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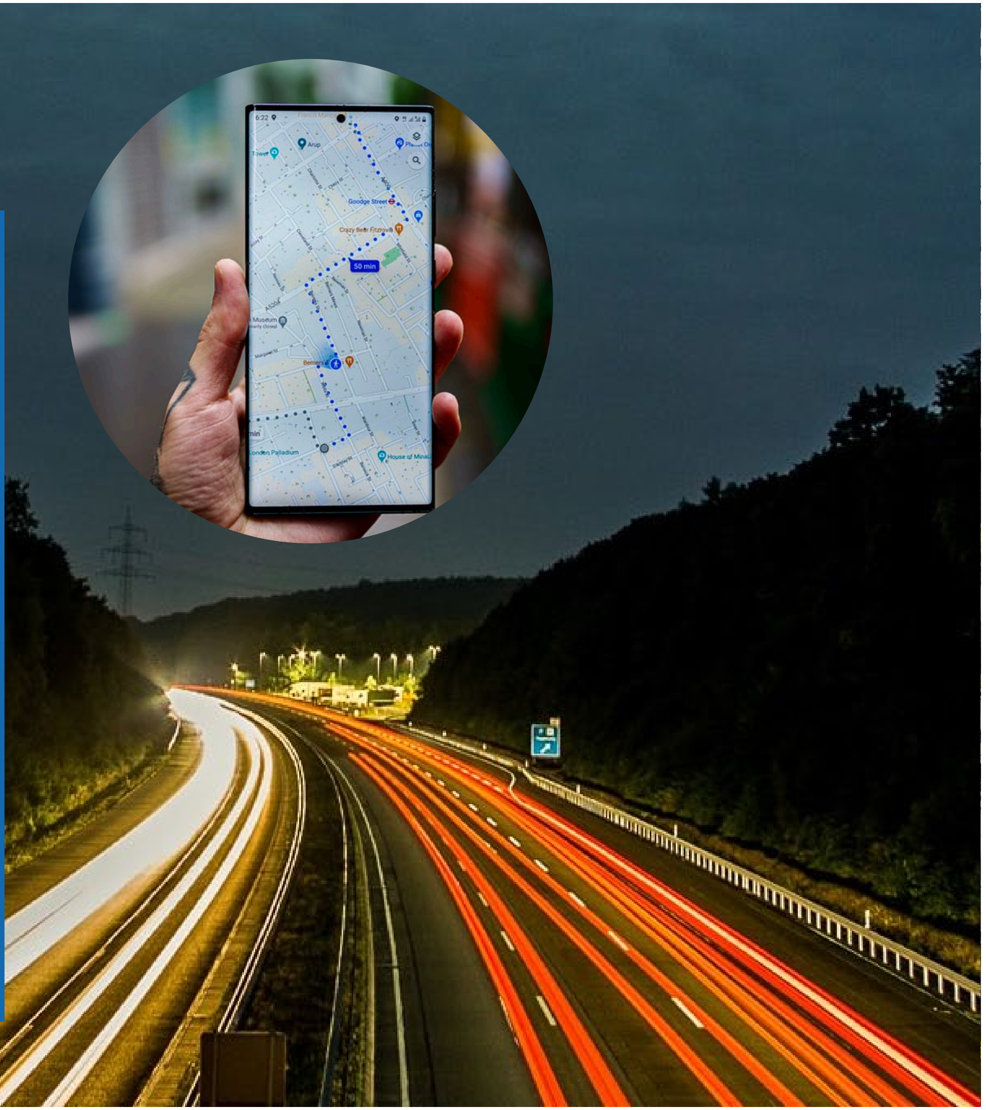

Spatial data analytics for sustainable mobility

Prof. Dr. Martin Raubal
Institute of Cartography and Geoinformation

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CSFM Seminar series
ETH Zürich

Overview

1. Sustainable mobility
2. Spatial data analytics
3. Mobility as a Service
4. Solar power for e-cars
5. Conclusions and outlook

Our society is becoming increasingly mobile!

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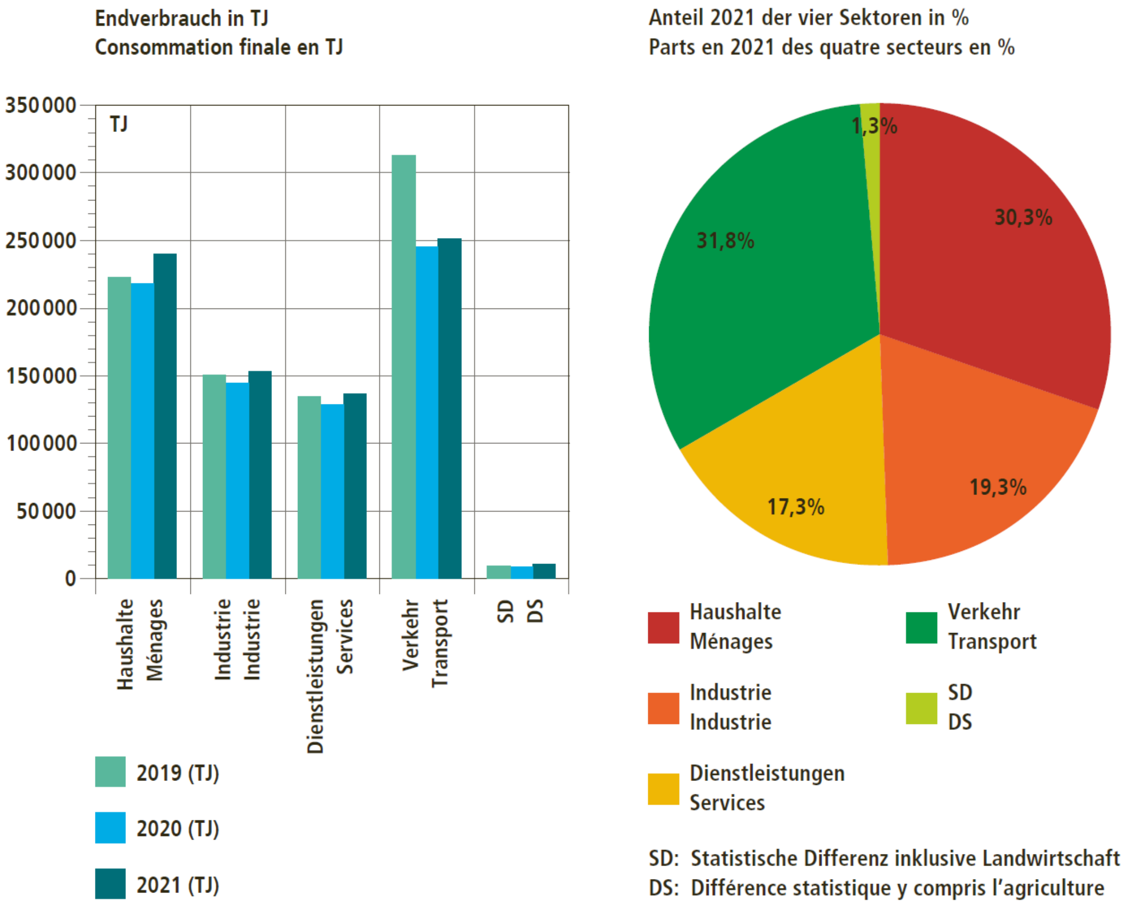
Swiss transport and mobility emissions

- Transport produces ~1/3 of total Swiss GHG emissions.
- 3/4 of transport GHG emissions are produced on roads.

Fig. 3 Aufteilung des Energie-Endverbrauchs nach Verbrauchergruppen
Répartition de la consommation finale d'énergie selon les groupes de consommateurs



BFE, Schweizerische Gesamtenergiestatistik 2021 (Fig. 3)
OFEN, Statistique globale suisse de l'énergie 2021 (fig. 3)

Sustainable mobility

- Guaranteeing mobility needs in an environmentally friendly way over the long term
- Technical and non-technical measures

Shared Mobility

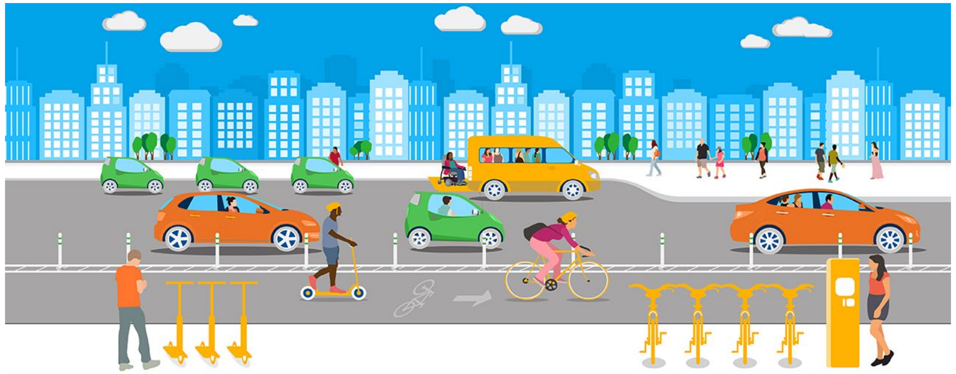


Image: SAE International

Mobility-as-a-Service (MaaS)

Image: Transport advancement

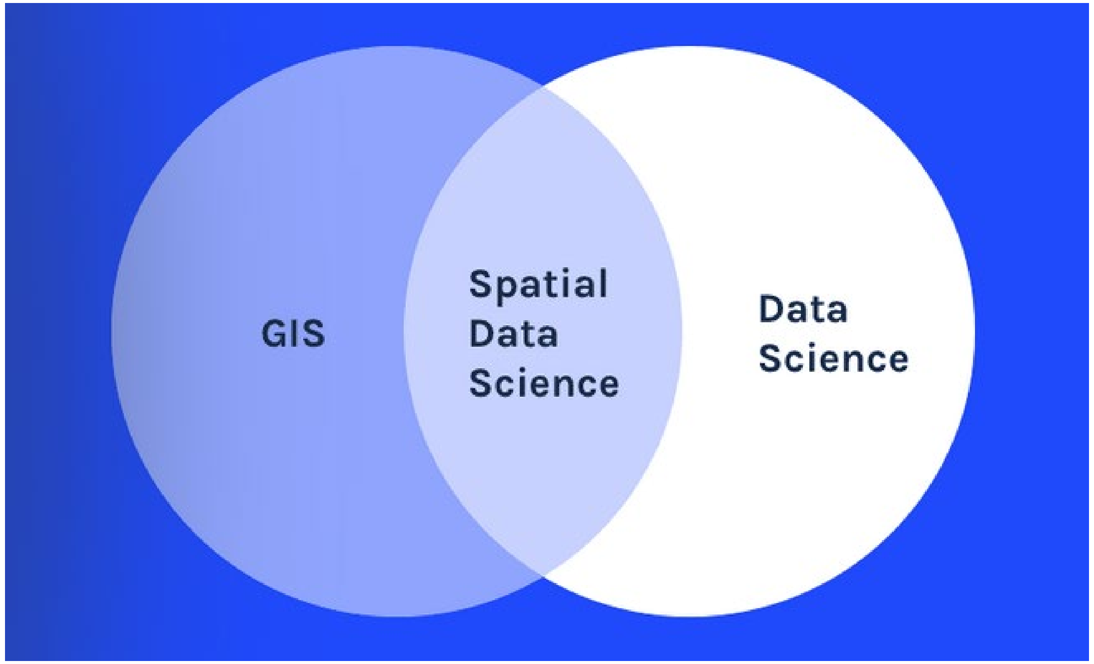
E-Mobility

Image: dpa-tmn

Spatial Data Science & Analytics

- Focuses on the unique characteristics of spatial data, moving beyond simply looking at where things happen to understand why they happen there.

- Treats location, distance & spatial interactions as core aspects of the data using specialized methods & software to analyze, visualize & apply findings to spatial use cases.



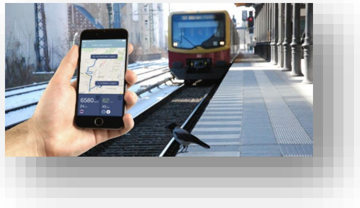
https://carto.com/what-is-spatial-data-science/

Spatial Data Analytics for Mobility

Big spatial data

Human Computer Interaction

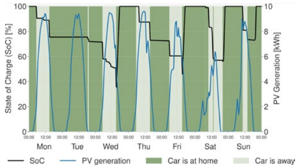
Location Based Services



Spatio-temporal analysis

Geo-Webservices

Location-Aware Technology



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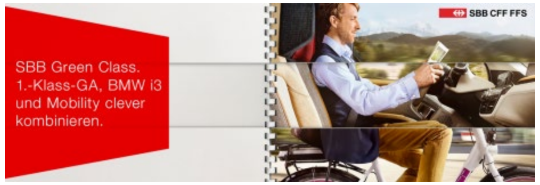
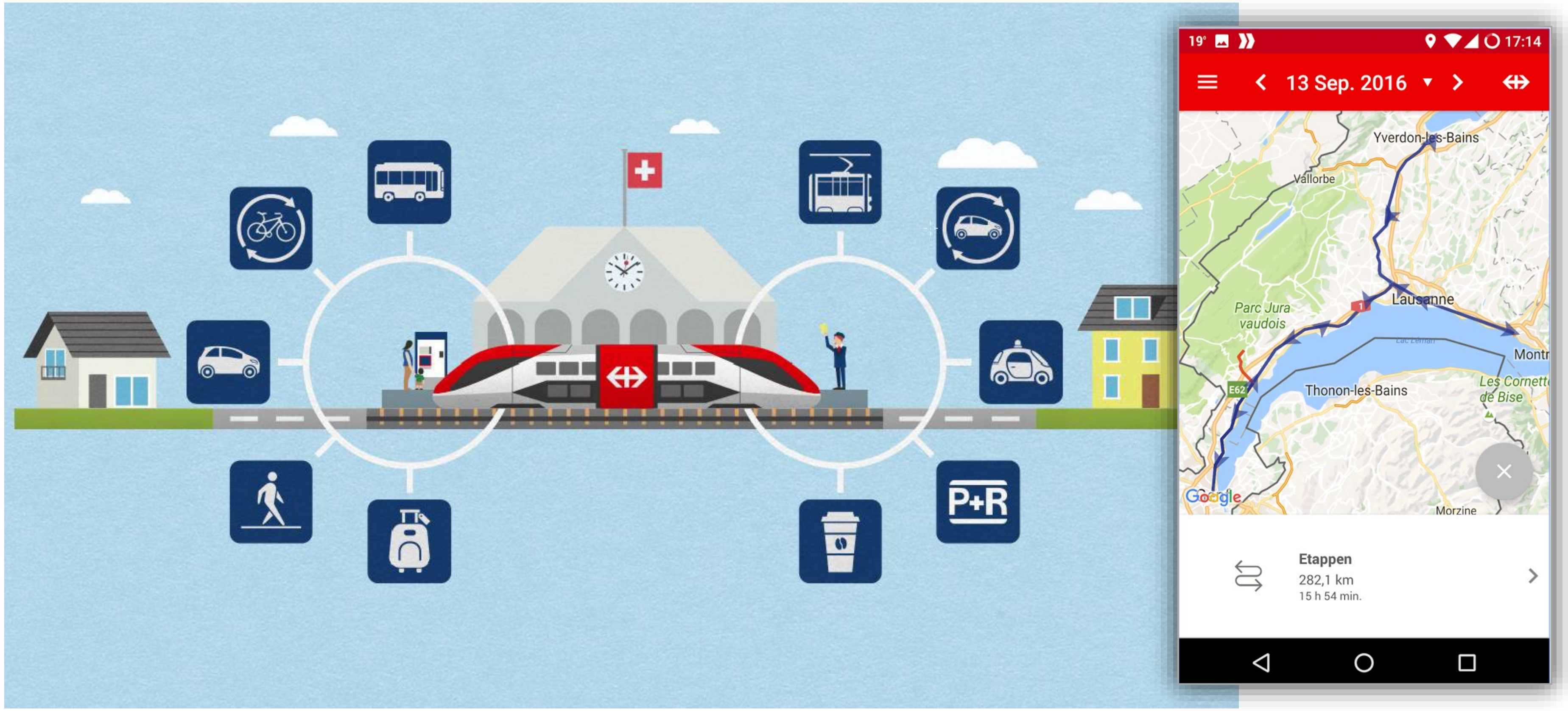
Mobility as a Service

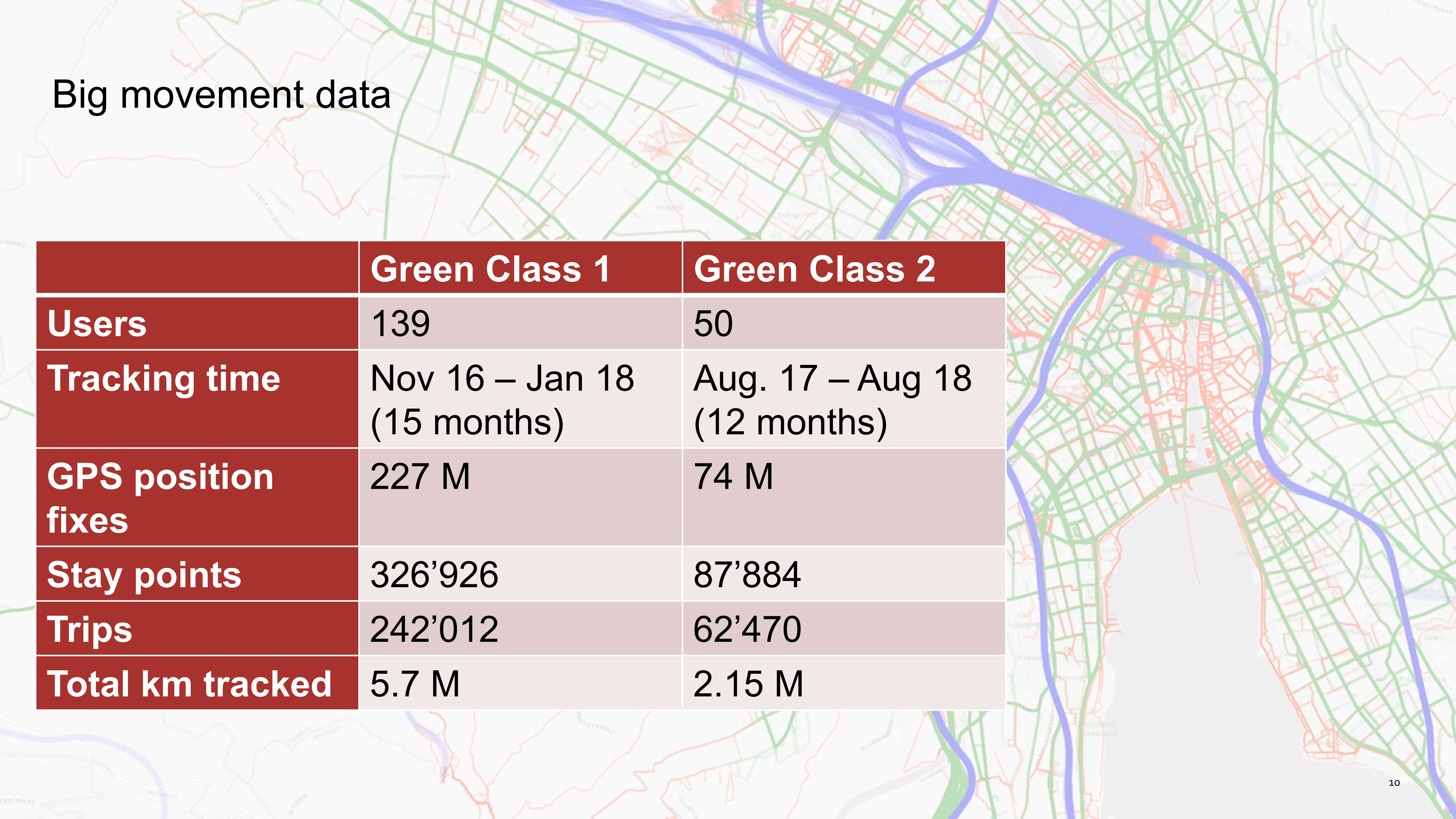
www.motorfinanceonline.com

SBB Green Class



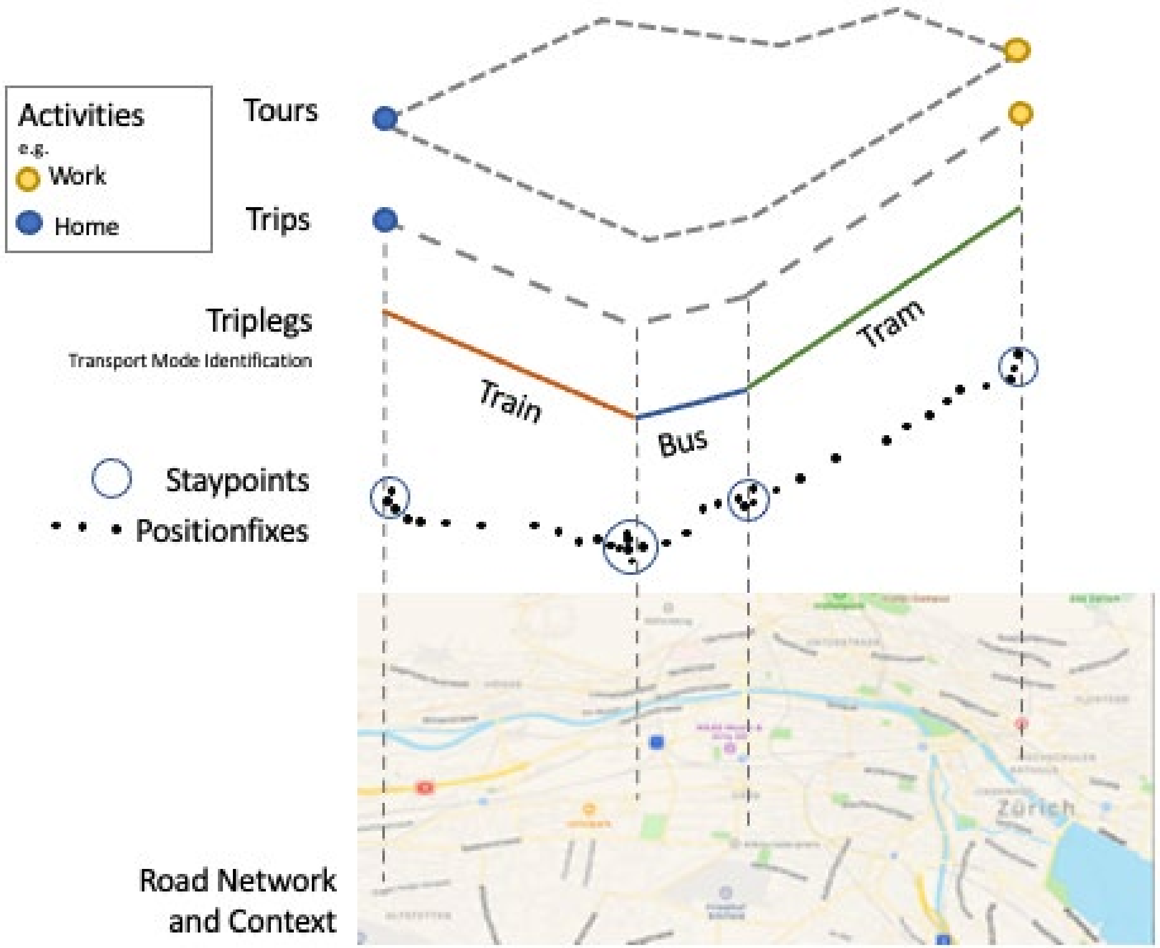


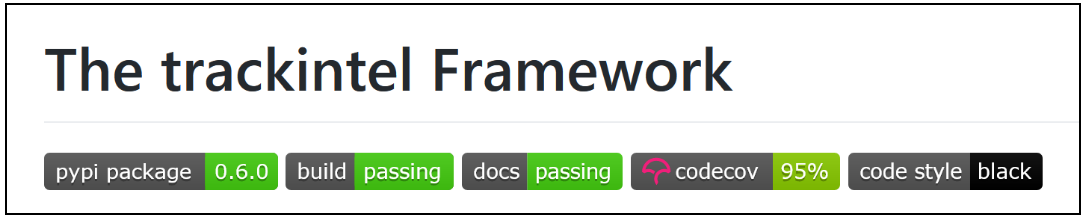
Big movement data



	Green Class 1	Green Class 2
Users	139	50
Tracking time	Nov 16 – Jan 18 (15 months)	Aug. 17 – Aug 18 (12 months)
GPS position fixes	227 M	74 M
Stay points	326’926	87’884
Trips	242’012	62’470
Total km tracked	5.7 M	2.15 M

trackintel Mobility Data Processing Library

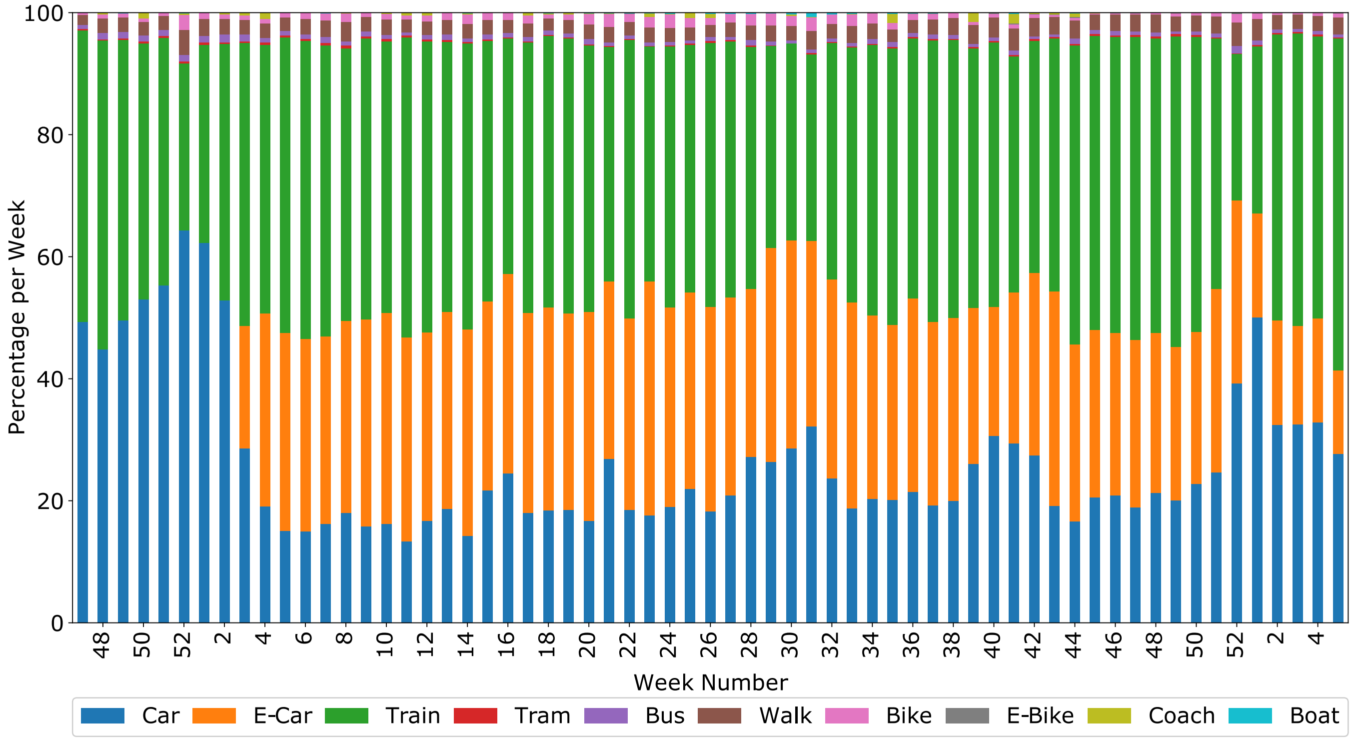


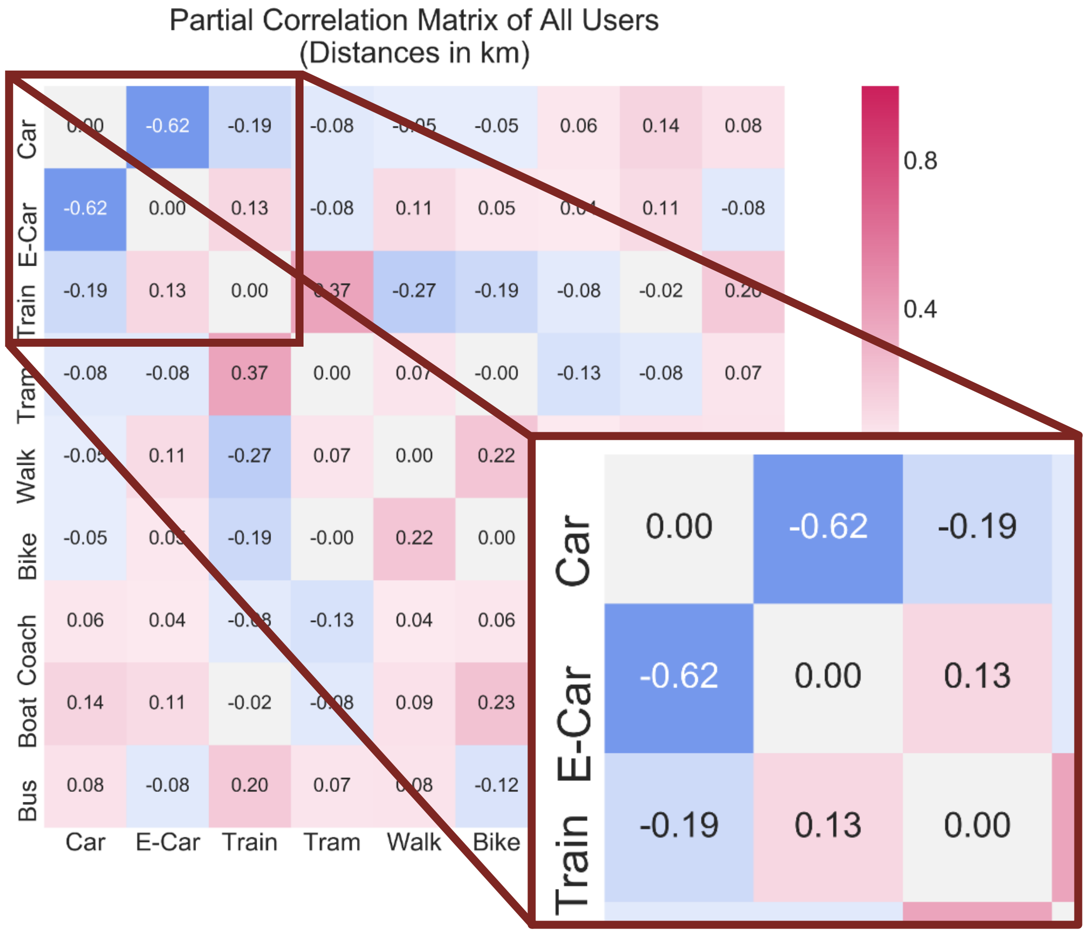


- Toolkit for context-aware mobility mining.
- Open-source implementation of GPS trackpoint processing steps.

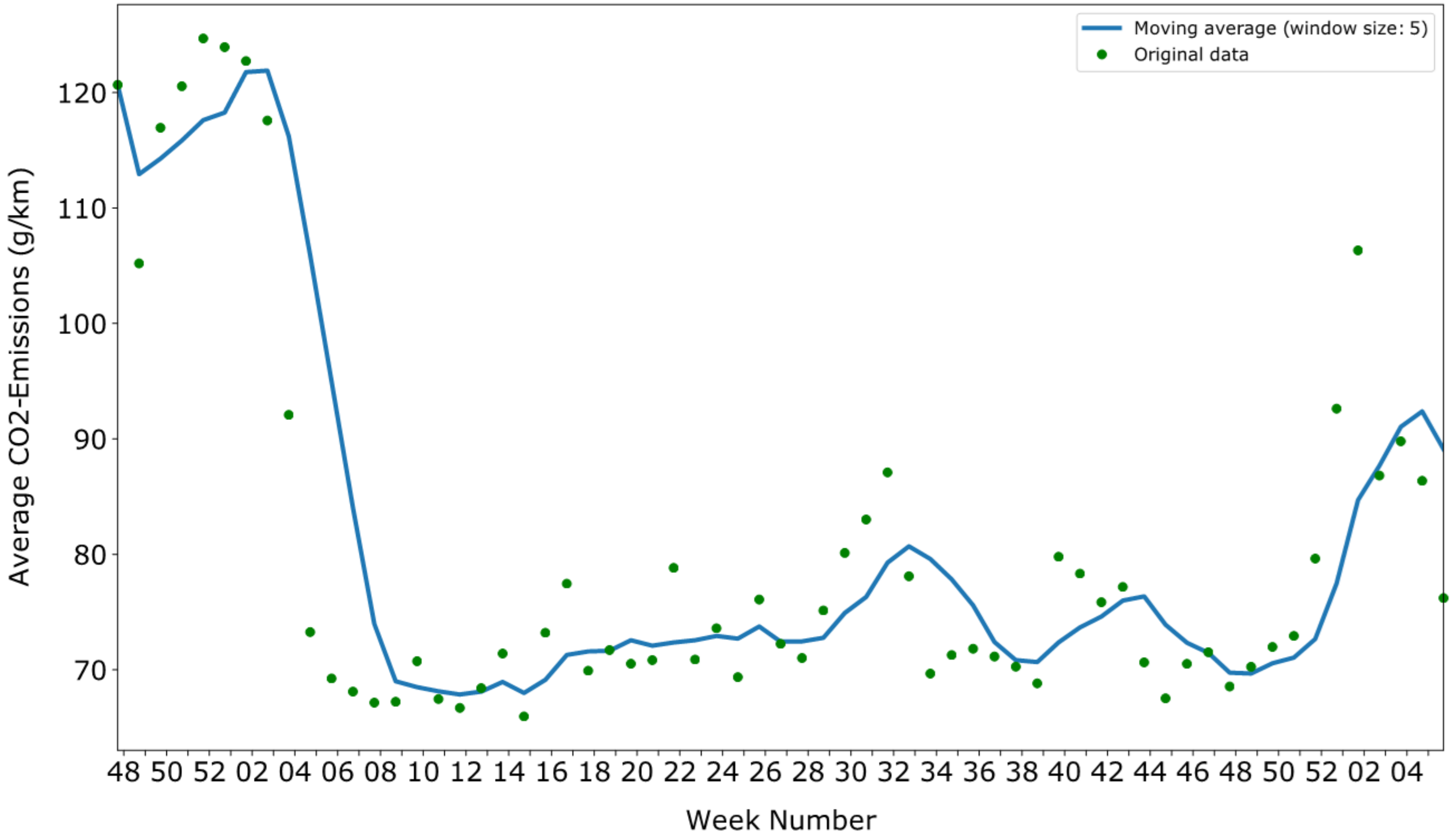
https://github.com/mie-lab/trackintel

Result 1: E-car becomes part of mobility mix (in the long term)





Result 2: New mobility options can reduce CO_2 emissions



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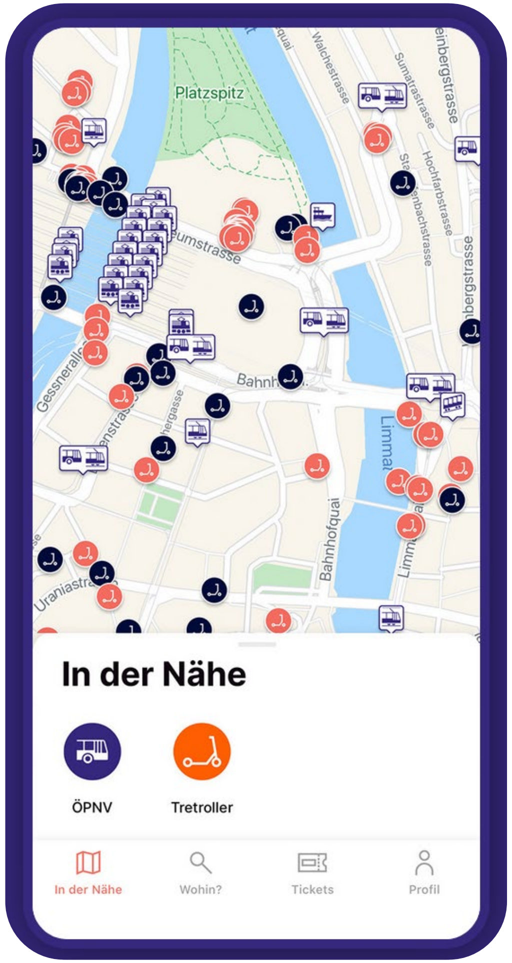
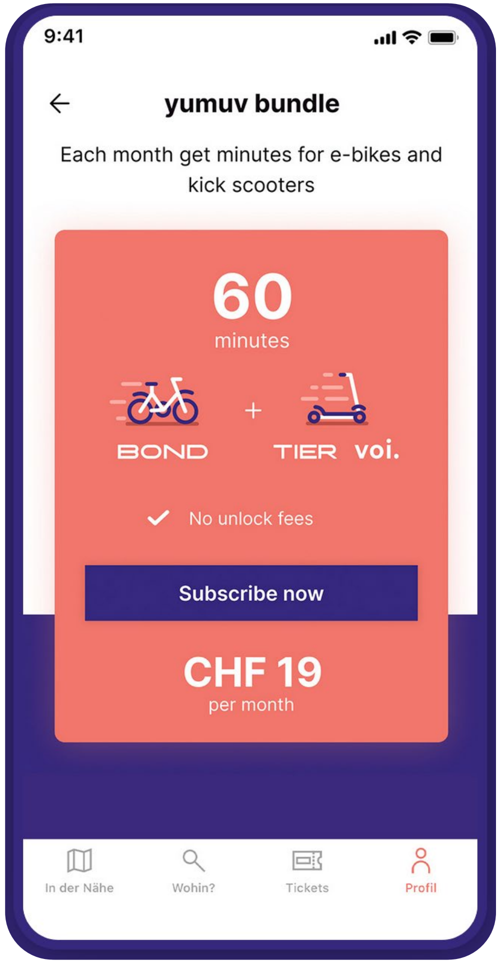
yumuv



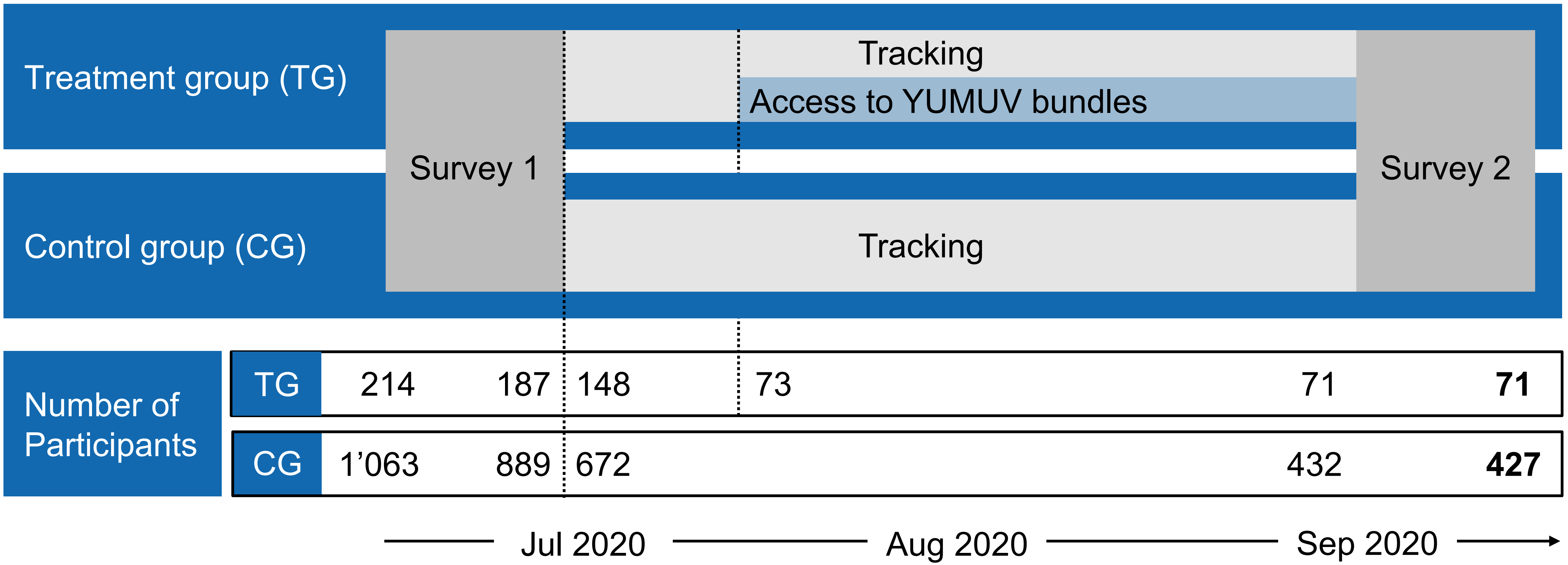


Yumuv.ch

Goals:

- Advance understanding of MaaS mobility bundles' impact on human mobility behavior
- Create application that generalizes over different datasets using an integrated representation of mobility, booking and context data

Study design



Data sources

Source	Description
SBB MyWay App	Tracking data (24h/day GPS based travel survey). App collects triplegs (=trajectories) and staypoints
Yumuv app (TG)	Shared vehicle booking information: price, position, timing and duration.
Surveys	Detailed information on socio-demographics and mobility behavior of participants
Availability of shared vehicles	Position of all relevant available shared vehicles in 5-minute resolution (~600’000 entries per day)
Weather data	Temperature, wind and precipitation in hourly resolution on a 30x30 km grid (ERA5T)
Elevation data	Trip level elevation data extracted from a 25m resolution DEM (Swisstopo DHM25 – Basismodell)

Collected tracking data

Tracking data	Control group	Treatment group
# users	672 (**427**)	148 (**71**)
Triplegs	371’000	112’000
Staypoints	248’000	65’000
Labels	Mode of transport + activity label	
Tracking time	3 - 4 months	
Total km tracked	3.9 M km	1.5 M km

Preprocessing methods are open source:
https://github.com/mie-lab/trackintel

trackintel

Mode choice analysis: effect of yumuv bundle on mobility behavior

Results of the trip-level mode choice model with preprocessed tracking and context data show that the yumuv bundle influenced the mode choice of participants in the following way:

- Increased usage*: public transport (0.23) and shared e-scooters (1.74)
- Decreased usage*: owned bikes (-0.75) and owned e-bikes (-1.99)
- No statistically significant effect: owned car, shared E-bike, owned e-scooters

*95% significance level

Analysis of scooter emissions under consideration of substitution patterns

Substituted mode	Gross emissions [g CO_2 / pkm]	Substitution rates (km-level) by micro-mobility mode			
		E-Bike (personal)	E-Bike (shared)	E-Scooter (personal)	E-Scooter (shared)
Walk	0†	9%	9%	19%	25%
PT (avg.)	72†	29%	43%	27%	38%
Car (avg.)	135†	48%	15%	25%	15%
Bike	17†	14%	29%	27%	13%
E-Bike (personal)	34†		5%	1%	2%
E-Bike (shared)	83†	0%		0%	5%
E-Scooter (personal)	42†	1%	0%		1%
E-Scooter (shared)	106†	0%	0%	0%	
Emissions of substituted modes		88	58	58	55
Emissions of micro-mobility mode		34†	83†	42†	106†
Net emissions [g CO_2 / pkm]		**-54**	**25**	**-16**	**51**

† Emission calculations drawn from ITF (2020a).

Reck, D. J., Martin, H., & Axhausen, K. W. (2022). Mode choice, substitution patterns and environmental impacts of shared and personal micro-mobility. *Transportation Research Part D: Transport and Environment, 102*, 103134.

Solar power for e-cars

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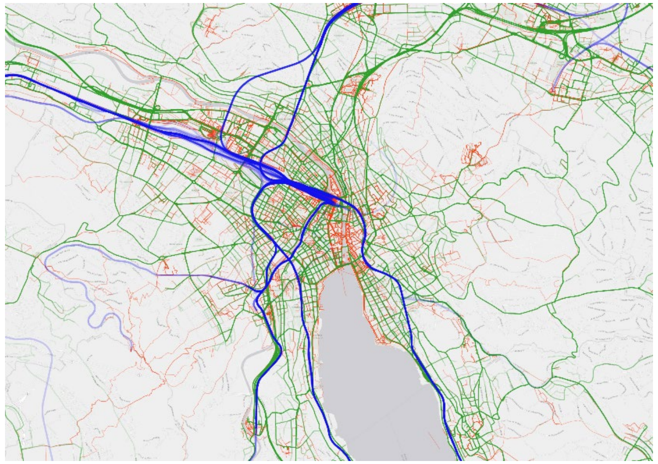
photovoltaik.org

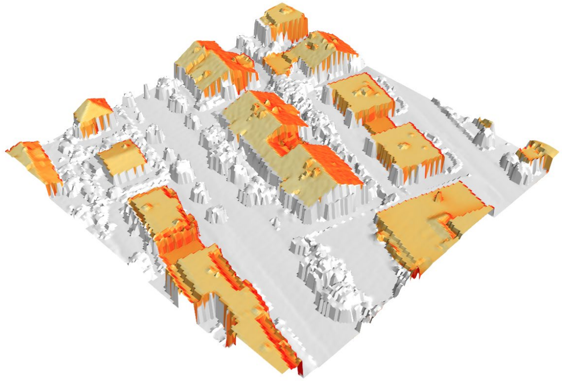
Using rooftop photovoltaic generation to cover individual electric vehicle demand - a detailed case study

How well can EV owners cover their mobility energy demand using solar panels on their own roofs?

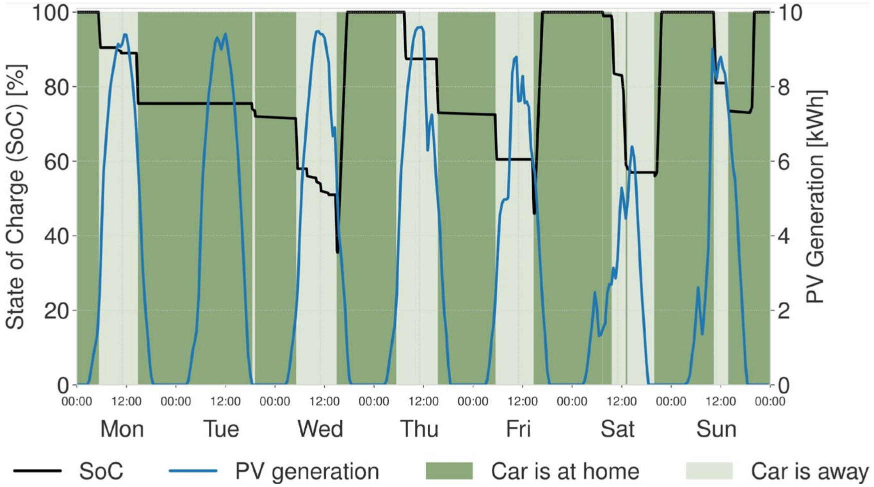
Can we use the information about mobility use to improve the utilization?



Tracking data and charging schedules of 78 EV owners over 1 year



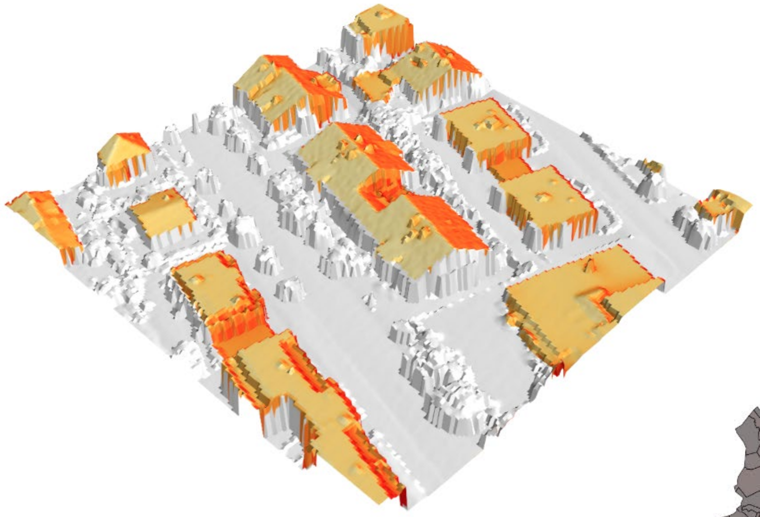
One-year solar generation curve for the home of each EV owner

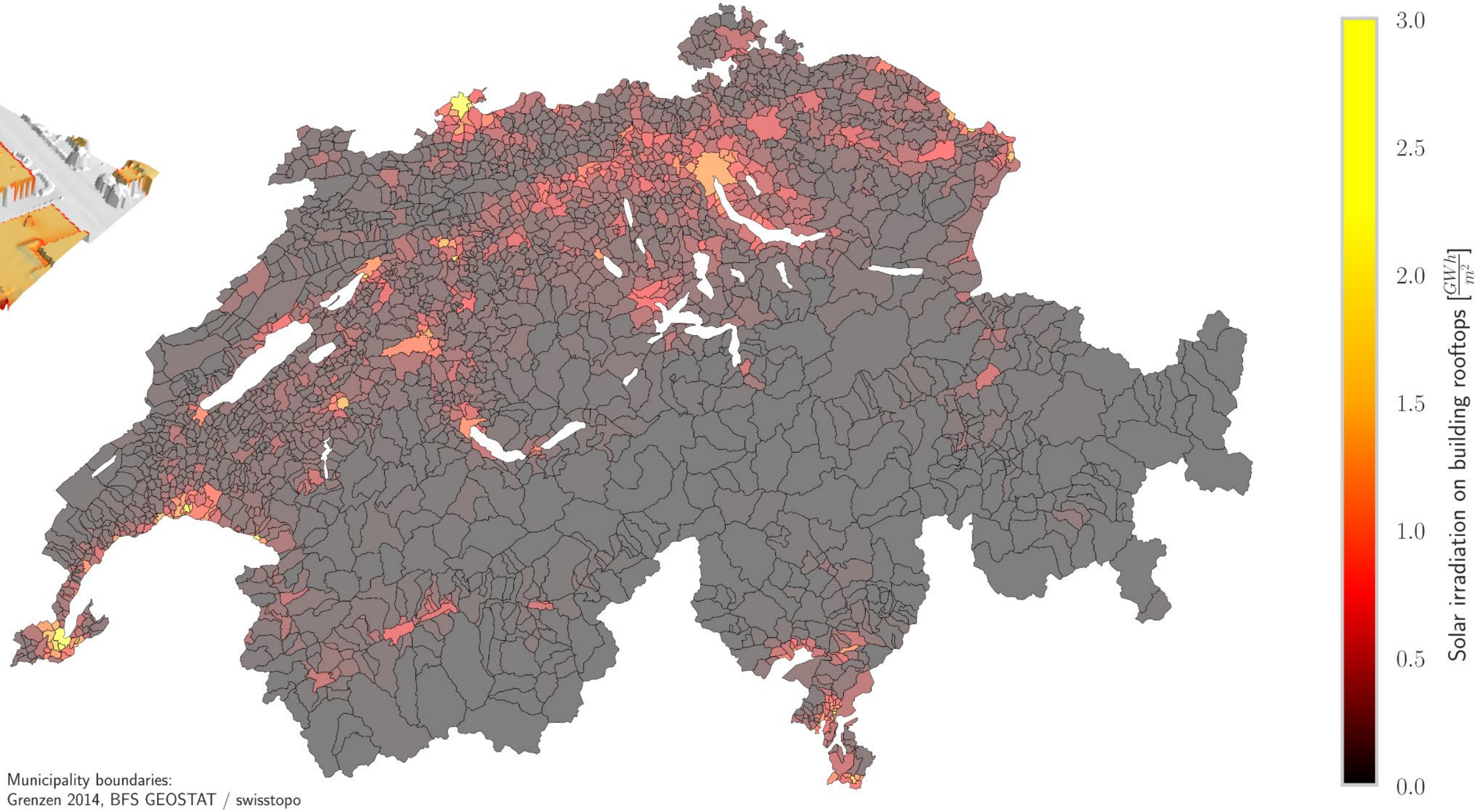


Spatio-temporal intersection of generation and demand for different smart charging scenarios

Martin, H., Buffat, R., Bucher, D., Hamper, J., & Raubal, M. (2022). Using rooftop photovoltaic generation to cover individual electric vehicle demand - a detailed case study. *Renewable and Sustainable Energy Reviews, 157(April 2022), 111969.*

Solar potential on roofs





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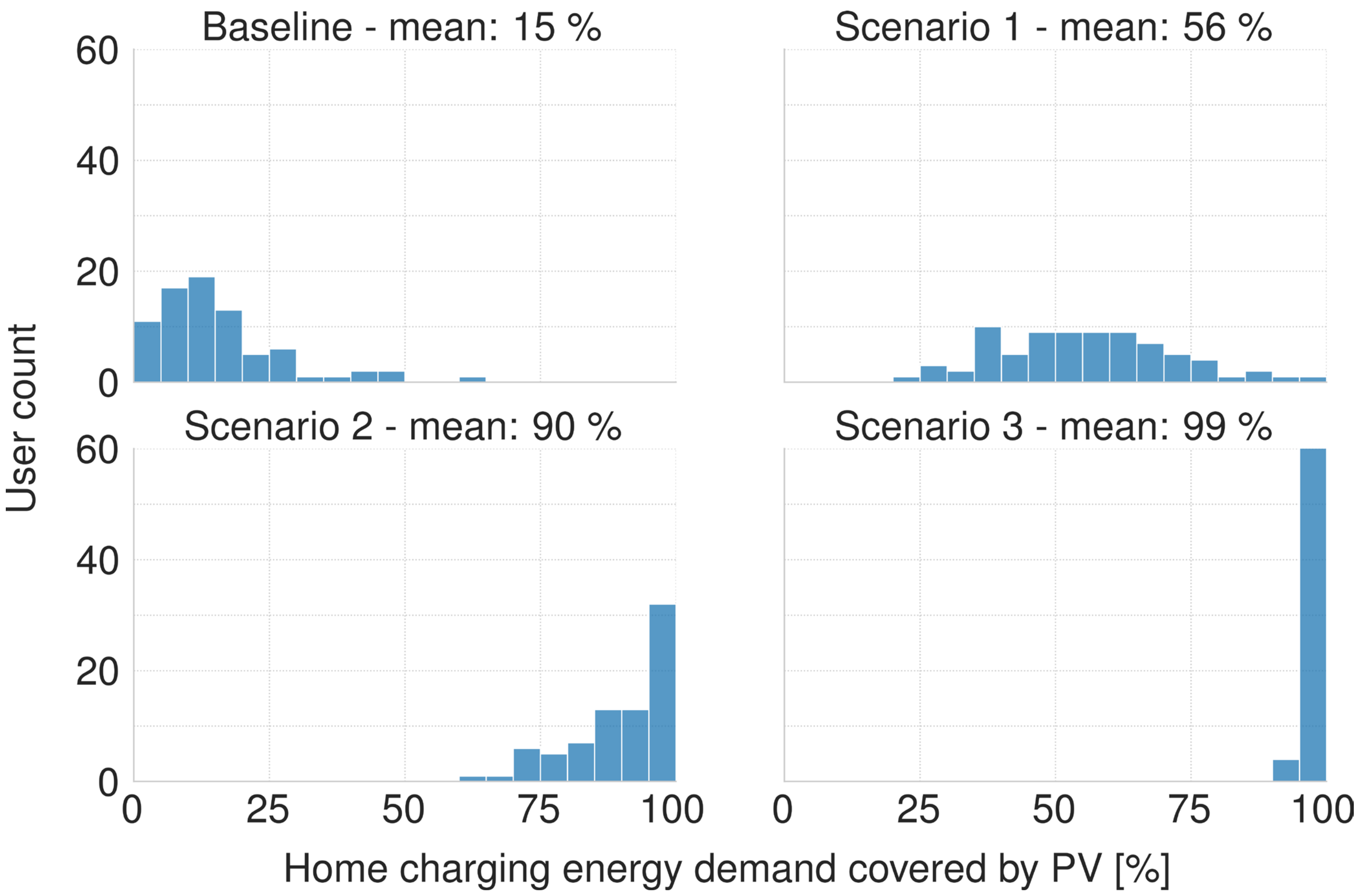
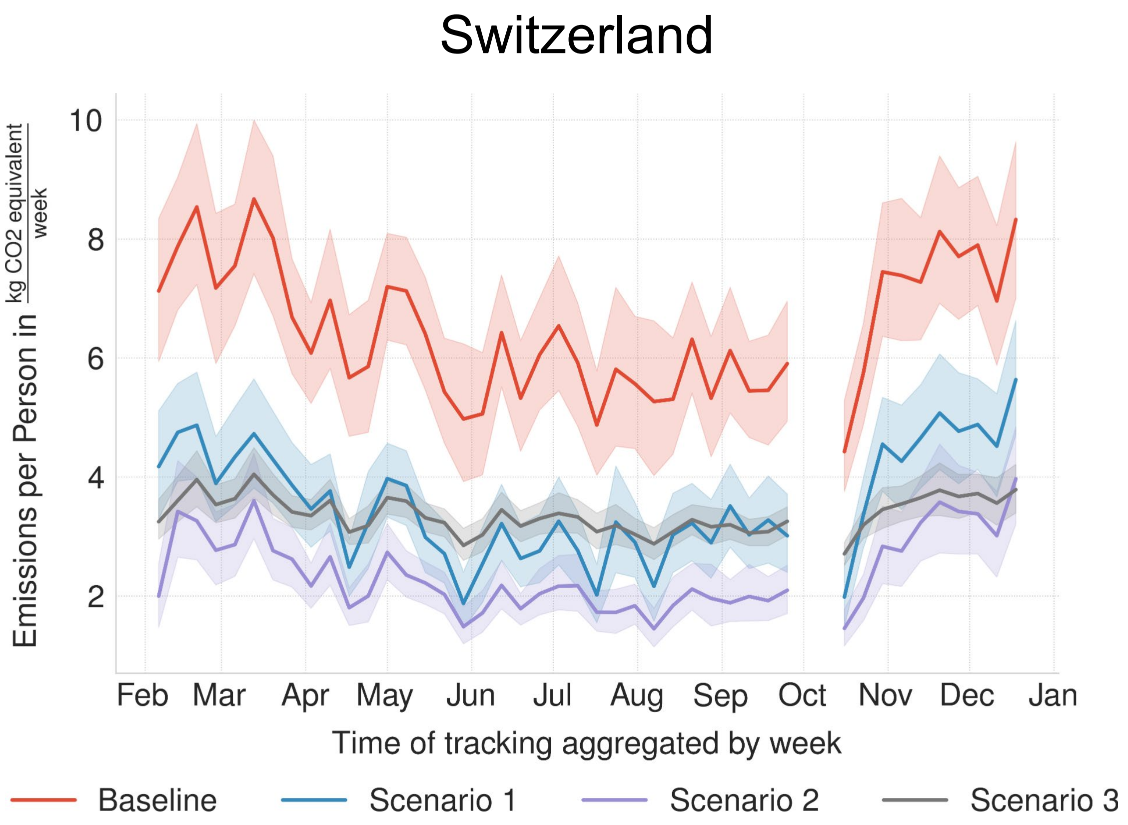
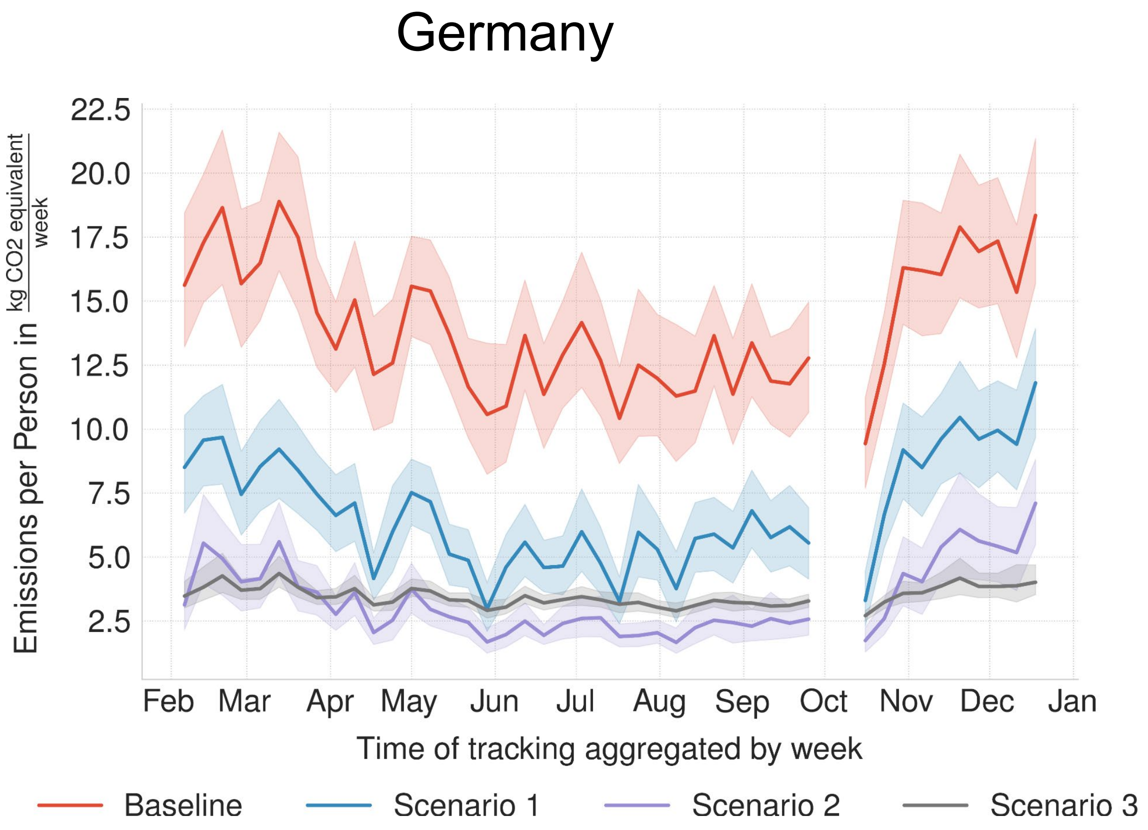
Smart charging strategies



The majority of the mobility energy demand can be covered using only the user’s own roof-top solar generation with smart charging.

Impact on GHG emissions





- Smart charging with roof-top solar generation significantly reduces the GHG impact of EVs
- Additional battery storage does not automatically lead to lower emissions.
- Strongly depends on footprint of grid electricity.

Conclusions

- Future sustainable mobility depends on highly complex and inter-related technological, social, economic and political developments.
- MaaS & E-mobility will play important parts on the way towards sustainable mobility.
- Spatial data analytics can help to
  - evaluate & predict people’s mobility behavior,
  - estimate the impact on GHG emissions,
  - calculate the potential of smart-charging e-cars
  - determine long-term behavior change;

Spatial Data Analytics is essential for Sustainable Mobility.

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ETH zürich MIE lab

Prof. Dr. Martin Raubal
mraubal@ethz.ch

ETH Zurich
Institute of Cartography and Geoinformation
HIL G 27.2
Stefano-Franscini-Platz 5
8093 Zürich, Switzerland

gis.ethz.ch
mie-lab.ethz.ch

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