
| secondary_link | 50.7 | 47.3 | 27.3 | 15.4 | 148.3 | 21 | 1.1e+03 |
| tertiary | 90.2 | 85.8 | 65.8 | 4.9 | 378.3 | 2'780 | 2.5e+05 |
| tertiary_link | 19.2 | 0.0 | 19.2 | 19.2 | 19.2 | 2 | 3.8e+01 |
| unclassified | 75.9 | 80.8 | 46.1 | 4.3 | 351.9 | 56 | 4.2e+03 |
| residential | 101.2 | 86.4 | 77.1 | 4.2 | 373.4 | 2'934 | 3.0e+05 |
| living_street | 111.4 | 96.5 | 88.3 | 6.9 | 369.8 | 91 | 1.0e+04 |
| construction | 36.7 | 0.0 | 36.7 | 36.7 | 36.7 | 2 | 7.3e+01 |
| speed_kph (MeTS-10 extent (bounding box)) | 46.5 | 11.0 | 50.0 | 30.0 | 80.0 | 16'229 | |
| motorway | 77.3 | 11.8 | 80.0 | 40.0 | 120.0 | 515 | |
| motorway_link | 60.1 | 10.0 | 60.0 | 40.0 | 80.0 | 384 | |
| trunk | 56.5 | 11.4 | 50.0 | 50.0 | 80.0 | 46 | |
| primary | 48.8 | 6.0 | 50.0 | 30.0 | 60.0 | 2'919 | |
| primary_link | 48.0 | 7.7 | 50.0 | 30.0 | 58.6 | 15 | |
| secondary | 48.8 | 5.3 | 50.0 | 30.0 | 60.0 | 6'464 | |
| secondary_link | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 21 | |
| tertiary | 45.7 | 8.1 | 50.0 | 30.0 | 50.0 | 2'780 | |
| tertiary_link | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 2 | |
| unclassified | 37.7 | 10.3 | 30.0 | 20.0 | 50.0 | 56 | |
| residential | 32.5 | 7.7 | 30.0 | 10.0 | 50.0 | 2'934 | |
| living_street | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 91 | |
| construction | 50.0 | 0.0 | 50.0 | 50.0 | 50.0 | 2 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| free_flow_kph (MeTS-10 extent (bounding box)) | 45.1 | 13.5 | 43.5 | 22.1 | 89.9 | 16’229 |
| motorway | 84.3 | 10.5 | 85.2 | 56.8 | 115.1 | 515 |
| motorway_link | 77.6 | 14.2 | 81.5 | 36.7 | 114.7 | 384 |
| trunk | 59.5 | 19.6 | 52.9 | 33.2 | 96.0 | 46 |
| primary | 47.1 | 8.8 | 47.1 | 28.7 | 70.8 | 2’919 |
| primary_link | 42.9 | 11.7 | 41.1 | 25.9 | 64.8 | 15 |
| secondary | 45.9 | 9.2 | 45.6 | 26.5 | 80.3 | 6’464 |
| secondary_link | 41.6 | 14.0 | 39.8 | 20.2 | 77.2 | 21 |
| tertiary | 41.4 | 8.8 | 40.9 | 23.4 | 75.6 | 2’780 |
| tertiary_link | 38.8 | 0.0 | 38.8 | 38.8 | 38.8 | 2 |
| unclassified | 44.8 | 7.8 | 46.1 | 21.8 | 54.3 | 56 |
| residential | 34.2 | 7.7 | 33.9 | 18.8 | 55.9 | 2’934 |
| living_street | 26.0 | 6.1 | 24.9 | 16.5 | 37.9 | 91 |
| construction | 42.4 | 0.0 | 42.4 | 42.4 | 42.4 | 2 |
| free_flow_kph-speed_kph (MeTS-10 extent (bounding box)) | -1.4 | 10.8 | -1.3 | -26.0 | 30.2 | 16’229 |
| motorway | 7.0 | 7.5 | 6.9 | -9.6 | 29.0 | 515 |
| motorway_link | 17.5 | 13.1 | 20.6 | -15.5 | 38.7 | 384 |
| trunk | 2.9 | 10.1 | 2.9 | -16.8 | 26.0 | 46 |
| primary | -1.6 | 8.2 | -1.1 | -20.5 | 19.2 | 2’919 |
| primary_link | -5.1 | 16.7 | -8.9 | -24.1 | 34.2 | 15 |
| secondary | -2.9 | 9.9 | -3.4 | -23.4 | 31.5 | 6’464 |
| secondary_link | -8.4 | 14.0 | -10.2 | -29.8 | 27.2 | 21 |
| tertiary | -4.4 | 10.8 | -5.3 | -26.0 | 25.6 | 2’780 |
| tertiary_link | -11.2 | 0.0 | -11.2 | -11.2 | -11.2 | 2 |
| unclassified | 7.1 | 13.6 | 12.4 | -28.2 | 23.3 | 56 |
| residential | 1.6 | 10.6 | 2.5 | -29.6 | 26.2 | 2’934 |
| living_street | -24.0 | 6.1 | -25.1 | -33.5 | -12.1 | 91 |
| construction | -7.6 | 0.0 | -7.6 | -7.6 | -7.6 | 2 |

TABLE XIX: Key figures Berlin for the generated data from 20 randomly sampled days (MeTS-10 extent (bounding box)). **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*4) Segment density map Berlin:*


Fig. 65: Segment-wise density 8am–6pm Berlin from 20 randomly sampled days.

*5) Daily density profile Berlin (full historic road graph):*

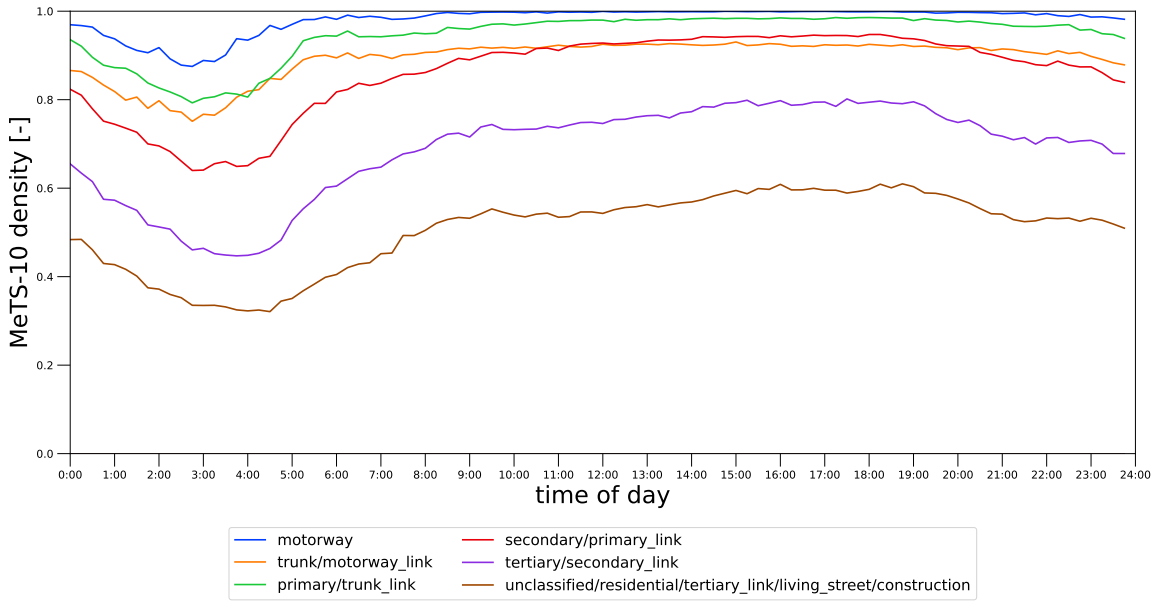



Fig. 66: Daily density profile for different road types for Berlin (full historic road graph). Data from 20 randomly sampled days.

*6) Daily speed profile Berlin (full historic road graph):*

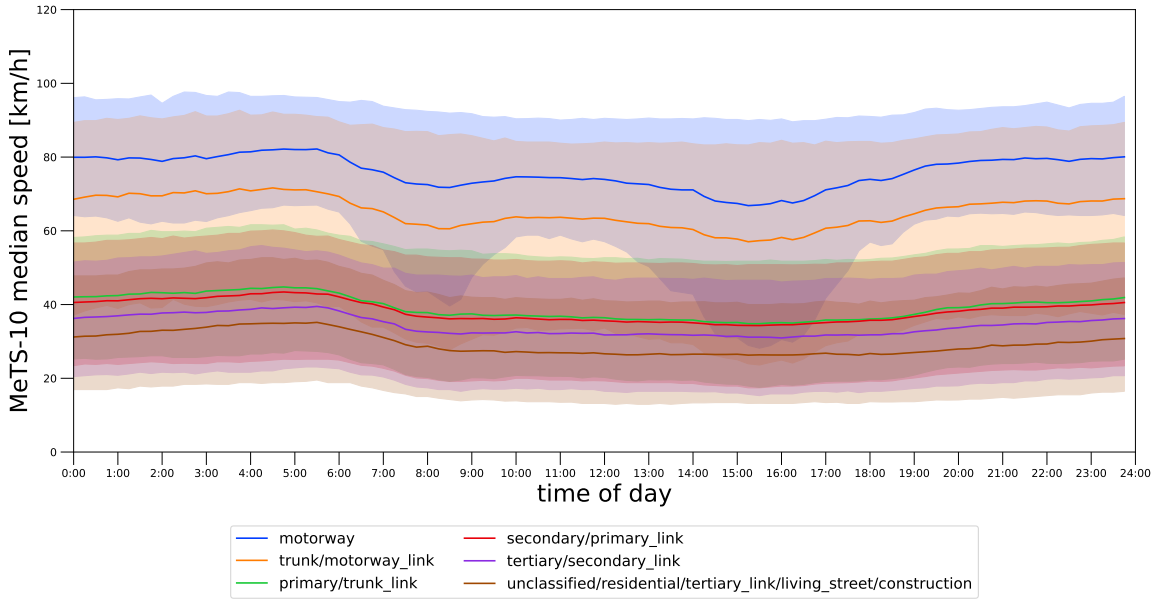



Fig. 67: Daily median 15 min speeds of all intersecting cells profile for different road types for Berlin (full historic road graph). The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

*7) Daily density profile Berlin (MeTS-10 extent (bounding box)):*

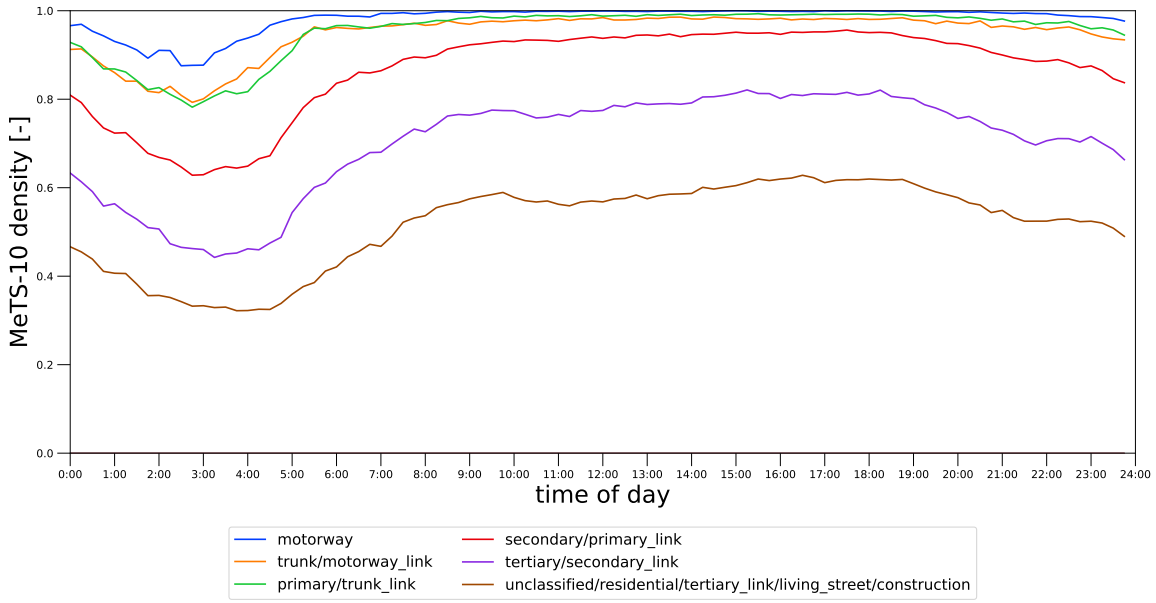



Fig. 68: Daily density profile for different road types for Berlin (MeTS-10 extent (bounding box)). Data from 20 randomly sampled days.

*8) Daily speed profile Berlin (MeTS-10 extent (bounding box)):*

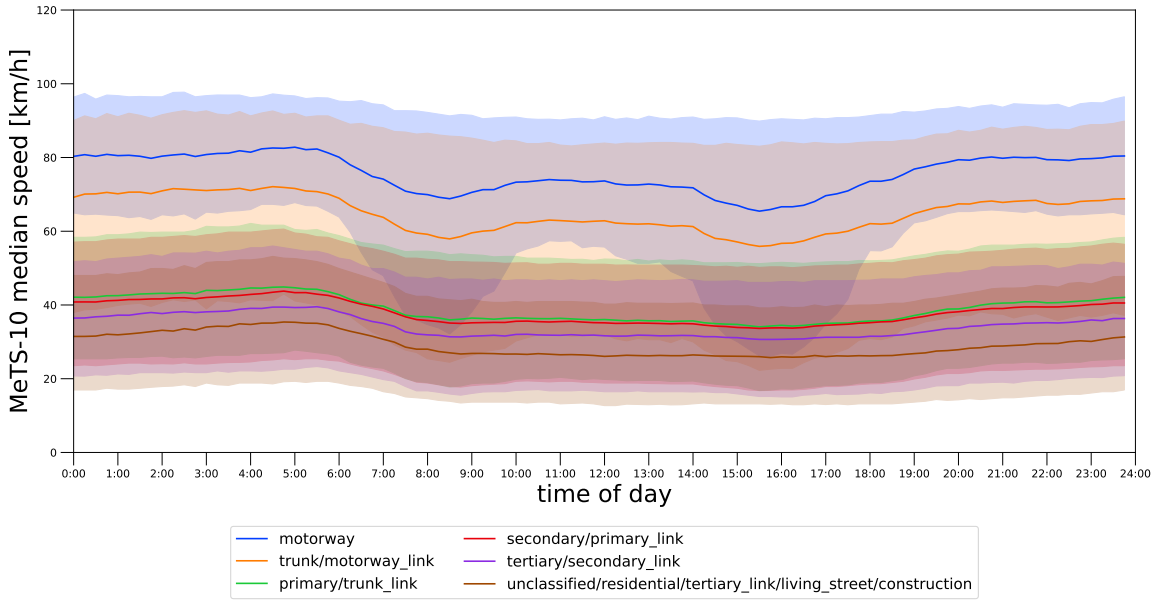



Fig. 69: Daily median 15 min speeds of all intersecting cells profile for different road types for Berlin (MeTS-10 extent (bounding box)). The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

## C. Key Figures Barcelona

### 1) Road graph map Barcelona:

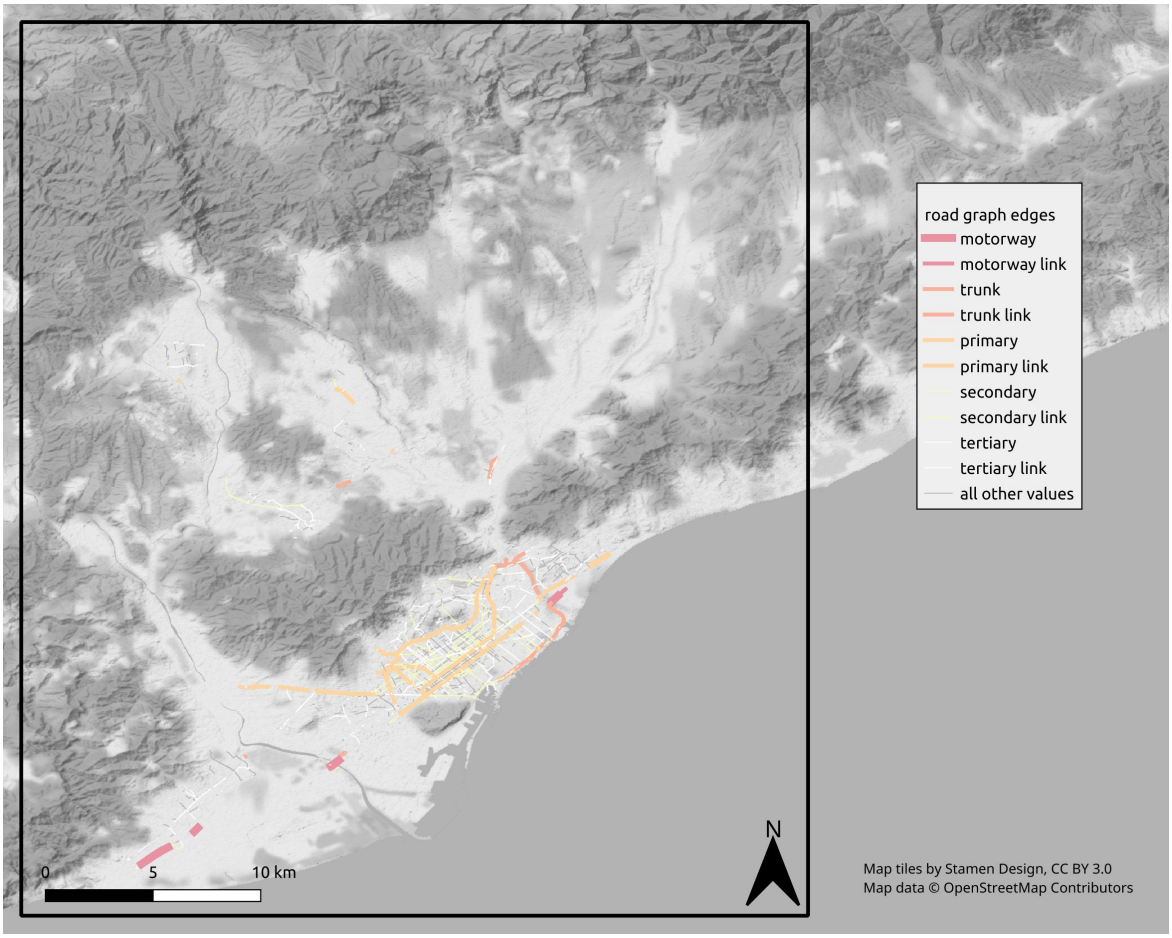



Fig. 70: Road graph Barcelona, OSM color scheme.

### 2) Static data Barcelona (full historic road graph):

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box (full historic road graph) | | | | | | 1.925–2.361 / 41.253–41.748 | |
| num_edges (full historic road graph) | | | | | | 5'943 | |
| motorway | | | | | | 16 | |
| motorway_link | | | | | | 3 | |
| trunk | | | | | | 56 | |
| trunk_link | | | | | | 44 | |
| primary | | | | | | 709 | |
| primary_link | | | | | | 216 | |
| secondary | | | | | | 1278 | |
| secondary_link | | | | | | 92 | |
| tertiary | | | | | | 2014 | |
| tertiary_link | | | | | | 130 | |
| unclassified | | | | | | 20 | |
| residential | | | | | | 1341 | |
| living_street | | | | | | 24 | |
| num_nodes (full historic road graph) | | | | | | 5530 | |
| num_edges_per_cell (full historic road graph) | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 13'823 | |
| num_intersecting_cells (full historic road graph) | 2.5 | 1.5 | 2.0 | 1.0 | 8.0 | 5'943 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| node_degree (full historic road graph) | 2.0 | 0.7 | 2.0 | 1.0 | 4.0 | 5’530 | |
| length_meters (full historic road graph) | 80.0 | 74.0 | 61.9 | 3.9 | 327.3 | 5’943 | 4.8e+05 |
| motorway | 225.8 | 223.5 | 133.2 | 25.4 | 651.4 | 16 | 3.6e+03 |
| motorway_link | 202.8 | 130.0 | 196.9 | 78.3 | 333.0 | 3 | 6.1e+02 |
| trunk | 212.8 | 202.4 | 130.6 | 7.9 | 880.2 | 56 | 1.2e+04 |
| trunk_link | 122.5 | 102.9 | 90.1 | 18.7 | 439.1 | 44 | 5.4e+03 |
| primary | 83.5 | 78.4 | 69.0 | 4.3 | 350.4 | 709 | 5.9e+04 |
| primary_link | 71.6 | 65.1 | 44.5 | 4.6 | 274.5 | 216 | 1.5e+04 |
| secondary | 86.8 | 80.8 | 68.0 | 4.4 | 365.5 | 1’278 | 1.1e+05 |
| secondary_link | 52.3 | 70.4 | 32.1 | 2.7 | 279.8 | 92 | 4.8e+03 |
| tertiary | 73.1 | 62.2 | 56.0 | 3.6 | 275.8 | 2’014 | 1.5e+05 |
| tertiary_link | 67.6 | 70.3 | 33.4 | 3.6 | 258.8 | 130 | 8.8e+03 |
| unclassified | 89.9 | 99.5 | 48.1 | 7.1 | 366.2 | 20 | 1.8e+03 |
| residential | 77.8 | 58.6 | 65.5 | 4.0 | 266.4 | 1’341 | 1.0e+05 |
| living_street | 68.6 | 42.6 | 63.2 | 6.2 | 153.9 | 24 | 1.6e+03 |
| speed_kph (full historic road graph) | 47.3 | 7.3 | 49.7 | 30.0 | 80.0 | 5’943 | |
| motorway | 90.0 | 11.0 | 90.0 | 80.0 | 117.0 | 16 | |
| motorway_link | 56.7 | 5.8 | 60.0 | 50.2 | 60.0 | 3 | |
| trunk | 78.5 | 6.4 | 80.0 | 60.0 | 89.0 | 56 | |
| trunk_link | 57.3 | 9.9 | 57.4 | 40.0 | 80.0 | 44 | |
| primary | 49.7 | 2.5 | 50.0 | 30.8 | 50.0 | 709 | |
| primary_link | 47.2 | 7.3 | 50.0 | 20.0 | 58.5 | 216 | |
| secondary | 49.7 | 1.5 | 50.0 | 40.0 | 50.0 | 1’278 | |
| secondary_link | 49.1 | 3.2 | 50.0 | 30.0 | 50.0 | 92 | |
| tertiary | 49.5 | 2.6 | 50.0 | 31.3 | 50.0 | 2’014 | |
| tertiary_link | 49.3 | 3.0 | 50.0 | 30.0 | 50.0 | 130 | |
| unclassified | 41.4 | 6.0 | 41.4 | 30.0 | 50.0 | 20 | |
| residential | 38.6 | 5.4 | 38.6 | 30.0 | 50.0 | 1’341 | |
| living_street | 16.6 | 7.8 | 16.3 | 10.0 | 30.0 | 24 | |
| free_flow_kph (full historic road graph) | 37.1 | 14.8 | 35.3 | 14.4 | 91.4 | 5’943 | |
| motorway | 103.7 | 13.4 | 93.6 | 90.8 | 119.8 | 16 | |
| motorway_link | 85.4 | 17.2 | 94.7 | 66.2 | 96.0 | 3 | |
| trunk | 80.8 | 8.6 | 82.1 | 63.5 | 99.8 | 56 | |
| trunk_link | 74.9 | 12.9 | 76.7 | 39.9 | 92.7 | 44 | |
| primary | 41.6 | 11.4 | 42.1 | 20.9 | 90.2 | 709 | |
| primary_link | 46.2 | 13.2 | 47.5 | 18.9 | 81.7 | 216 | |
| secondary | 38.8 | 11.5 | 37.6 | 17.8 | 80.9 | 1’278 | |
| secondary_link | 39.0 | 14.8 | 35.3 | 18.4 | 85.0 | 92 | |
| tertiary | 35.7 | 13.6 | 32.9 | 15.1 | 88.5 | 2’014 | |
| tertiary_link | 35.9 | 11.5 | 34.1 | 14.3 | 78.8 | 130 | |
| unclassified | 47.4 | 29.2 | 36.7 | 19.2 | 117.1 | 20 | |
| residential | 30.0 | 12.2 | 28.7 | 11.5 | 83.0 | 1’341 | |
| living_street | 25.0 | 10.4 | 20.5 | 9.1 | 43.8 | 24 | |
| free_flow_kph-speed_kph (full historic road graph) | -10.2 | 13.7 | -11.9 | -33.5 | 38.5 | 5’943 | |
| motorway | 13.7 | 13.5 | 11.9 | -6.4 | 29.8 | 16 | |
| motorway_link | 28.8 | 11.4 | 34.7 | 16.0 | 36.0 | 3 | |
| trunk | 2.3 | 7.6 | 3.2 | -13.3 | 19.8 | 56 | |
| trunk_link | 17.6 | 15.1 | 16.7 | -14.2 | 52.7 | 44 | |
| primary | -8.1 | 11.4 | -7.3 | -29.1 | 40.2 | 709 | |
| primary_link | -1.0 | 15.8 | -1.1 | -31.0 | 50.0 | 216 | |
| secondary | -10.9 | 11.8 | -12.1 | -32.0 | 31.2 | 1’278 | |
| secondary_link | -10.1 | 15.5 | -14.7 | -29.0 | 45.0 | 92 | |
| tertiary | -13.9 | 13.5 | -16.1 | -34.9 | 36.3 | 2’014 | |
| tertiary_link | -13.4 | 12.2 | -15.2 | -35.0 | 29.7 | 130 | |
| unclassified | 6.0 | 29.9 | -3.8 | -22.2 | 75.7 | 20 | |
| residential | -8.6 | 12.9 | -9.4 | -33.1 | 44.4 | 1’341 | |
| living_street | 8.4 | 17.0 | 5.0 | -20.9 | 33.8 | 24 | |

TABLE XX: Key figures Barcelona for the generated data from 20 randomly sampled days (full historic road graph). **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge's intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*3) Static data Barcelona (MeTS-10 extent (bounding box)):*

| Attribute | mean | std | median | q01 | q99 | data points | sum |
|---|---|---|---|---|---|---|---|
| bounding box (MeTS-10 extent (bounding box)) | | | | | | 1.925–2.361 / 41.253–41.748 | |
| num_edges (MeTS-10 extent (bounding box)) | | | | | | 5'943 | |
| motorway | | | | | | 16 | |
| motorway_link | | | | | | 3 | |
| trunk | | | | | | 56 | |
| trunk_link | | | | | | 44 | |
| primary | | | | | | 709 | |
| primary_link | | | | | | 216 | |
| secondary | | | | | | 1278 | |
| secondary_link | | | | | | 92 | |
| tertiary | | | | | | 2014 | |
| tertiary_link | | | | | | 130 | |
| unclassified | | | | | | 20 | |
| residential | | | | | | 1341 | |
| living_street | | | | | | 24 | |
| num_nodes (MeTS-10 extent (bounding box)) | | | | | | 5530 | |
| num_edges_per_cell (MeTS-10 extent (bounding box)) | 1.1 | 0.4 | 1.0 | 1.0 | 3.0 | 13'823 | |
| num_intersecting_cells (MeTS-10 extent (bounding box)) | 2.5 | 1.5 | 2.0 | 1.0 | 8.0 | 5'943 | |
| node_degree (MeTS-10 extent (bounding box)) | 2.0 | 0.7 | 2.0 | 1.0 | 4.0 | 5'530 | |
| length_meters (MeTS-10 extent (bounding box)) | 80.0 | 74.0 | 61.9 | 3.9 | 327.3 | 5'943 | 4.8e+05 |
| motorway | 225.8 | 223.5 | 133.2 | 25.4 | 651.4 | 16 | 3.6e+03 |
| motorway_link | 202.8 | 130.0 | 196.9 | 78.3 | 333.0 | 3 | 6.1e+02 |
| trunk | 212.8 | 202.4 | 130.6 | 7.9 | 880.2 | 56 | 1.2e+04 |
| trunk_link | 122.5 | 102.9 | 90.1 | 18.7 | 439.1 | 44 | 5.4e+03 |
| primary | 83.5 | 78.4 | 69.0 | 4.3 | 350.4 | 709 | 5.9e+04 |
| primary_link | 71.6 | 65.1 | 44.5 | 4.6 | 274.5 | 216 | 1.5e+04 |
| secondary | 86.8 | 80.8 | 68.0 | 4.4 | 365.5 | 1'278 | 1.1e+05 |
| secondary_link | 52.3 | 70.4 | 32.1 | 2.7 | 279.8 | 92 | 4.8e+03 |
| tertiary | 73.1 | 62.2 | 56.0 | 3.6 | 275.8 | 2'014 | 1.5e+05 |
| tertiary_link | 67.6 | 70.3 | 33.4 | 3.6 | 258.8 | 130 | 8.8e+03 |
| unclassified | 89.9 | 99.5 | 48.1 | 7.1 | 366.2 | 20 | 1.8e+03 |
| residential | 77.8 | 58.6 | 65.5 | 4.0 | 266.4 | 1'341 | 1.0e+05 |
| living_street | 68.6 | 42.6 | 63.2 | 6.2 | 153.9 | 24 | 1.6e+03 |
| speed_kph (MeTS-10 extent (bounding box)) | 47.3 | 7.3 | 49.7 | 30.0 | 80.0 | 5'943 | |
| motorway | 90.0 | 11.0 | 90.0 | 80.0 | 117.0 | 16 | |
| motorway_link | 56.7 | 5.8 | 60.0 | 50.2 | 60.0 | 3 | |
| trunk | 78.5 | 6.4 | 80.0 | 60.0 | 89.0 | 56 | |
| trunk_link | 57.3 | 9.9 | 57.4 | 40.0 | 80.0 | 44 | |
| primary | 49.7 | 2.5 | 50.0 | 30.8 | 50.0 | 709 | |
| primary_link | 47.2 | 7.3 | 50.0 | 20.0 | 58.5 | 216 | |
| secondary | 49.7 | 1.5 | 50.0 | 40.0 | 50.0 | 1'278 | |
| secondary_link | 49.1 | 3.2 | 50.0 | 30.0 | 50.0 | 92 | |
| tertiary | 49.5 | 2.6 | 50.0 | 31.3 | 50.0 | 2'014 | |
| tertiary_link | 49.3 | 3.0 | 50.0 | 30.0 | 50.0 | 130 | |
| unclassified | 41.4 | 6.0 | 41.4 | 30.0 | 50.0 | 20 | |
| residential | 38.6 | 5.4 | 38.6 | 30.0 | 50.0 | 1'341 | |
| living_street | 16.6 | 7.8 | 16.3 | 10.0 | 30.0 | 24 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| free_flow_kph (MeTS-10 extent (bounding box)) | 37.1 | 14.8 | 35.3 | 14.4 | 91.4 | 5’943 |
| motorway | 103.7 | 13.4 | 93.6 | 90.8 | 119.8 | 16 |
| motorway_link | 85.4 | 17.2 | 94.7 | 66.2 | 96.0 | 3 |
| trunk | 80.8 | 8.6 | 82.1 | 63.5 | 99.8 | 56 |
| trunk_link | 74.9 | 12.9 | 76.7 | 39.9 | 92.7 | 44 |
| primary | 41.6 | 11.4 | 42.1 | 20.9 | 90.2 | 709 |
| primary_link | 46.2 | 13.2 | 47.5 | 18.9 | 81.7 | 216 |
| secondary | 38.8 | 11.5 | 37.6 | 17.8 | 80.9 | 1’278 |
| secondary_link | 39.0 | 14.8 | 35.3 | 18.4 | 85.0 | 92 |
| tertiary | 35.7 | 13.6 | 32.9 | 15.1 | 88.5 | 2’014 |
| tertiary_link | 35.9 | 11.5 | 34.1 | 14.3 | 78.8 | 130 |
| unclassified | 47.4 | 29.2 | 36.7 | 19.2 | 117.1 | 20 |
| residential | 30.0 | 12.2 | 28.7 | 11.5 | 83.0 | 1’341 |
| living_street | 25.0 | 10.4 | 20.5 | 9.1 | 43.8 | 24 |
| free_flow_kph-speed_kph (MeTS-10 extent (bounding box)) | -10.2 | 13.7 | -11.9 | -33.5 | 38.5 | 5’943 |
| motorway | 13.7 | 13.5 | 11.9 | -6.4 | 29.8 | 16 |
| motorway_link | 28.8 | 11.4 | 34.7 | 16.0 | 36.0 | 3 |
| trunk | 2.3 | 7.6 | 3.2 | -13.3 | 19.8 | 56 |
| trunk_link | 17.6 | 15.1 | 16.7 | -14.2 | 52.7 | 44 |
| primary | -8.1 | 11.4 | -7.3 | -29.1 | 40.2 | 709 |
| primary_link | -1.0 | 15.8 | -1.1 | -31.0 | 50.0 | 216 |
| secondary | -10.9 | 11.8 | -12.1 | -32.0 | 31.2 | 1’278 |
| secondary_link | -10.1 | 15.5 | -14.7 | -29.0 | 45.0 | 92 |
| tertiary | -13.9 | 13.5 | -16.1 | -34.9 | 36.3 | 2’014 |
| tertiary_link | -13.4 | 12.2 | -15.2 | -35.0 | 29.7 | 130 |
| unclassified | 6.0 | 29.9 | -3.8 | -22.2 | 75.7 | 20 |
| residential | -8.6 | 12.9 | -9.4 | -33.1 | 44.4 | 1’341 |
| living_street | 8.4 | 17.0 | 5.0 | -20.9 | 33.8 | 24 |

TABLE XXI: Key figures Barcelona for the generated data from 20 randomly sampled days (MeTS-10 extent (bounding box)). **num_edges** number of edges in the street network graph; **num_nodes** number of nodes in the street network graph; **num_edges_per_cell** number of edges a cell (row,col,heading) has in its intersecting cells; **num_intersecting_cells** number of cells (row,col,heading) in an edge’s intersecting cells; **node_degree** number of (unique) neighbor nodes per node; **length_meters** free flow speed derived from data; **speed_kph** signalled speed; **free_flow_kph** free flow speed derived from data; **free_flow_kph-speed_kph** difference

*4) Segment density map Barcelona:*

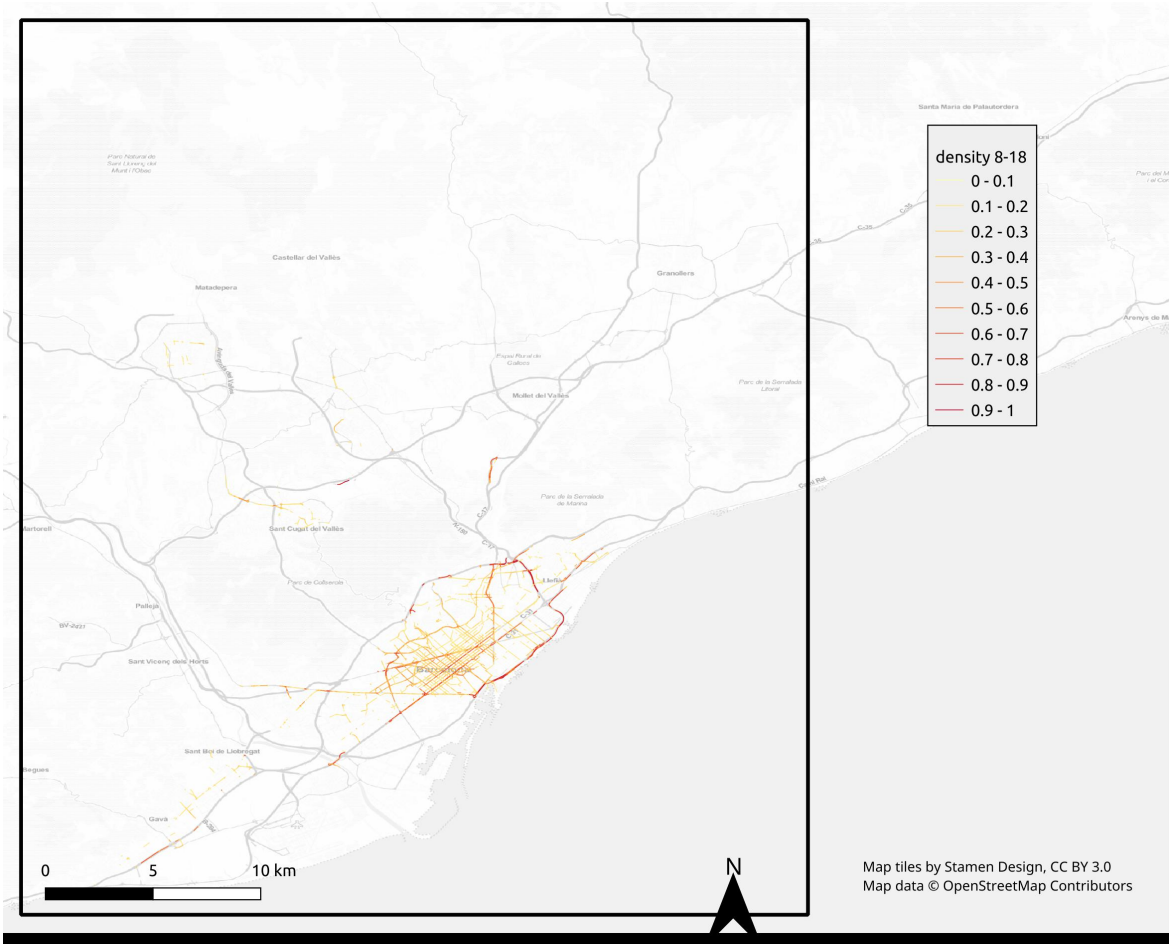



Fig. 71: Segment-wise density 8am–6pm Barcelona from 20 randomly sampled days.

*5) Daily density profile Barcelona (full historic road graph):*

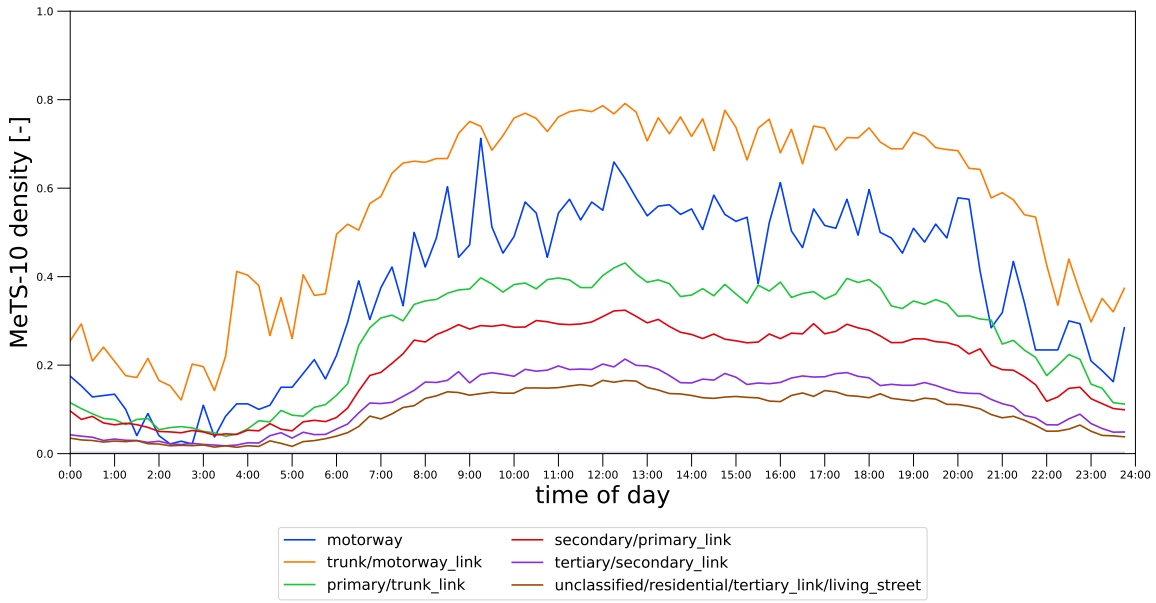



Fig. 72: Daily density profile for different road types for Barcelona (full historic road graph). Data from 20 randomly sampled days.

*6) Daily speed profile Barcelona (full historic road graph):*

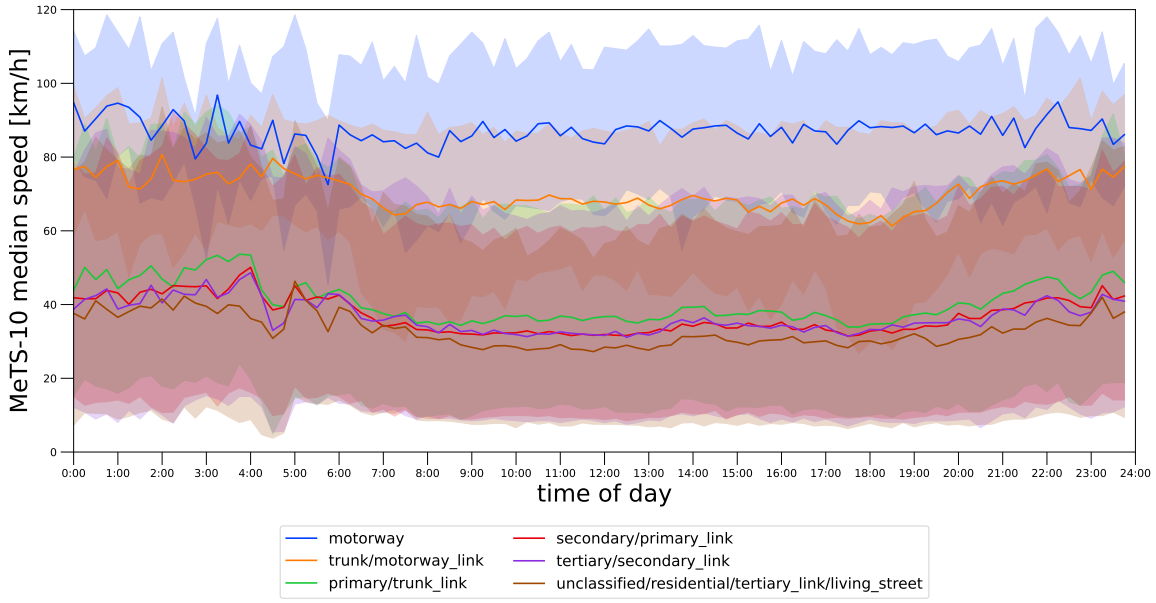



Fig. 73: Daily median 15 min speeds of all intersecting cells profile for different road types for Barcelona (full historic road graph). The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

*7) Daily density profile Barcelona (MeTS-10 extent (bounding box)):*

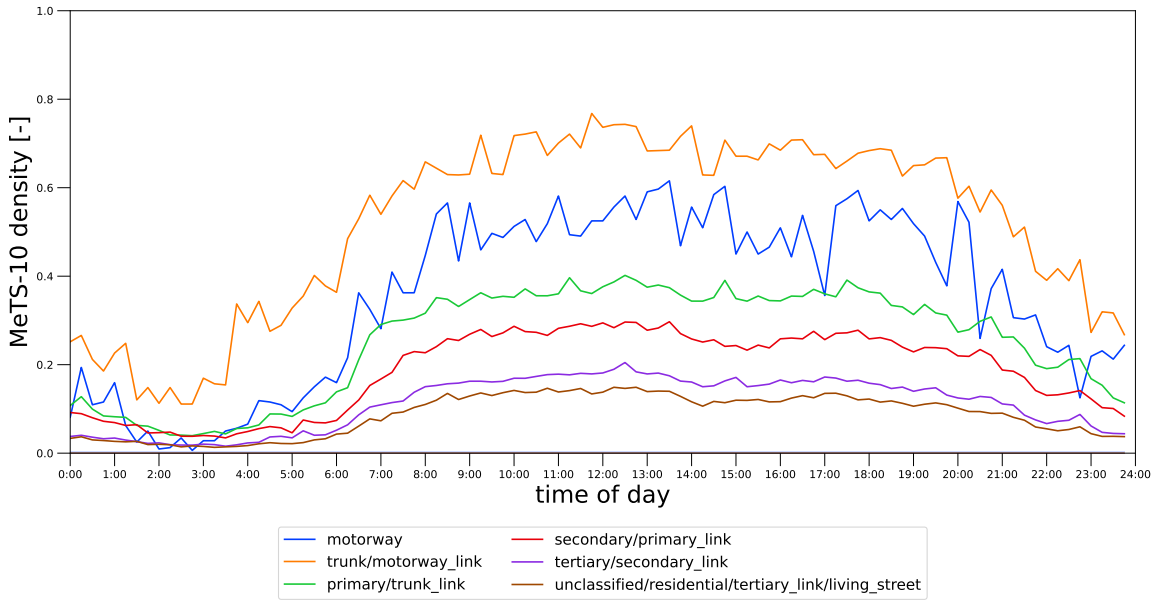



Fig. 74: Daily density profile for different road types for Barcelona (MeTS-10 extent (bounding box)). Data from 20 randomly sampled days.

*8) Daily speed profile Barcelona (MeTS-10 extent (bounding box)):*

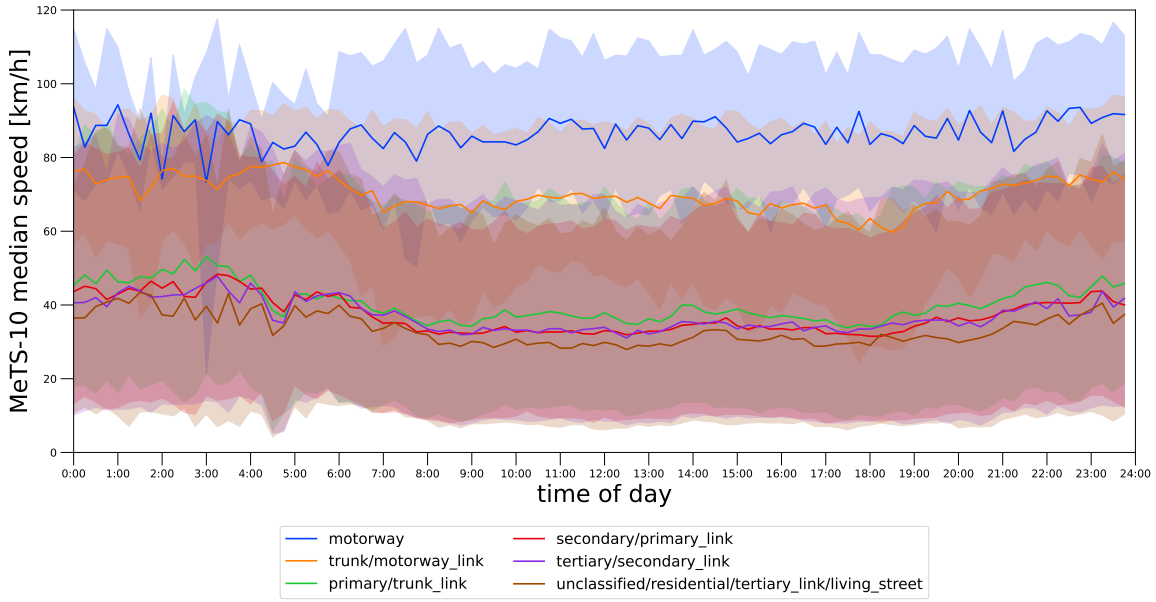
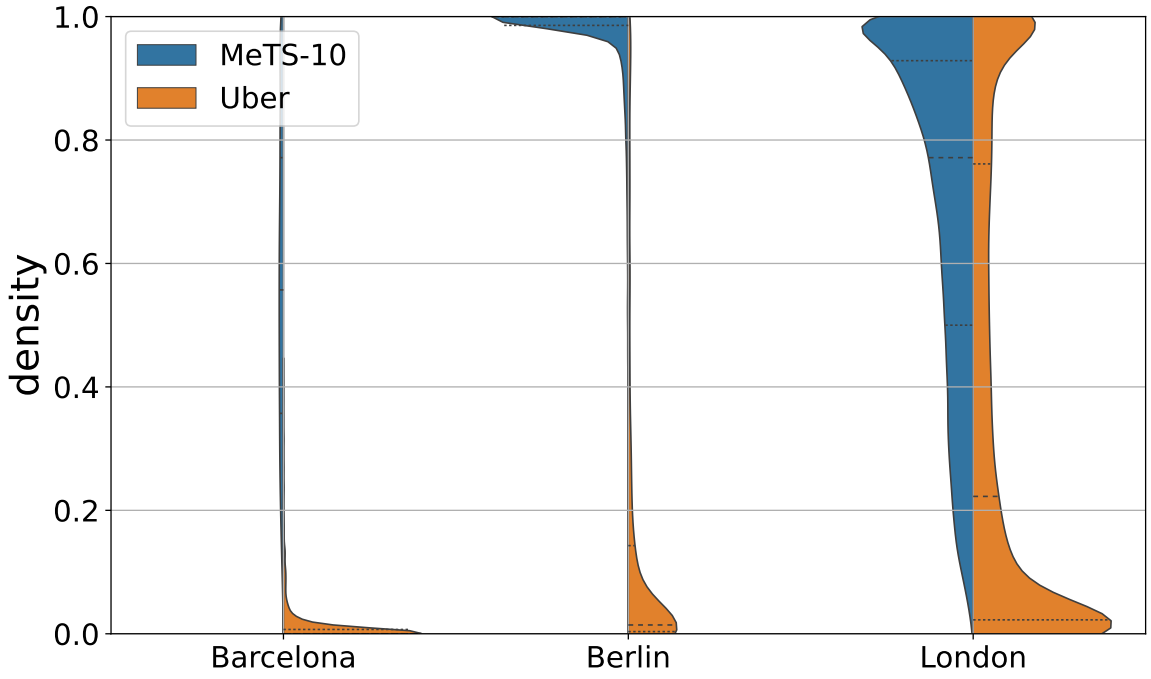


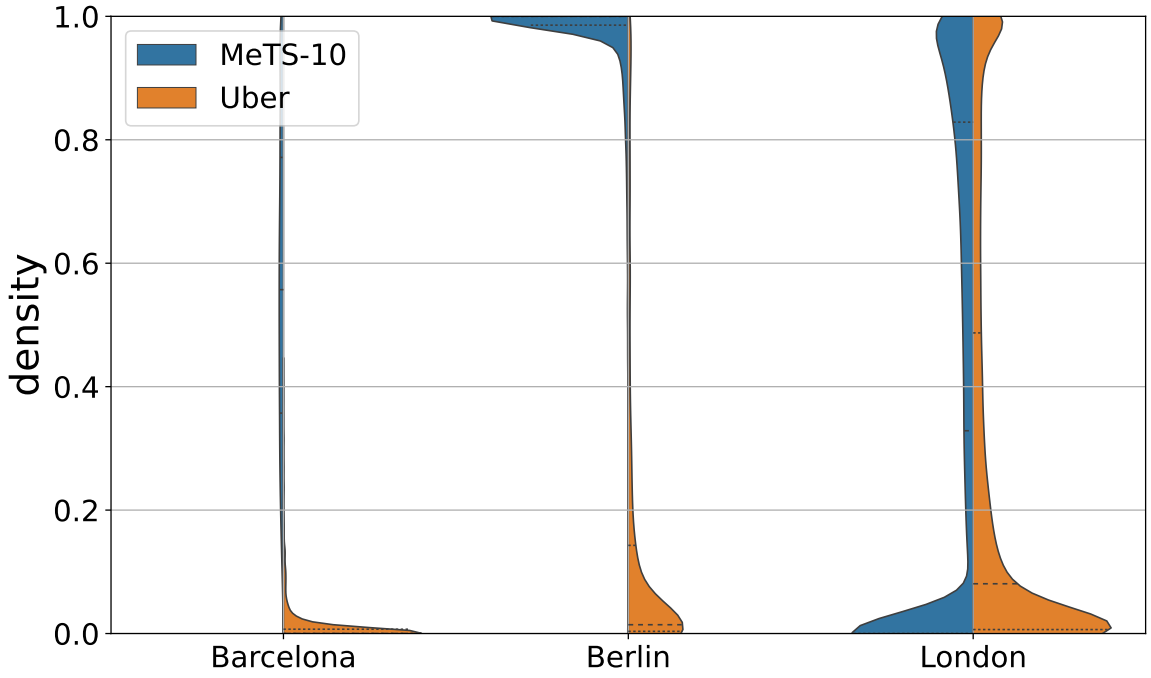

Fig. 75: Daily median 15 min speeds of all intersecting cells profile for different road types for Barcelona (MeTS-10 extent (bounding box)). The error hull is the 80% data interval [10.0–90.0 percentiles] of daily means from 20 randomly sampled days.

## SUPPLEMENT H
## KEY FIGURES UBER COMPARISON

### A. *Temporal coverage all 3 cities*




(a) Uber segments in *Traffic4cast* bounding box only




(b) full historic road graph (all Uber segments)

Fig. 76: Violin plot of segment-wise temporal coverage for *MeTS-10* and Uber on the historic road graph for the 3 cities Barcelona, Berlin and London.

*B. Barcelona*

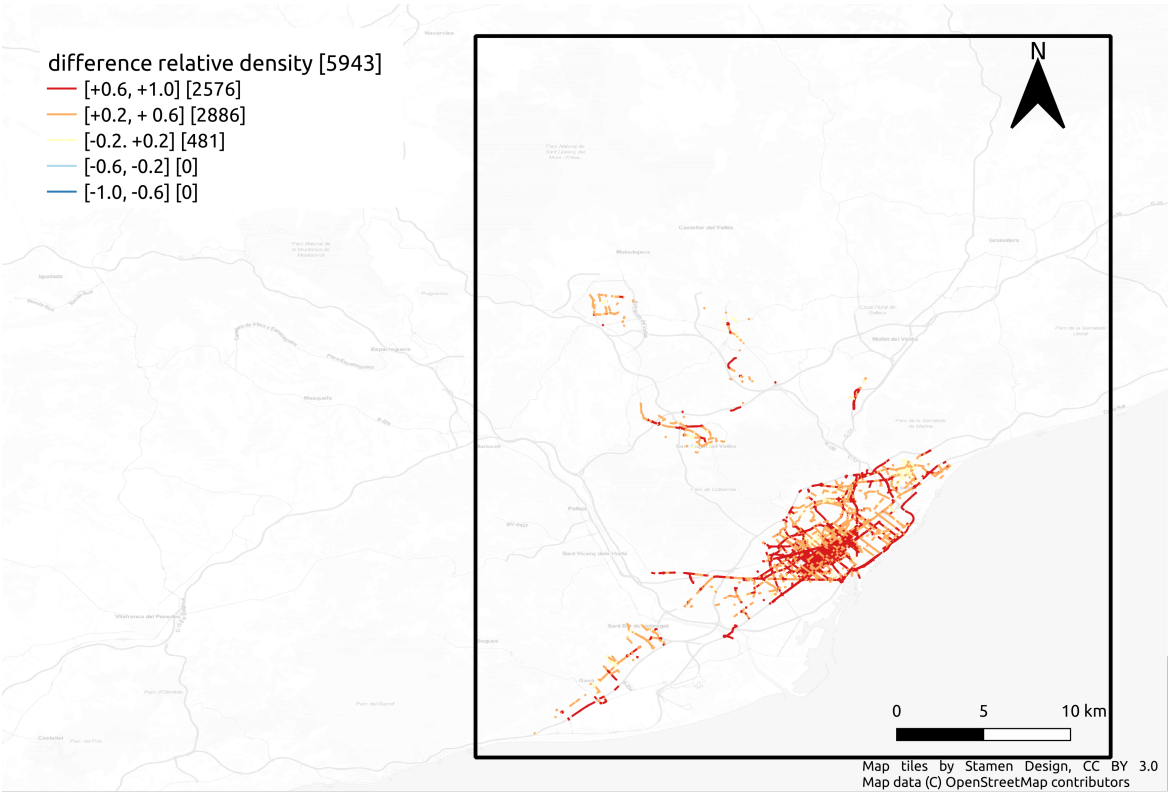



Fig. 77: Segment density differences of Uber and *MeTS-10* on the historic road graph Barcelona (8am–6pm). The color encoding shows the edge density difference, negative means higher temporal coverage of *MeTS-10* and positive values mean higher temporal coverage..

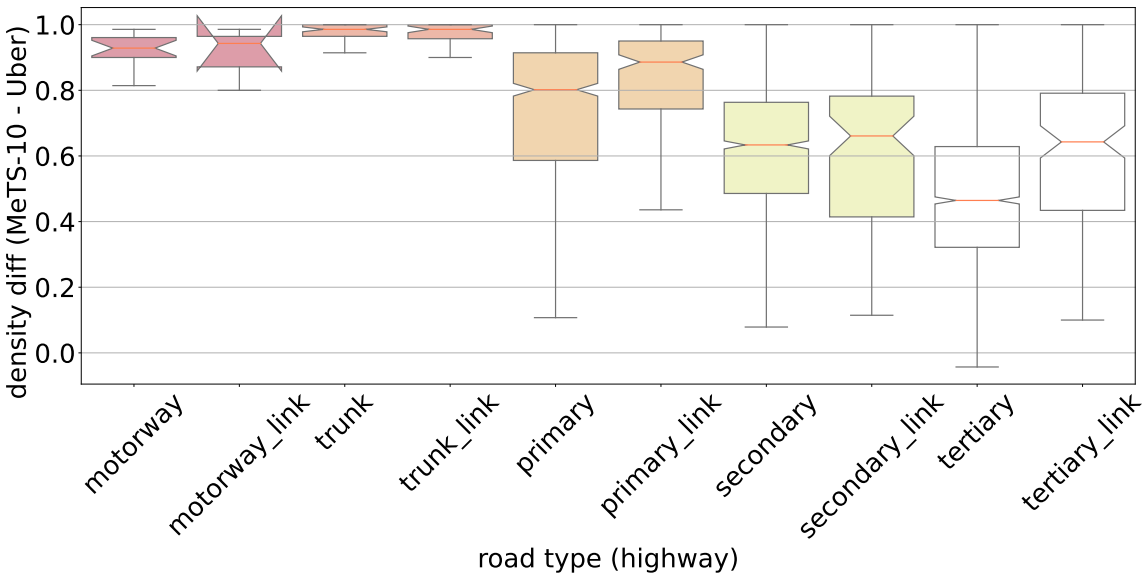
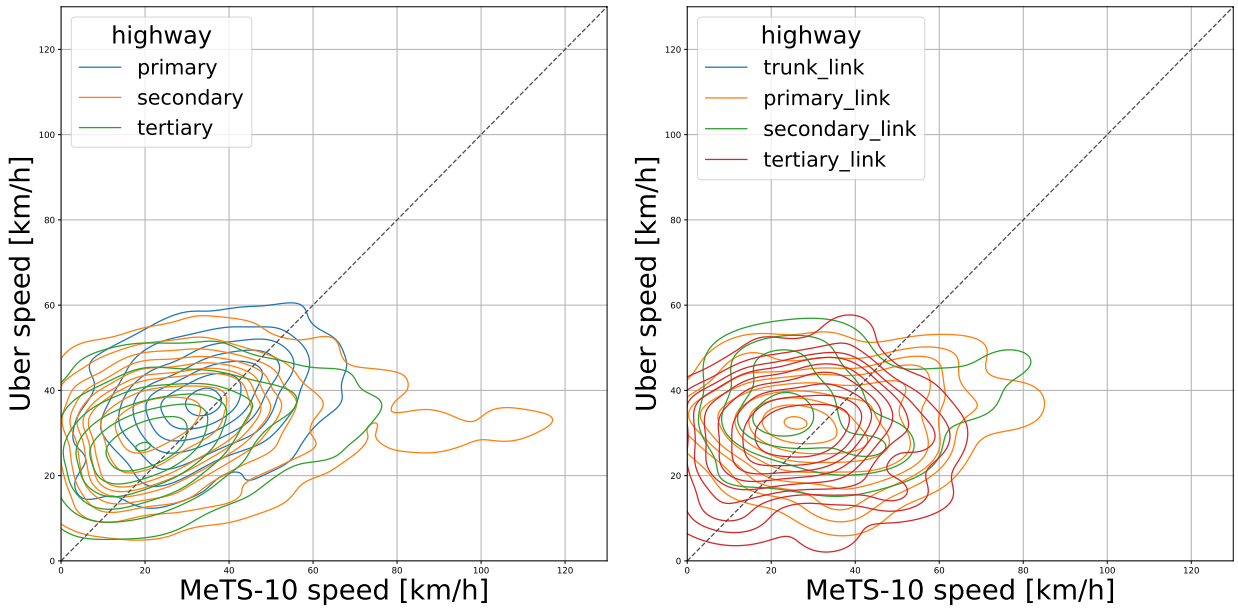


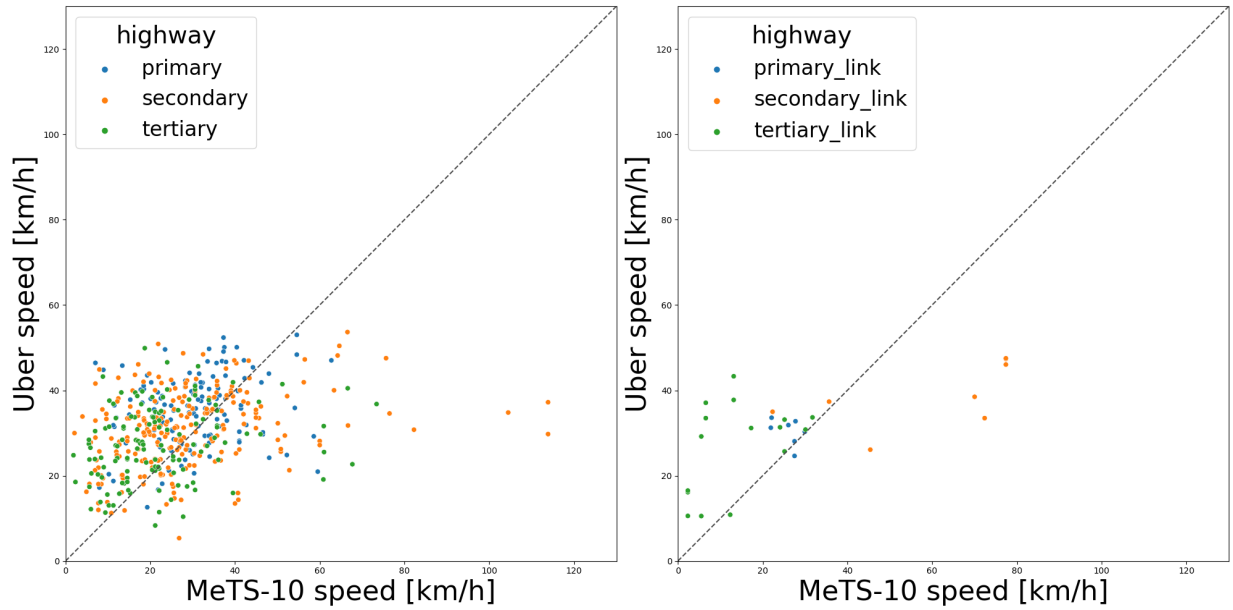

Fig. 78: Segment density differences Uber and *MeTS-10* on the historic road graph Barcelona daytime (8am–6pm, segments within 4c bounding box only). Mean density difference by road type (*i. e.* OSM highway attribute); positive density difference means higher temporal coverage of *MeTS-10* and negative mean higher temporal coverage.




(a) KDE non-link road types.




(b) KDE link road types.




(c) Scatter non-link (left) and link (right) road types.

Fig. 79: Kernel Distribution Estimation and Scatter Plots of speeds of *MeTS-10* (x-axis, `median_speed_kph`) and Uber (y-axis, `speed_kph_mean`) on the historic road graph Barcelona daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment, for the most important road types.

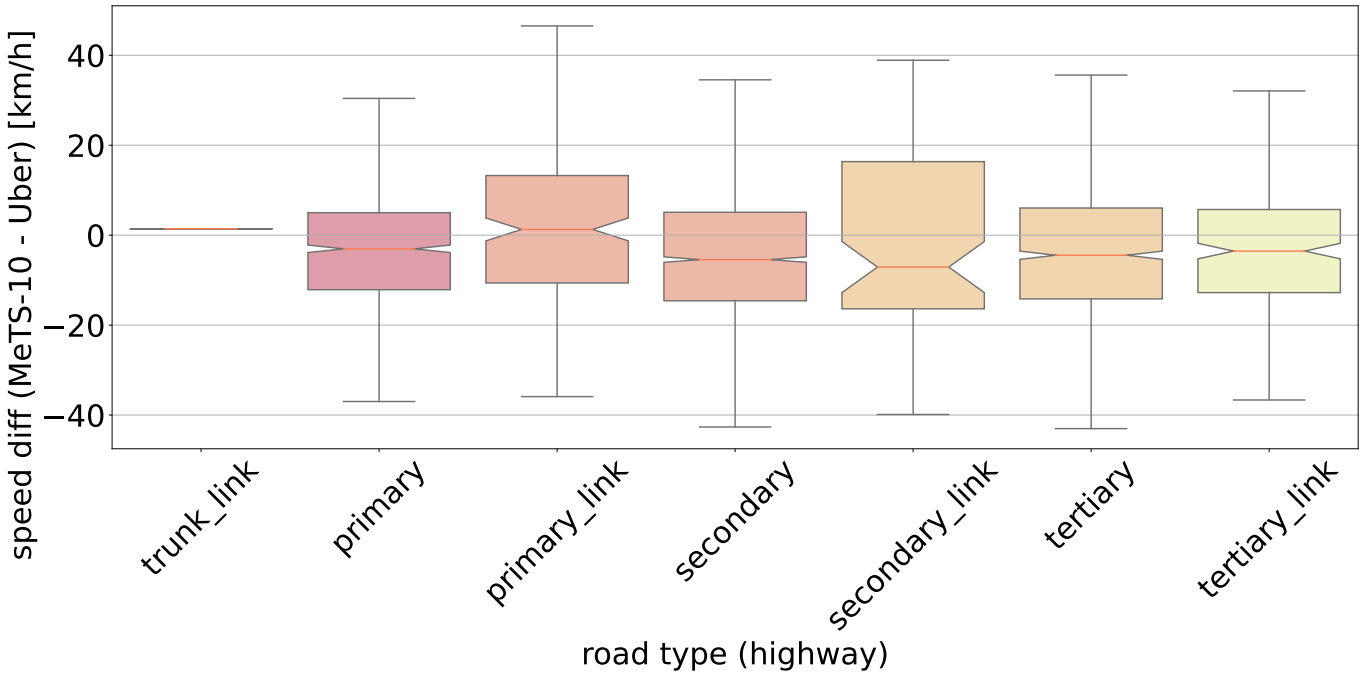



Fig. 80: Speed differences Uber and *MeTS-10* on the historic road graph Barcelona daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment. Mean difference by road class (OSM highway attribute). Positive speed difference means higher values in *MeTS-10*.

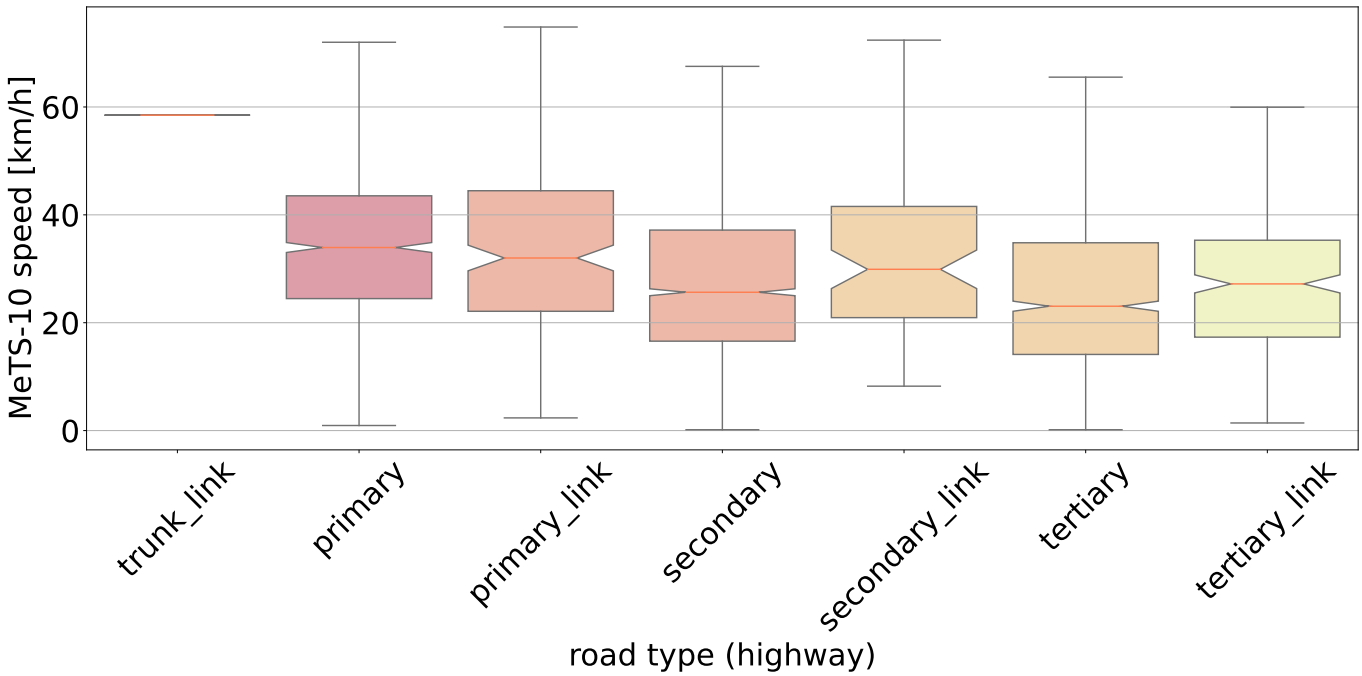



Fig. 81: *MeTS-10* speeds on the historic road graph Barcelona daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment. By road class (OSM highway attribute).

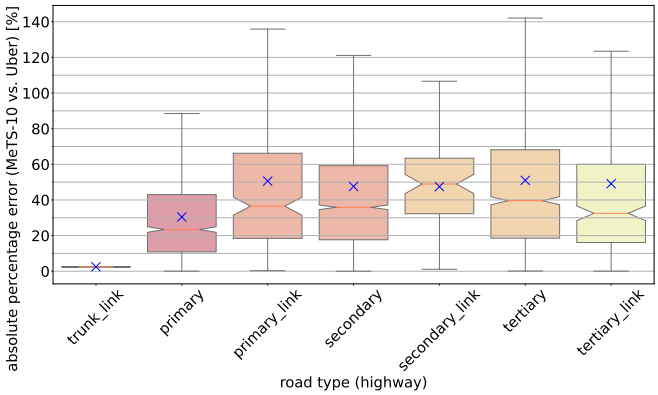



Fig. 82: Barcelona absolute percentage error *MeTS-10* vs. Uber by road type. Blue crosses indicate the mean per road type.

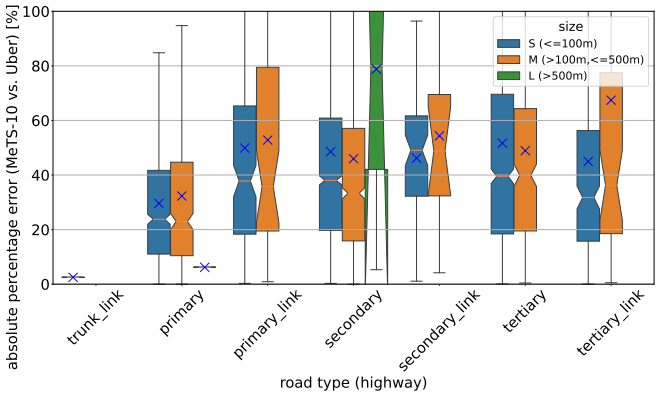



Fig. 83: Barcelona absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

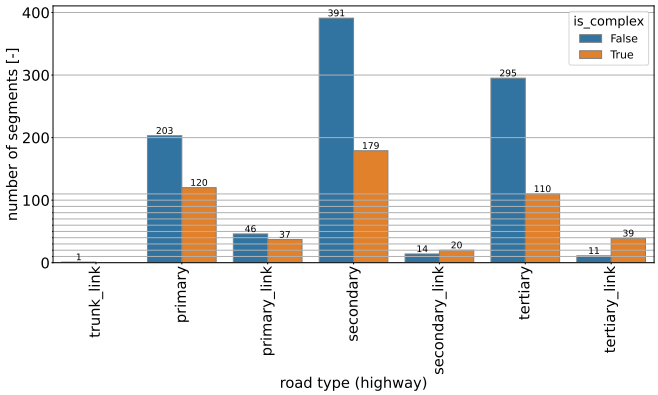
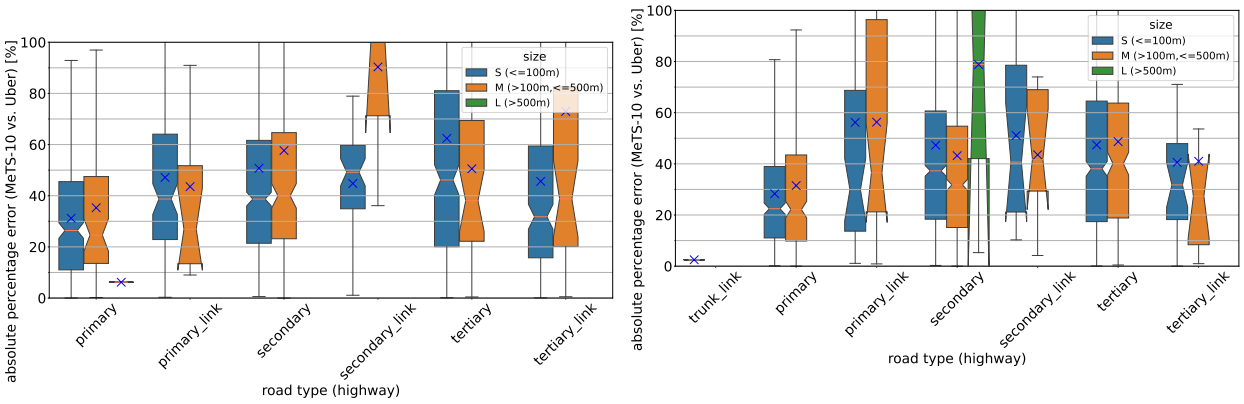



Fig. 84: Segment counts *MeTS-10* – Uber matched data.




(a) complex road segments

(b) non-complex road segments

Fig. 85: Barcelona absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

## C. Berlin

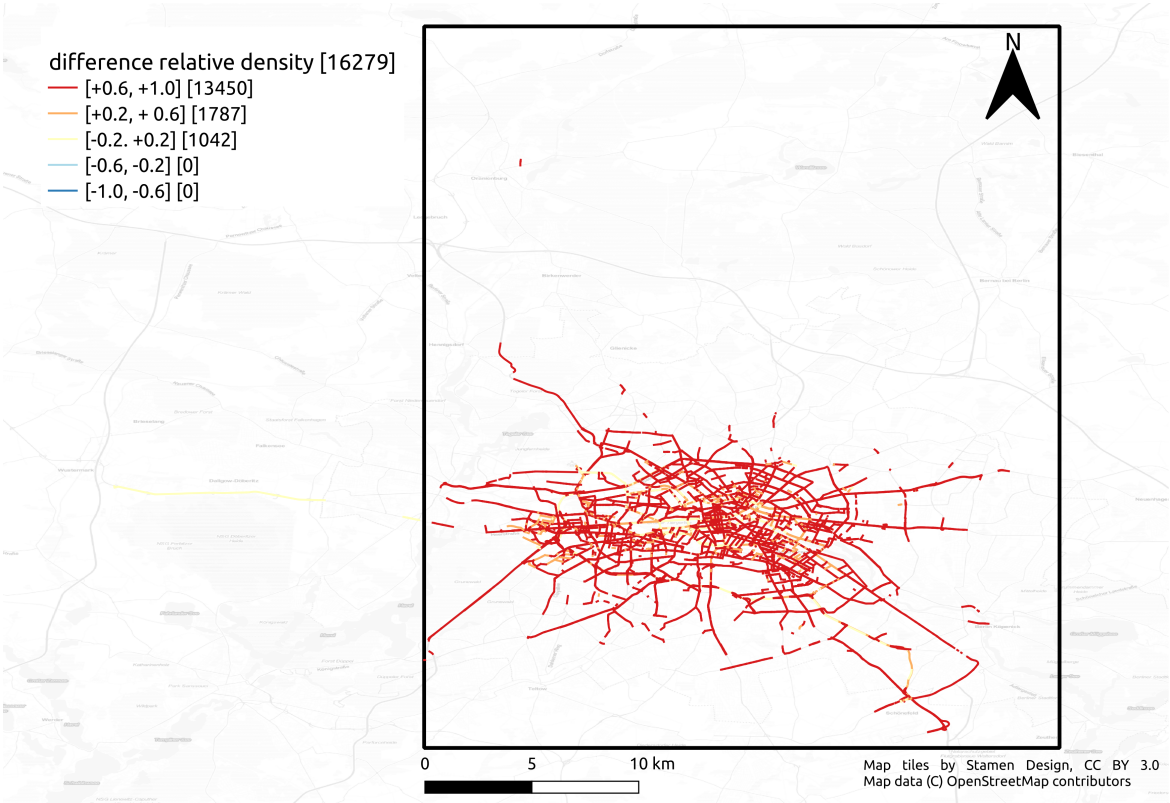



Fig. 86: Segment density differences of Uber and *MeTS-10* on the historic road graph Berlin (8am–6pm). The color encoding shows the edge density difference, negative means higher temporal coverage of *MeTS-10* and positive values mean higher temporal coverage..

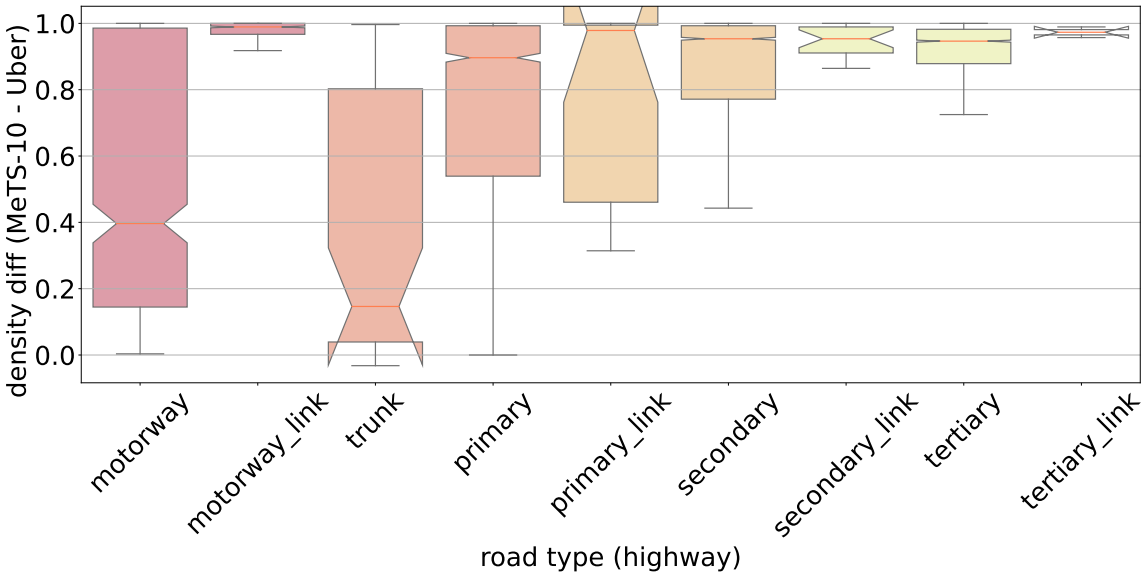
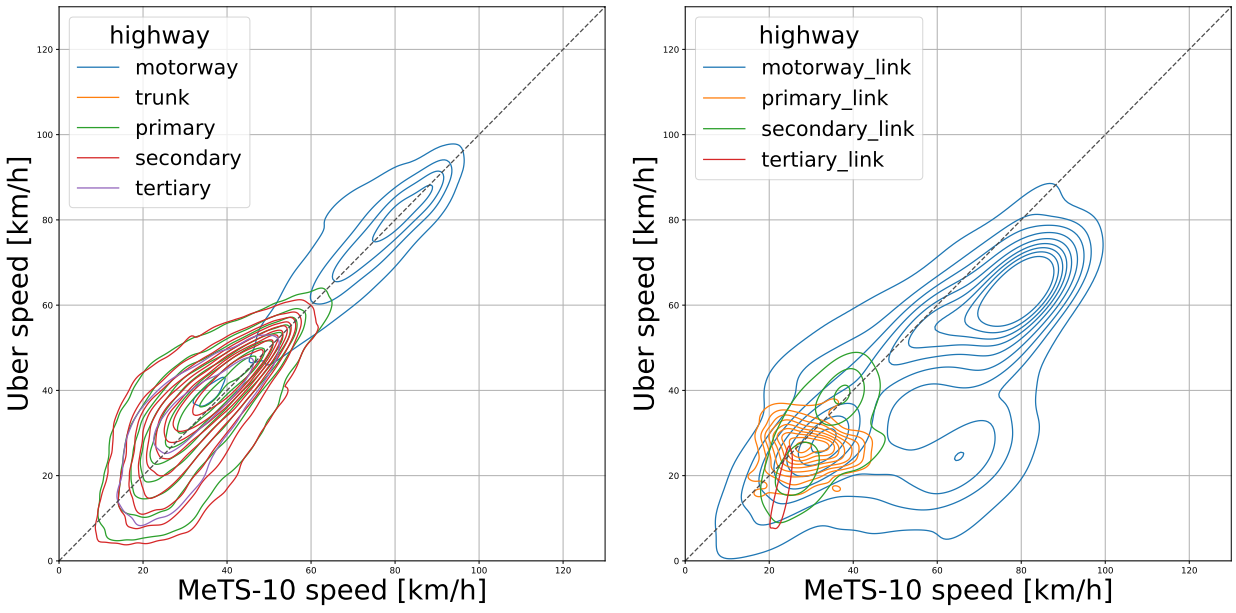


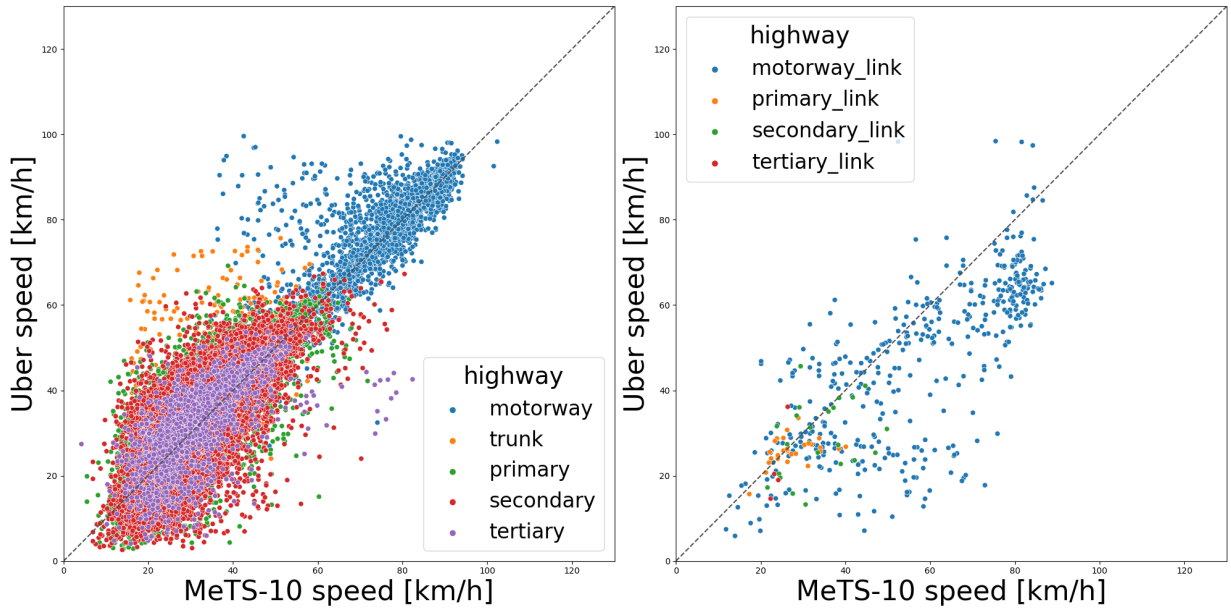

Fig. 87: Segment density differences Uber and *MeTS-10* on the historic road graph Berlin daytime (8am–6pm, segments within 4c bounding box only). Mean density difference by road class (*i. e.* OSM highway attribute); positive density difference means higher temporal coverage of *MeTS-10* and negative mean higher temporal coverage.




(a) KDE non-link road types.




(b) KDE link road types.




(c) Scatter non-link (left) and link (right) road types.

Fig. 88: Kernel Distribution Estimation and Scatter Plots of speeds of *MeTS-10* (x-axis, `median_speed_kph`) and Uber (y-axis, `speed_kph_mean`) on the historic road graph Berlin daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment, for the most important road types.

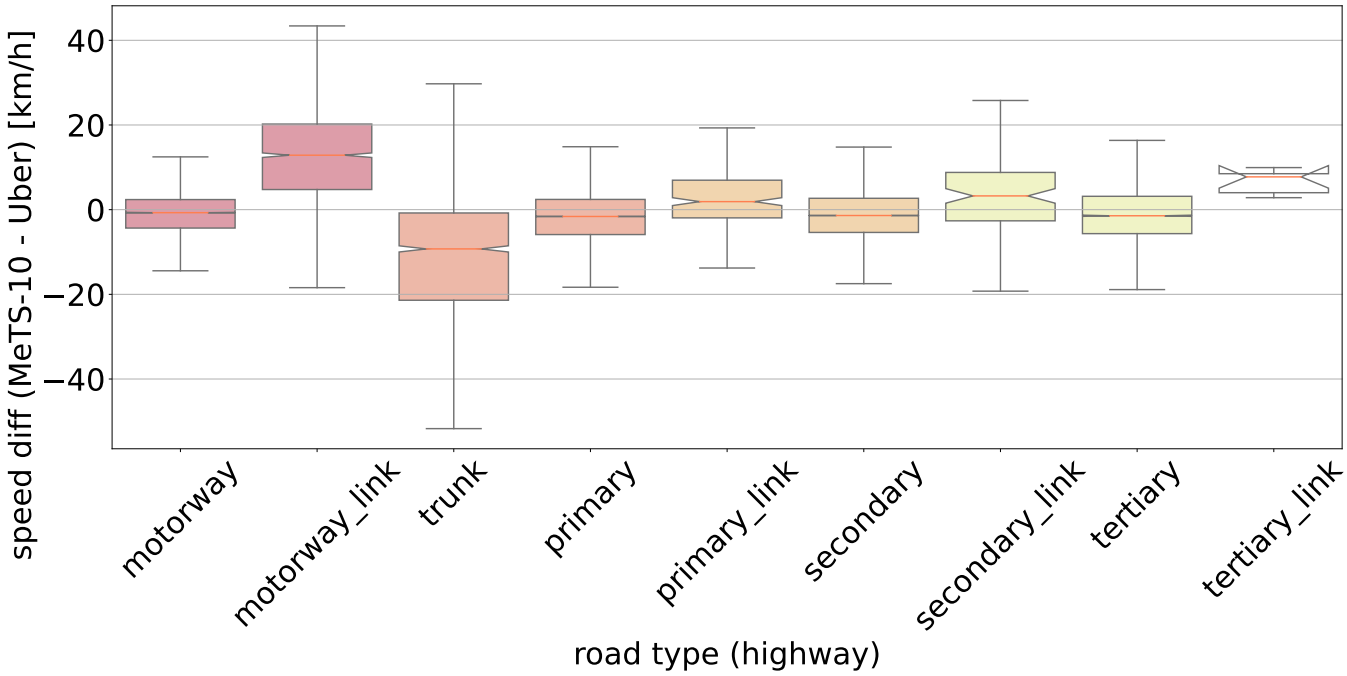



Fig. 89: Speed differences Uber and *MeTS-10* on the historic road graph Berlin daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment. Mean difference by road class (OSM highway attribute). Positive speed difference means higher values in *MeTS-10*.

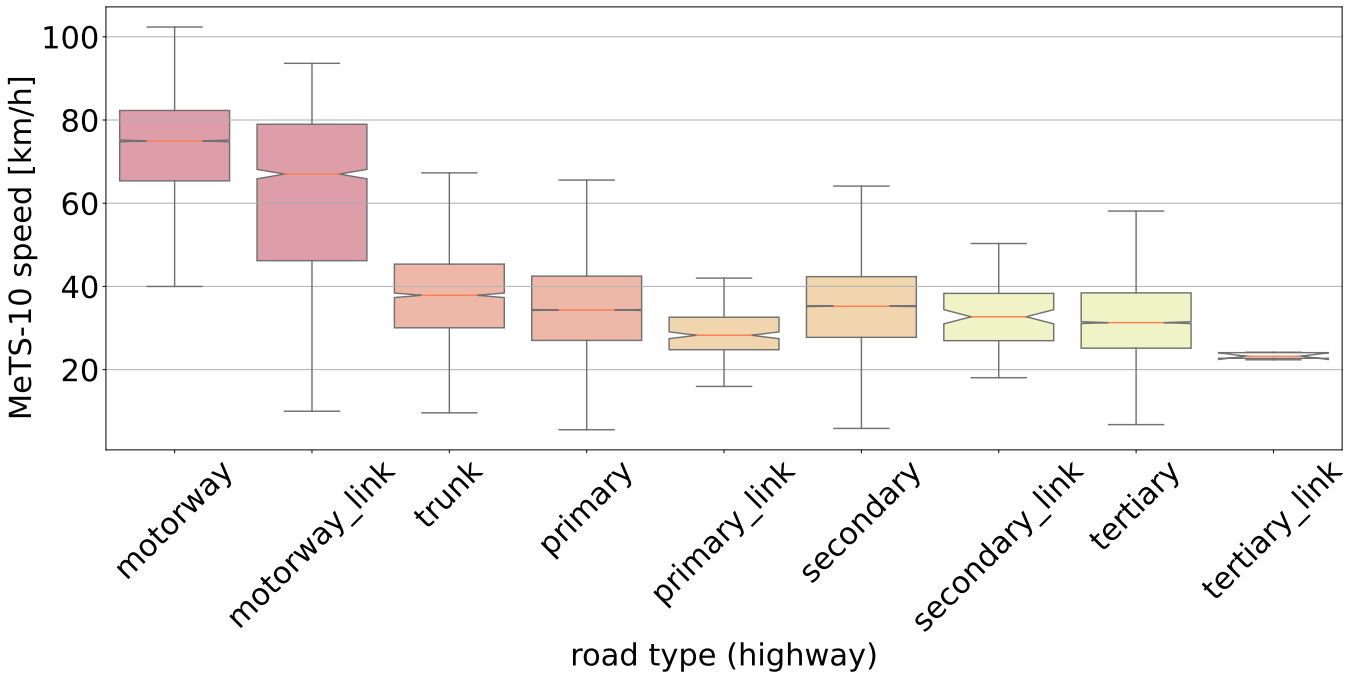



Fig. 90: *MeTS-10* speeds on the historic road graph Berlin daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment. By road class (OSM highway attribute).

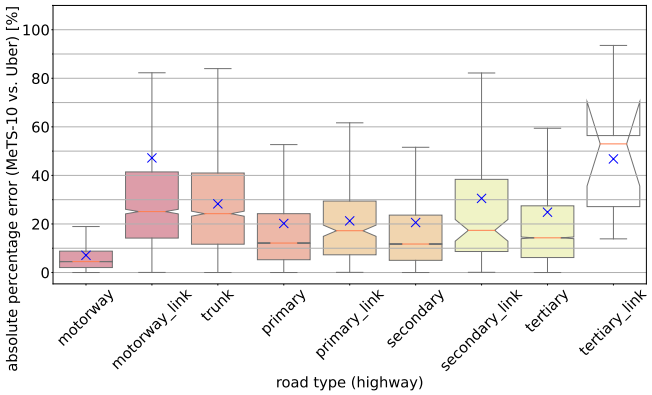



Fig. 91: Berlin absolute percentage error *MeTS-10* vs. Uber by road type. Blue crosses indicate the mean per road type.

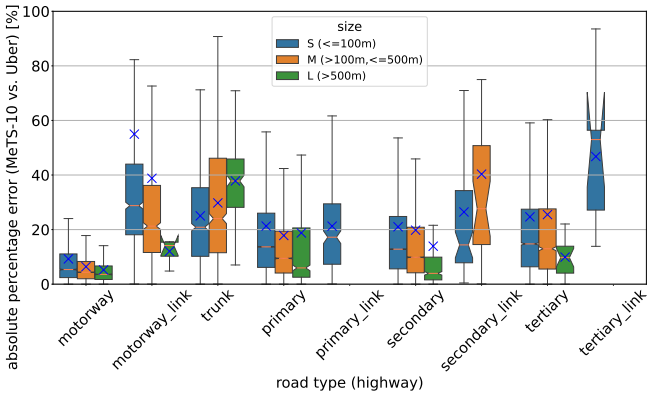



Fig. 92: Berlin absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

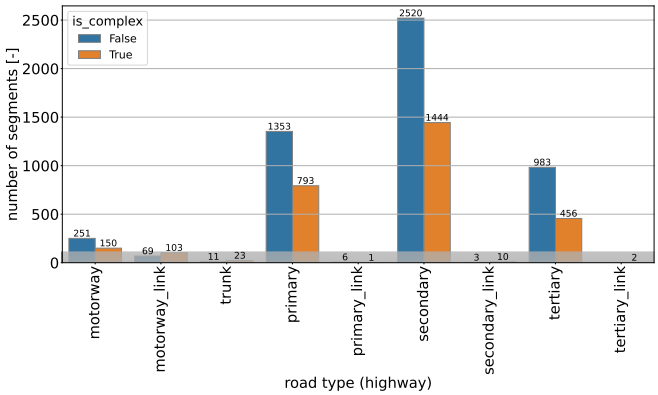
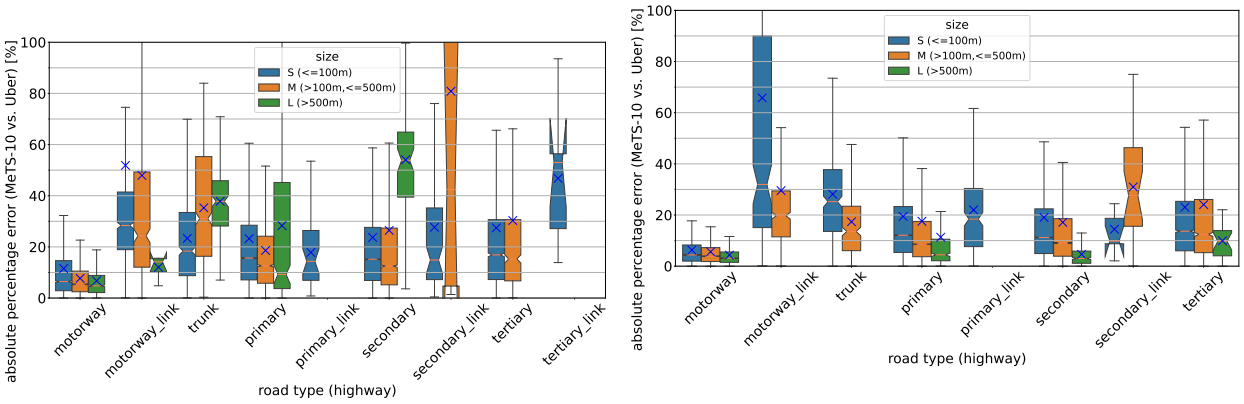



Fig. 93: Segment counts *MeTS-10* – Uber matched data.




(a) complex road segments

(b) non-complex road segments

Fig. 94: Berlin absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

## *D. London*

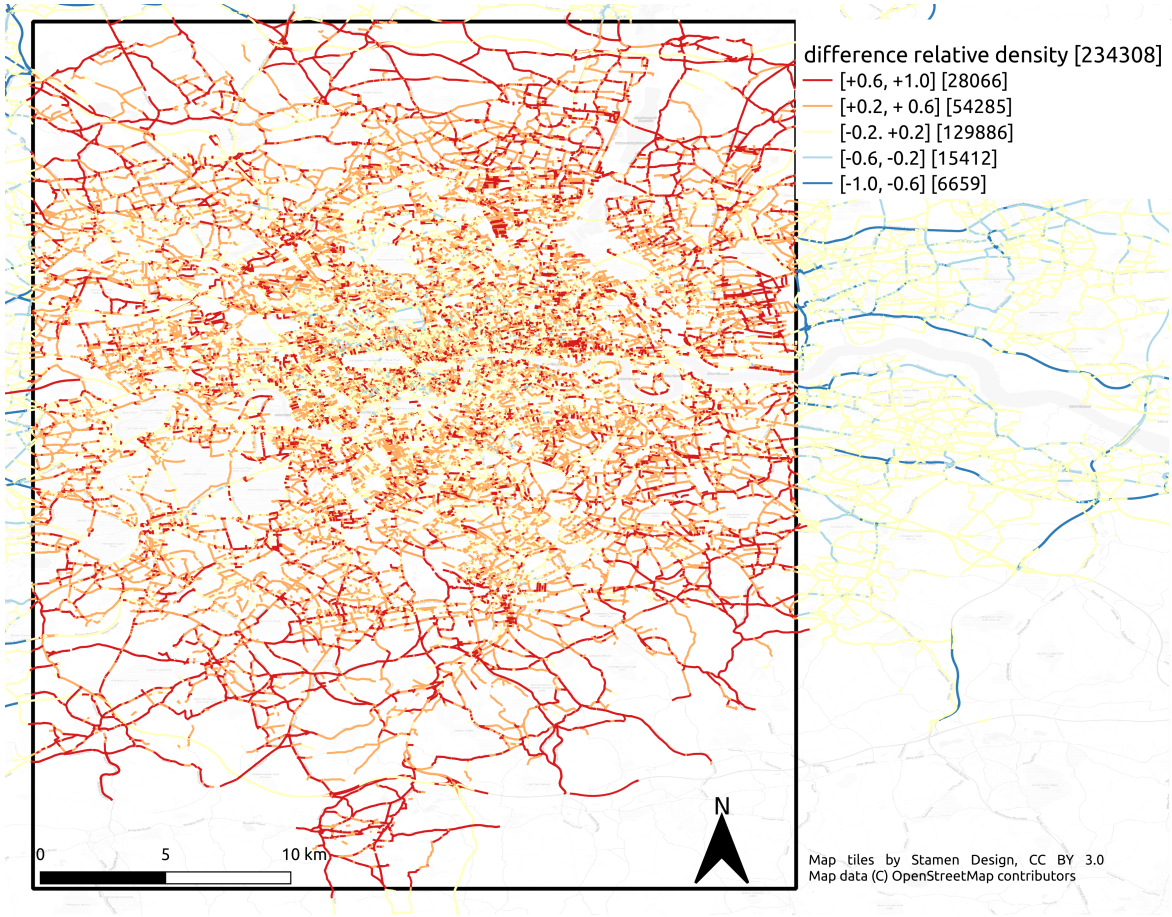



Fig. 95: Segment density differences of Uber and *MeTS-10* on the historic road graph London (8am–6pm). The color encoding shows the edge density difference, negative means higher temporal coverage of *MeTS-10* and positive values mean higher temporal coverage..

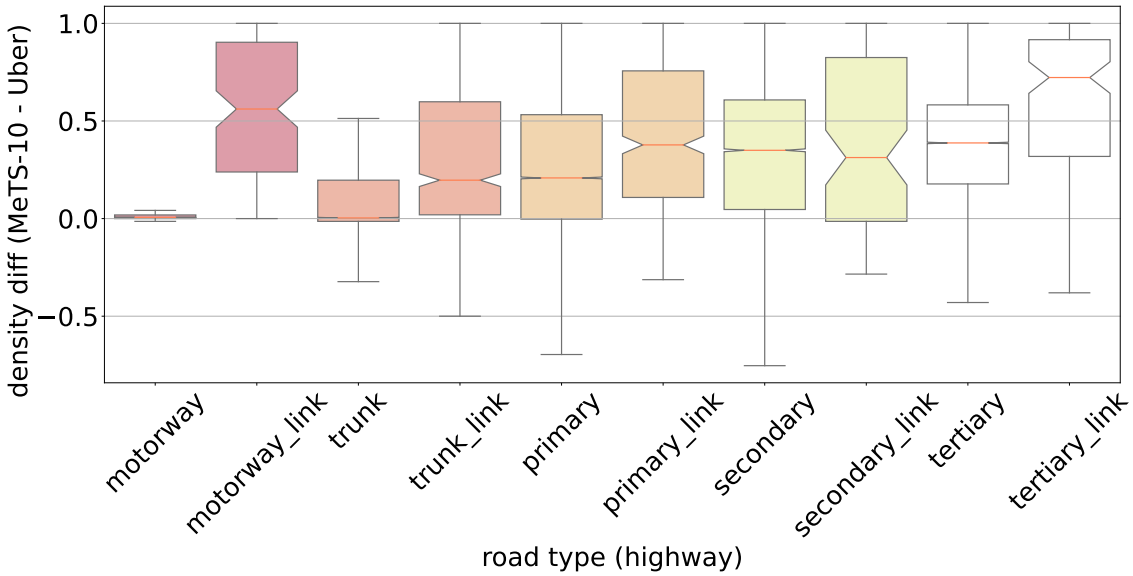
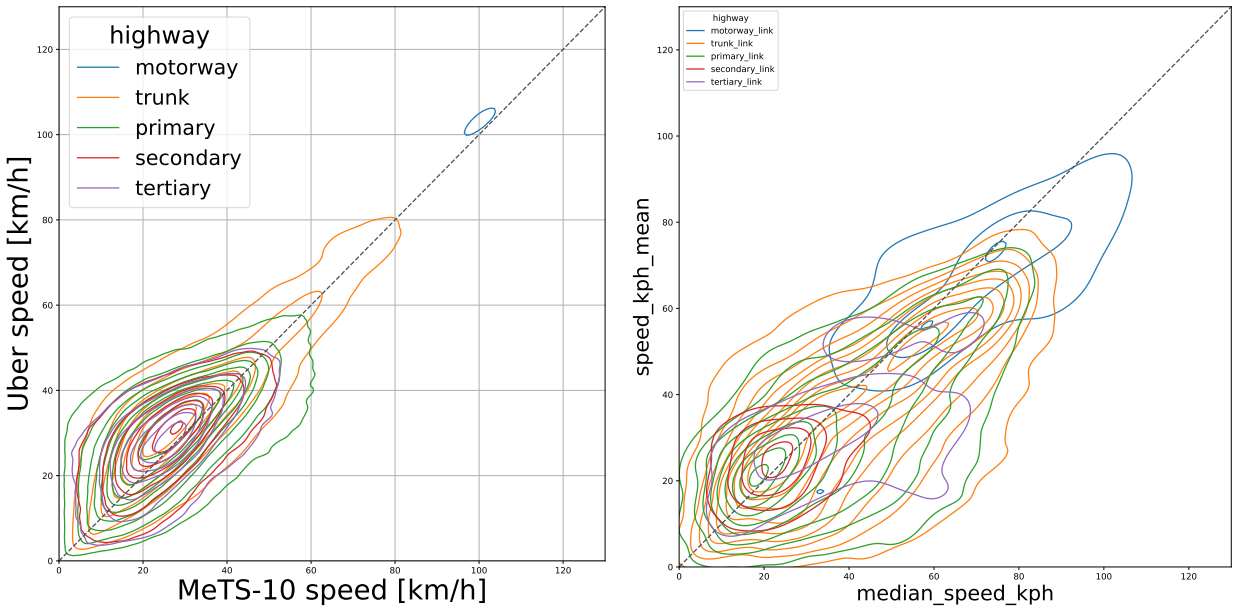


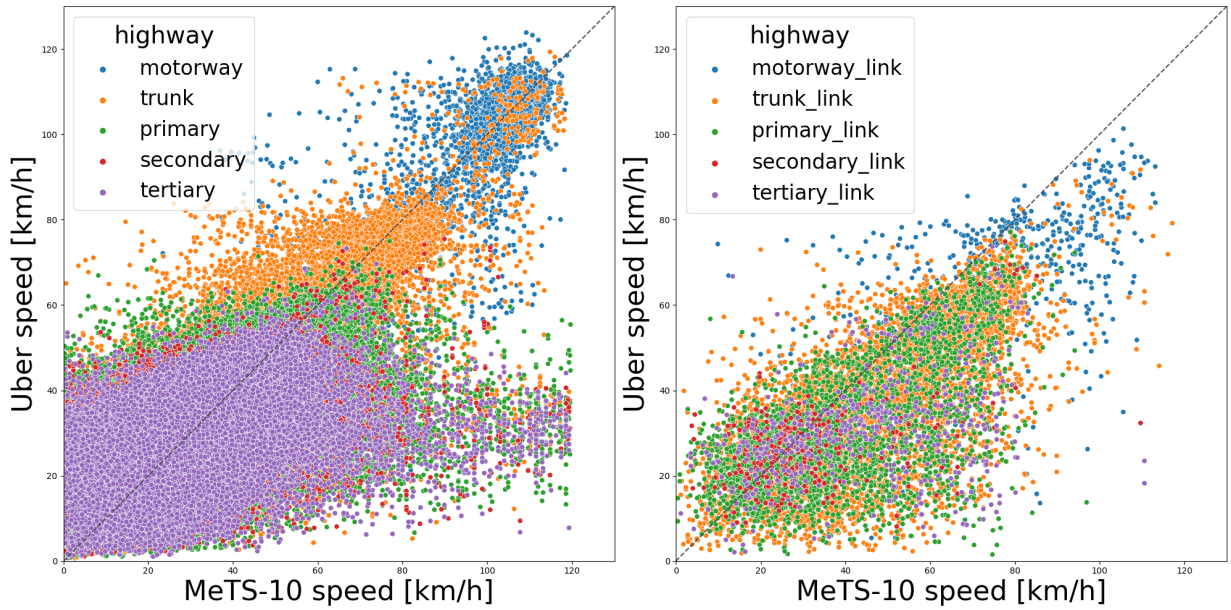

Fig. 96: Segment density differences Uber and *MeTS-10* on the historic road graph London daytime (8am–6pm, segments within 4c bounding box only). Mean density difference by road class (*i. e.* OSM highway attribute); positive density difference means higher temporal coverage of *MeTS-10* and negative mean higher temporal coverage.




(a) KDE non-link road types.




(b) KDE link road types.




(c) Scatter non-link (left) and link (right) road types.

Fig. 97: Kernel Distribution Estimation and Scatter Plots of speeds of *MeTS-10* (x-axis, `median_speed_kph`) and Uber (y-axis, `speed_kph_mean`) on the historic road graph London daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment, for the most important road types.

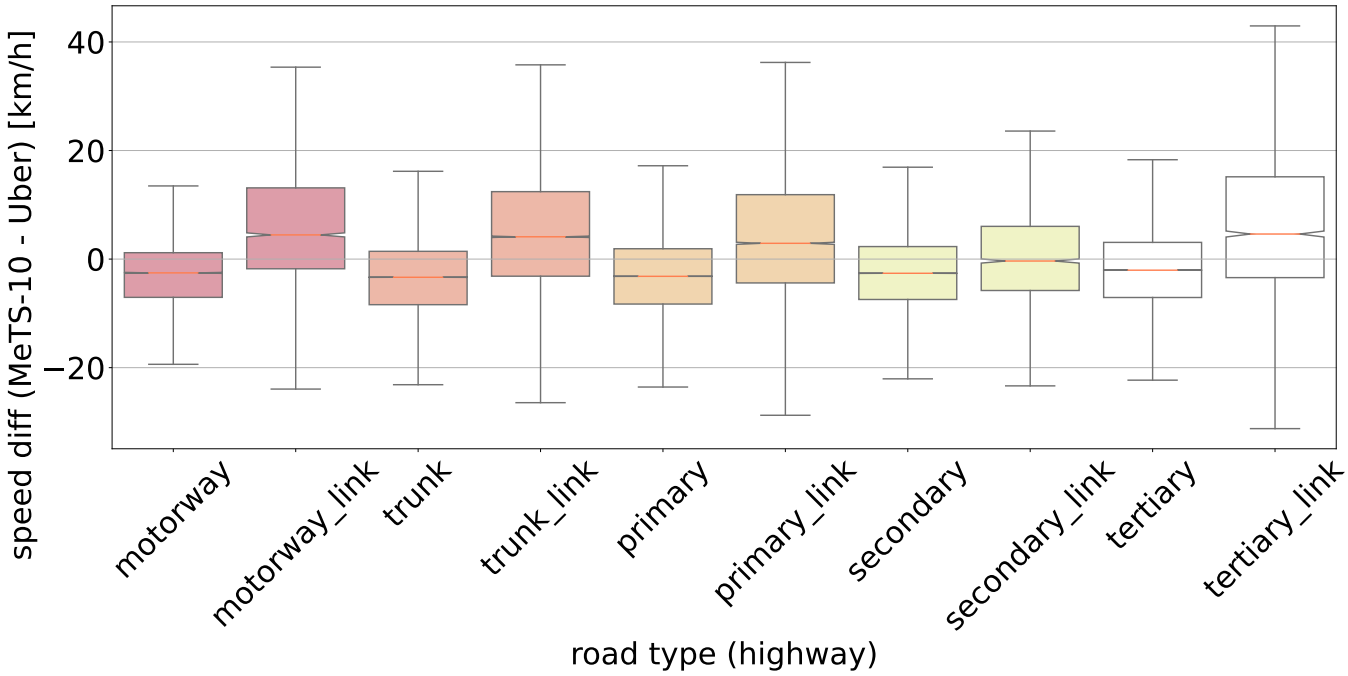



Fig. 98: Speed differences Uber and *MeTS-10* on the historic road graph London daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment. Mean difference by road class (OSM highway attribute). Positive speed difference means higher values in *MeTS-10*.

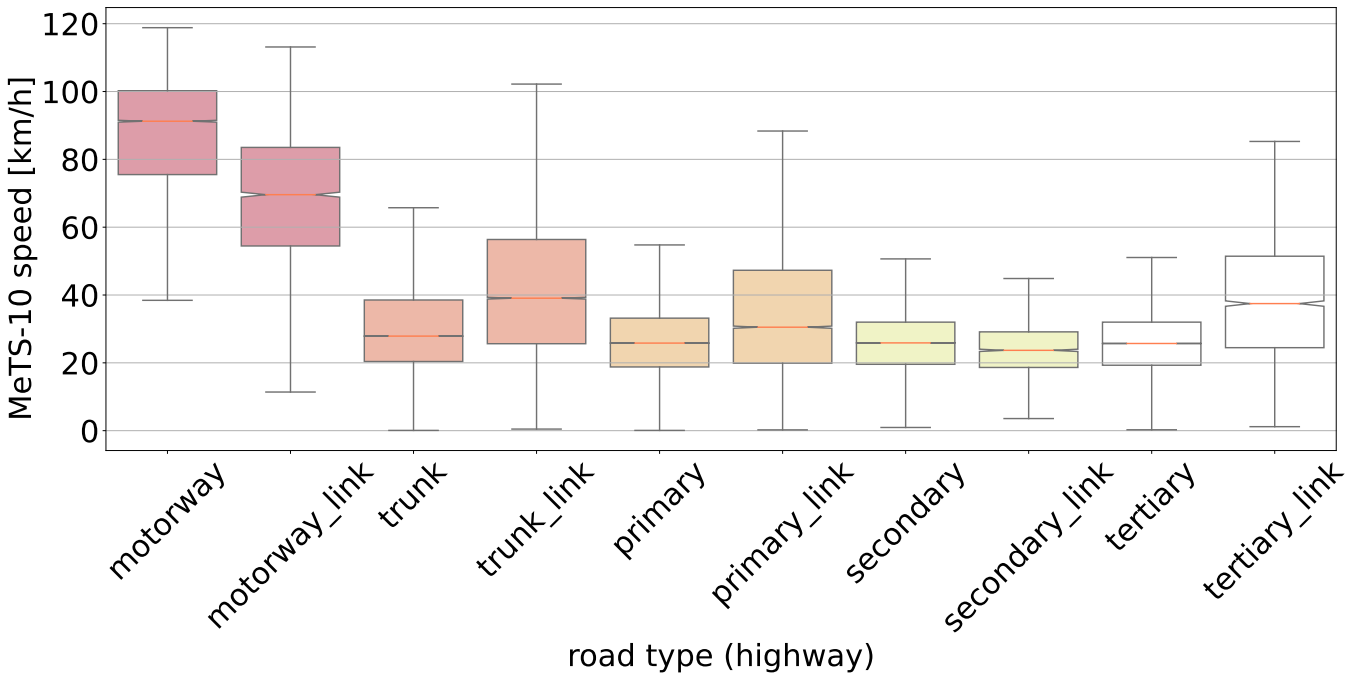



Fig. 99: *MeTS-10* speeds on the historic road graph London daytime (8am–6pm) on the matching data, *i. e.* within *MeTS-10* bounding box only and where data is available at the same time and segment. By road class (OSM highway attribute).

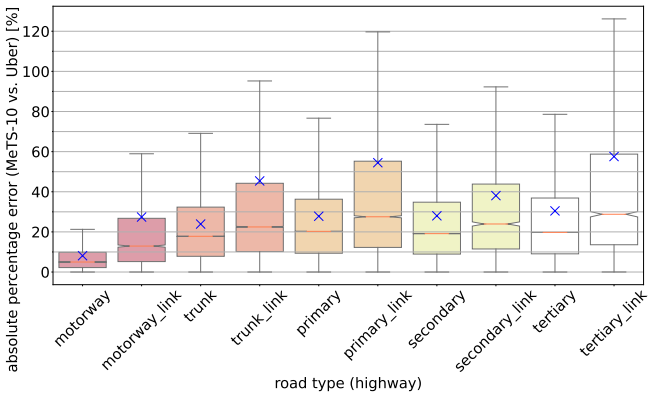



Fig. 100: London absolute percentage error *MeTS-10* vs. Uber by road type. Blue crosses indicate the mean per road type.

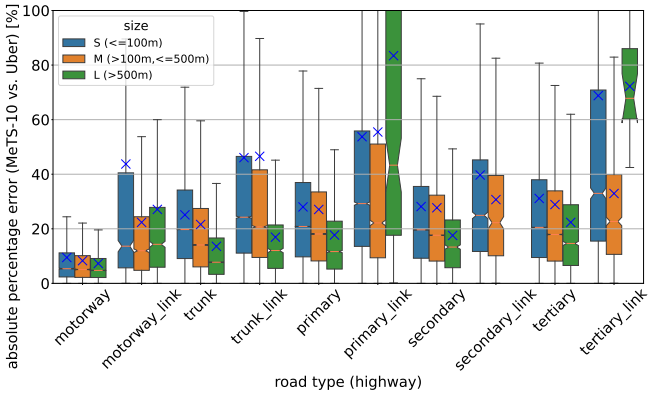



Fig. 101: London absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

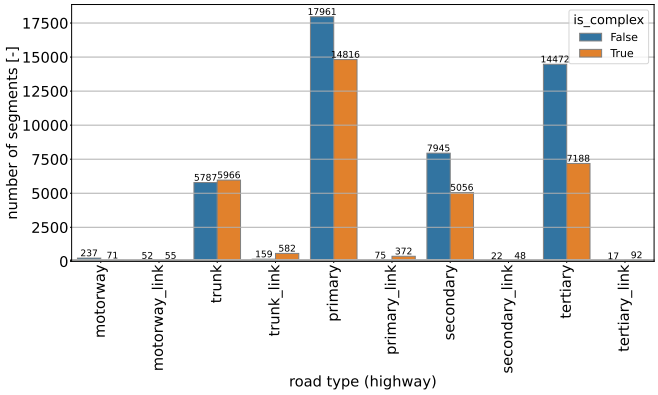
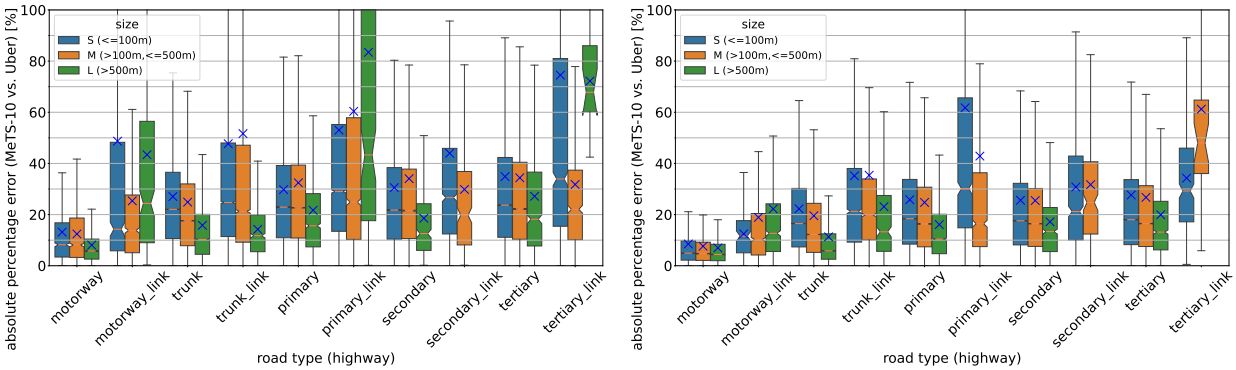



Fig. 102: Segment counts *MeTS-10* – Uber matched data.




(a) complex road segments

(b) non-complex road segments

Fig. 103: London absolute percentage error *MeTS-10* vs. Uber by road type and segment length. Blue crosses indicate the mean per road type.

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