Quantifying the presence of air pollutants over a road network in high spatio-temporal resolution

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Motivation

Health

Environment

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Environment

"Greenhouse gas (GHG) emissions from the transport sector have more than doubled since 1970 [...]. Around 80% of this increase has come from road vehicles." [2]

[2] "*Transportation*" (Ch. 8) in "*Climate Change 2014: Mitigation of Climate Change*", Working Group III Contribution to the IPCC Fifth Assessment Report (2014)

Motivation

Health

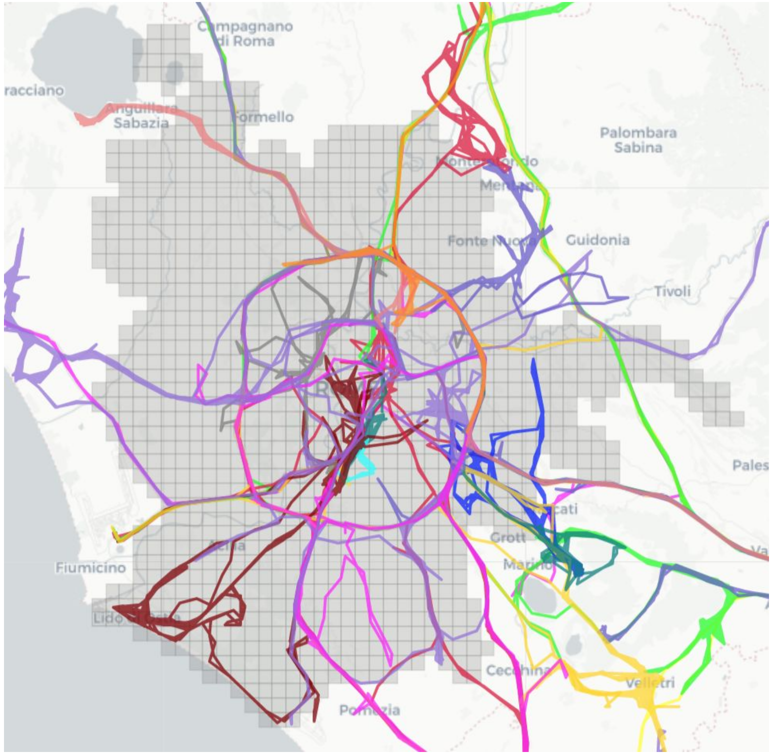
"Air pollution is the principal environmental factor driving disease, with around 400 000 premature deaths attributed to ambient air pollution annually in the EU." [1]

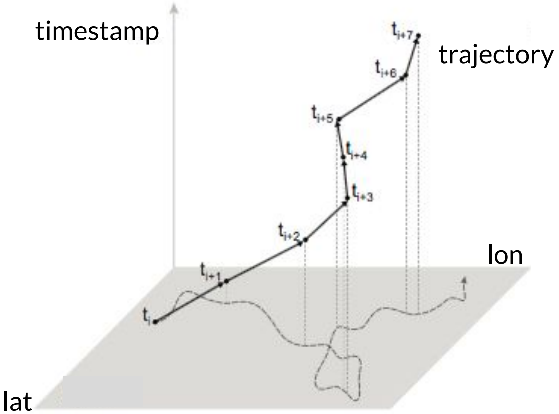
Environment

"Greenhouse gas (GHG) emissions from the transport sector have more than doubled since 1970 [...]. Around 80% of this increase has come from road vehicles." [2]

[1] "*Healthy environment, healthy lives: how the environment influences health and well-being in Europe*", European Environment Agency (**8 Sept. 2020**).
[2] "*Transportation*" (Ch. 8) in "*Climate Change 2014: Mitigation of Climate Change*", Working Group III Contribution to the IPCC Fifth Assessment Report (2014)

Data

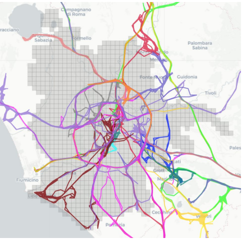




traj_id	timestamp	lat	lon
1	2019-01-01 08:00:00.000000	46.397461	11.829286
1	2019-01-01 08:58:07.838255	46.479001	11.807456
1	2019-01-01 10:23:02.268305	46.479001	11.807456
1	2019-01-01 17:21:08.304837	46.506604	11.782809
1	2019-01-01 19:34:35.687601	46.515593	11.783268

Figure 1. Raw **GPS trajectories of vehicles** moving in the area of the municipality of **Rome**.
Each color represents a **single trajectory**.

Methods



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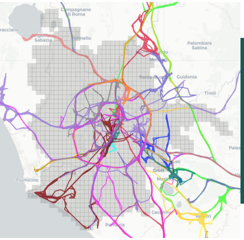

Filtering, speed and acceleration

Extraction of **sub-trajectories** with $dist(p_i, p_{i+1}) < t$.

Estimate instantaneous **speed** and **acceleration** in each point.

Filter points based on values of speed and acceleration.

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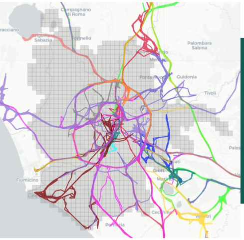

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Map matching

The geolocalized points are mapped to the edges of the **road network**.

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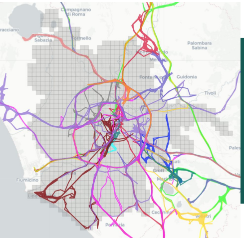

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Emissions model

Microscopic emissions model to compute the instantaneous **emissions** of four pollutants:
CO_2, NO_x, PM, VOC.

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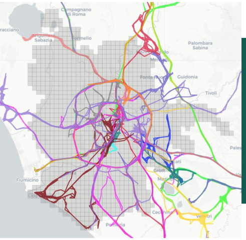

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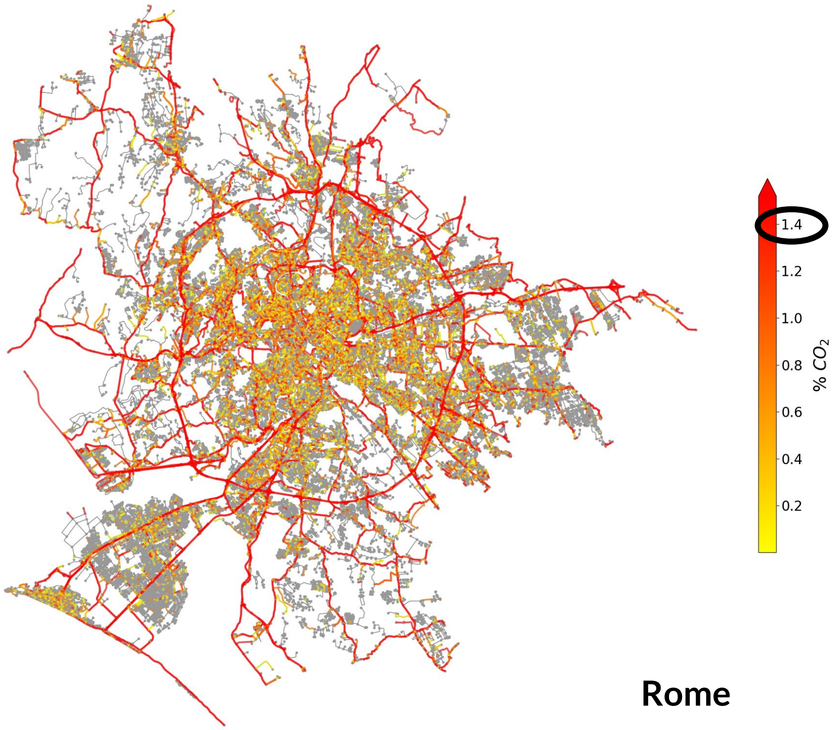
The spread of air pollution across the network



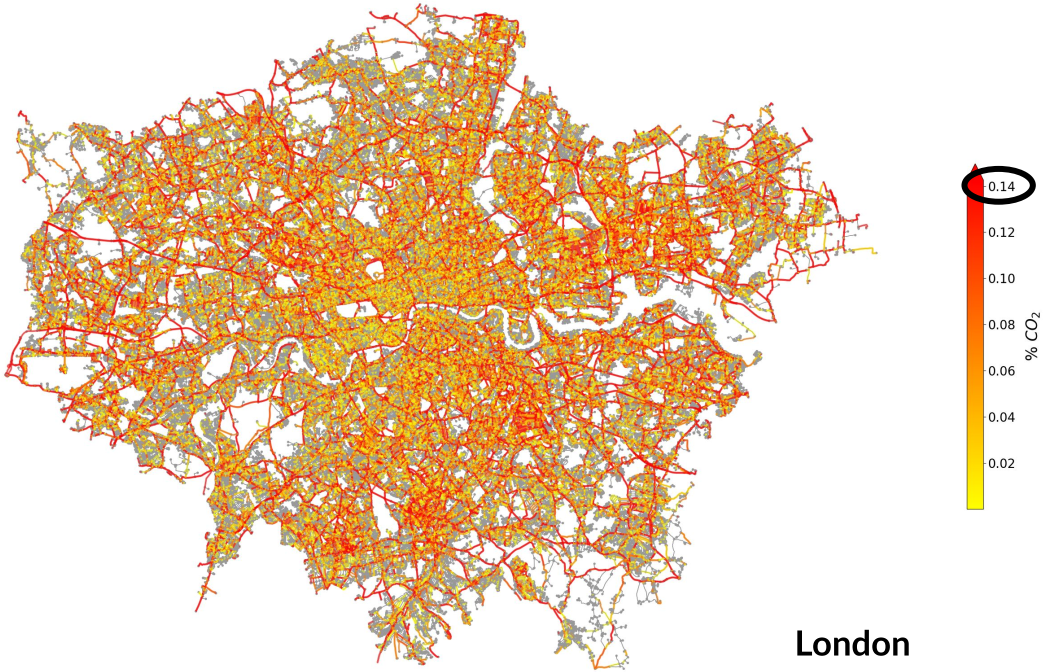


Figure 2. Road networks of **Rome** and **London**: **share of CO_2** emitted in each road in January 2017.

There are **~6.7K** vehicles moving in **Rome** and **~2.5K** in **London**.

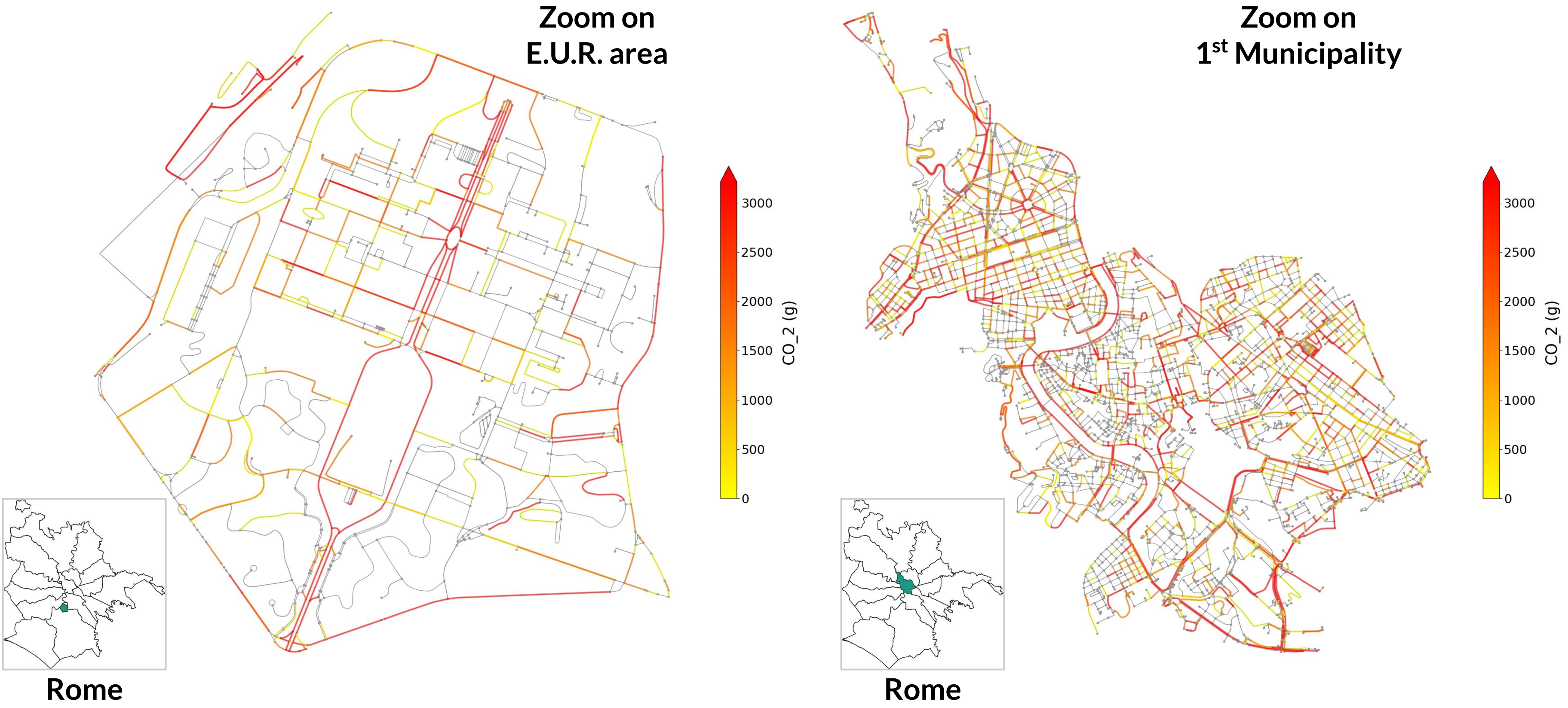
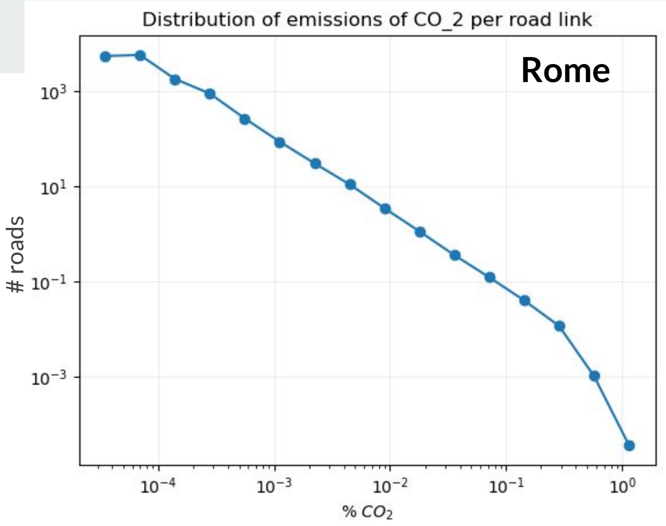


Figure 3. Road networks of **E.U.R.** area and **1st Municipality** in Rome: **quantity of CO_2** (in grams) emitted in each road.

Air pollution distribution

Power-law distribution:

- a few vehicles are responsible for a great quantity of emissions [GBP94], [HOZ18];
- a few roads have the **greatest share of emissions** in the network.



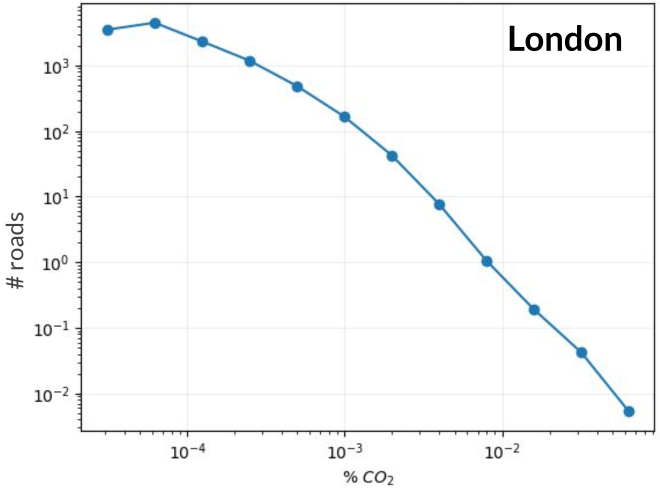


Figure 4. The **loglog distribution** of the share of emissions of **CO_2** per road for **Rome** and **London.**

Fitting the distributions of air pollution per road

For both the cities, the distribution of the **quantity of CO_2, NO_x and PM emitted per road** are well approximated by a **truncated power-law**.

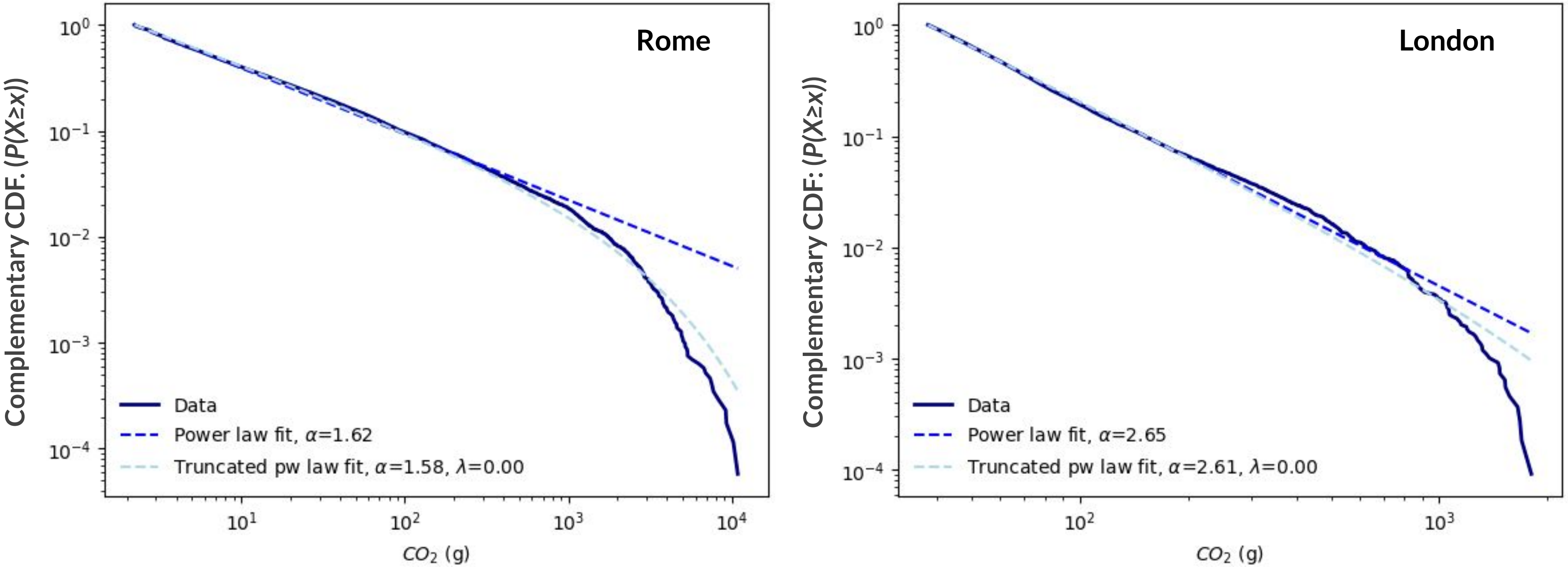


Figure 5. The **complementary CDF** of the data, its best **power-law**, and **truncated power-law** fits.

Ongoing and future work

Discovering which are the **features** of **roads and road networks** that are more related with **high quantities of air pollution**.

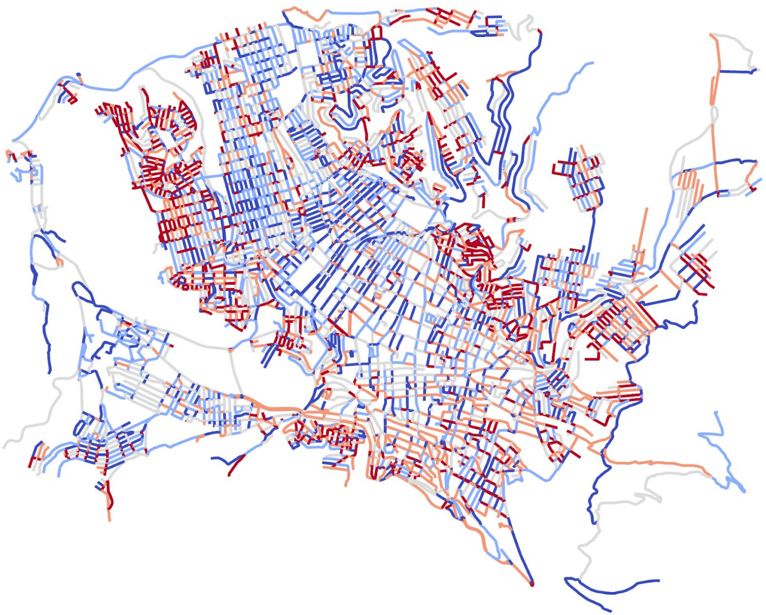


Figure 6. Roads' **slope** in Potosi (Bolivia), from flat (**violet**) to steep (**red**).

That' all... for now.

Many thanks for your attention!

Main references

[GBP94] P.L. Guenther, G.A. Bishop, J.E. Peterson, D.H. Stedman, *Emissions from 200 000 vehicles: a remote sensing study*, Science of The Total Environment, Volumes 146–147, 1994

[HOZ18] Y. Huang, B. Organ, J.L. Zhou, N.C. Surawski, G. Hong, E.F.C. Chan, Y.S. Yam, *Remote sensing of on-road vehicle emissions: Mechanism, applications and a case study from Hong Kong*, Atmospheric Environment, Volume 182, 2018

[NSK16] M. Nyhan, S. Sobolevsky, C. Kang, P. Robinson, A. Corti, M. Szell, D. Streets, Z. Lu, R. Britter, S.R.H. Barrett, C. Ratti, *Predicting vehicular emissions in high spatial resolution using pervasively measured transportation data and microscopic emissions model*, Atmospheric Environment, Volume 140, 2016

[LHC19] J. Liu, K. Han, X.(Michael) Chen, G.P. Ong, *Spatial-temporal inference of urban traffic emissions based on taxi trajectories and multi-source urban data*, Transportation Research Part C: Emerging Technologies, Volume 106, 2019