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aufgrund eines Beschlusses des Deutschen Bundestages

PANDEMOS: PANDEmic MObility Scenarios

Martin J. Kühn

3RD (INTER-) NATIONAL CONFERENCE ON INFECTIOUS DISEASE MODELING

26 – 28 FEBRUARY 2025

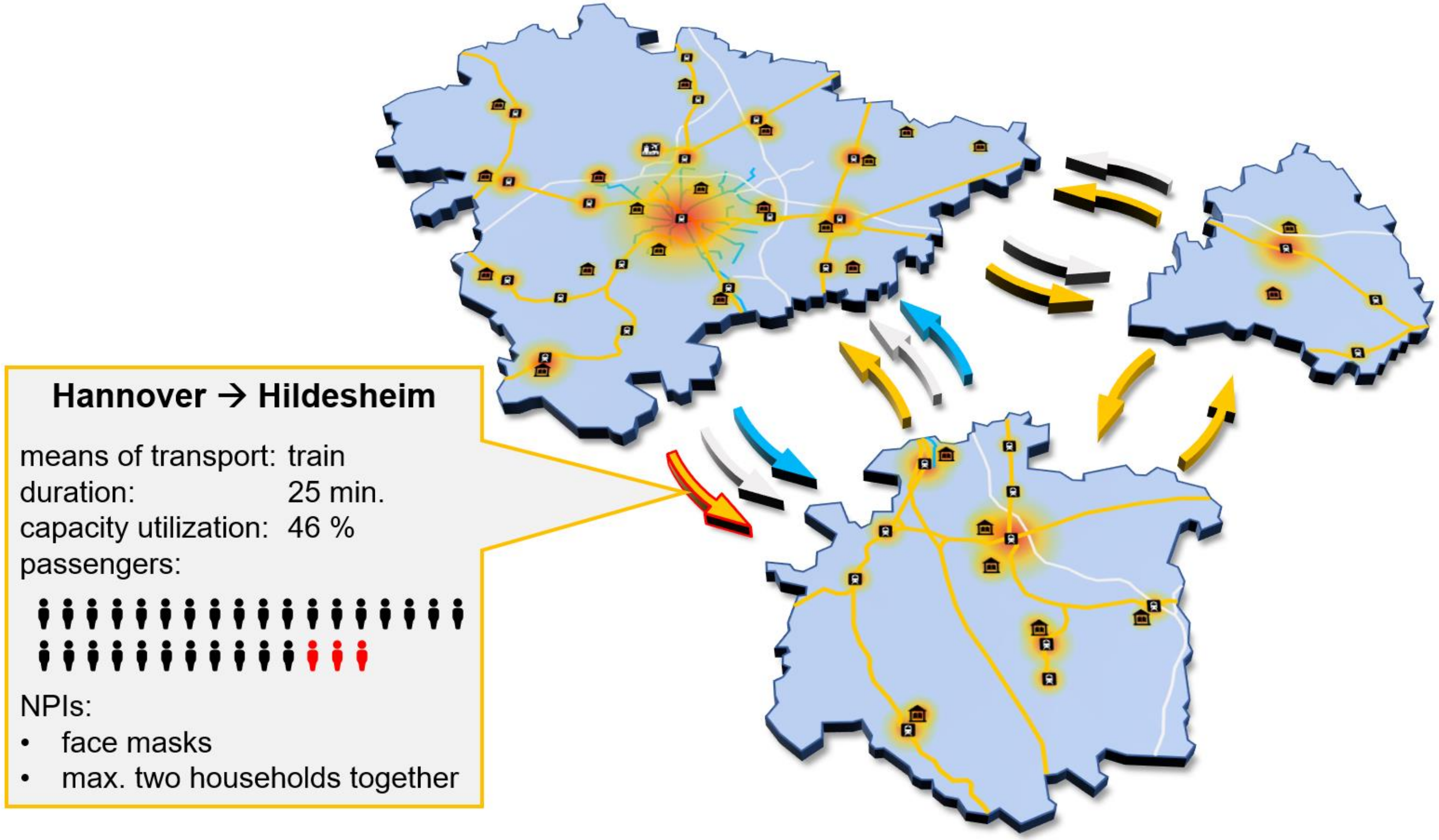
MONID

PANDEMOS

DLR

PANDEMOS: Pandemic Mobility Scenarios

09/2021-12/2024



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Goals and methods

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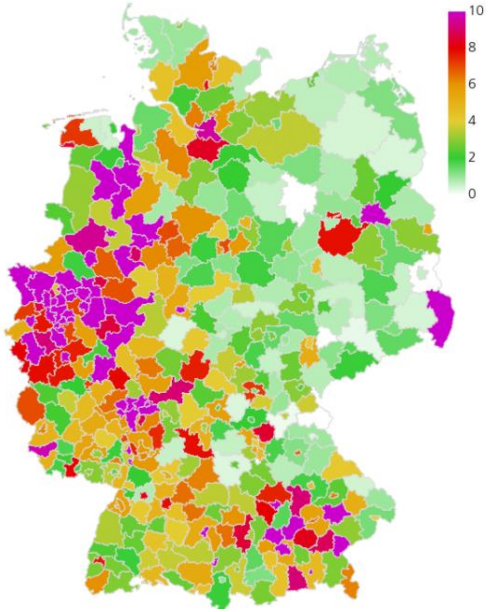
„[...] to answer the question how mobility and disease dynamics interact with each other.“

„The challenge is to maintain mobility as a social good while preventing it from driving disease dynamics.“



- Combination heterogeneous data sets
- Epidemiological models with traffic component
- Surrogat models of artificial intelligence

→ Open Source Software Framework

- Interactive User Interface

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Georeferencing of Social Media Posts

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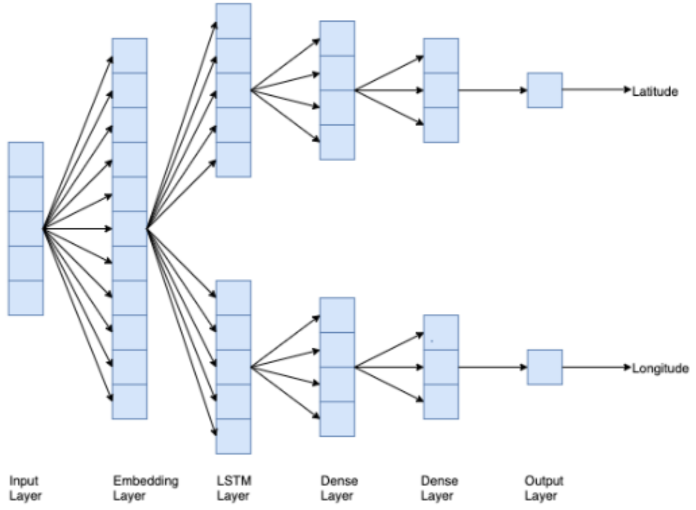
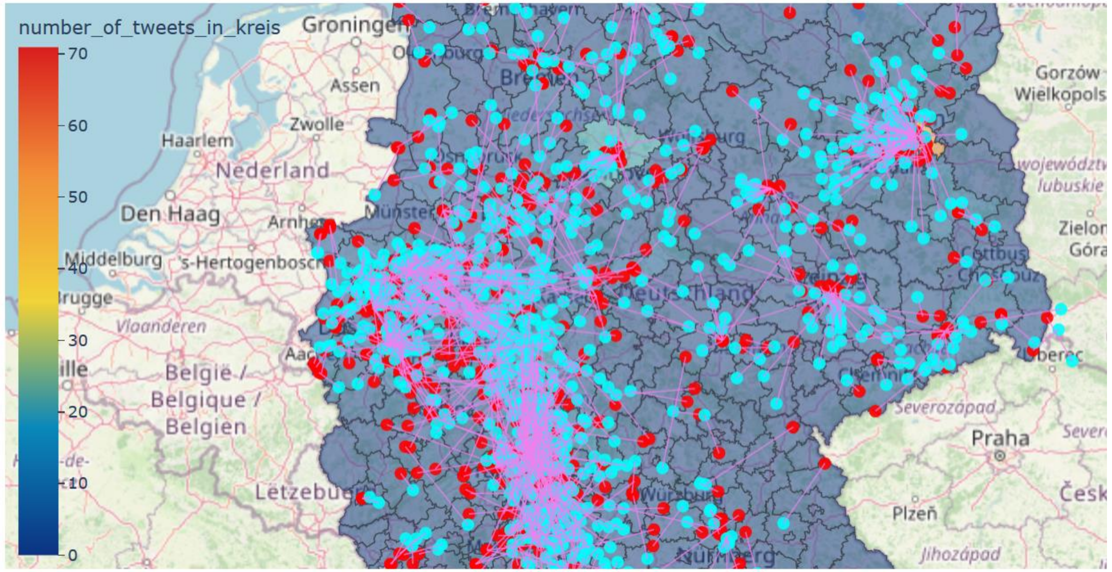
- Different approaches for automatic georeferencing
  - „Geolocation of Tweets with a BiLSTM Regression Model“ [1]
  - „Social Media Variety Geolocation with geoBERT” [2]

Figure 4: Neural model architecture





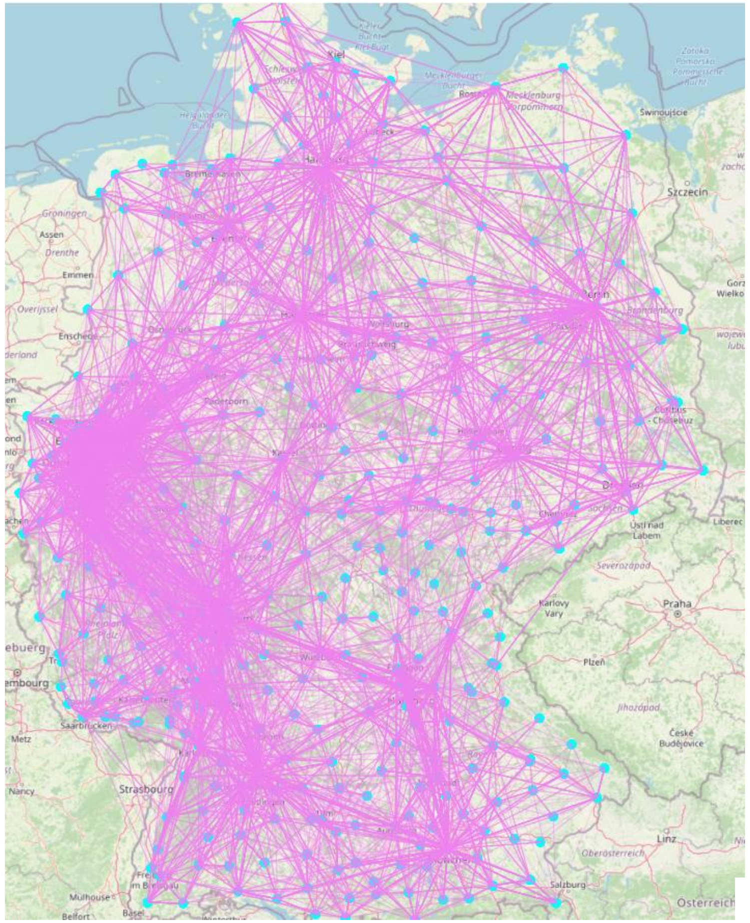
Not enough data available

[1] Mishra, Piyush. "Geolocation of tweets with a BiLSTM regression model." *Proceedings of the 7th Workshop on NLP for Similar Languages, Varieties and Dialects*. 2020.
[2] Scherrer, Yves, and Nikola Ljubešić. "Social media variety geolocation with geobert." Proceedings of the Eighth Workshop on NLP for Similar Languages, Varieties and Dialects. 2021.

County Changes

- A couple of consecutive tweets by a user from different counties counts as one trip
  - Only geo-tagged tweets coming from crossposts are being used

- Idea: Tracking average capacities between counties to detect sudden changes (NPI's like lockdown, schools closed etc.)



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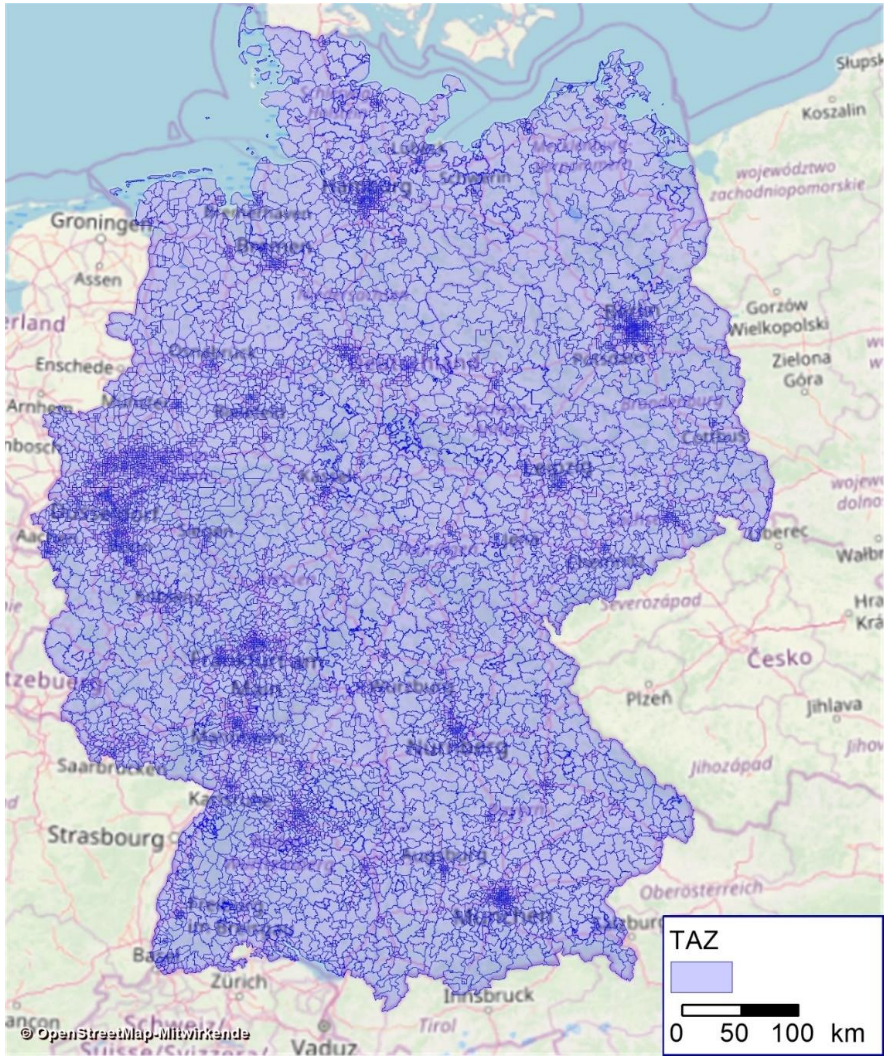
Transport model

- Macroscopic demand model
  - No individual persons
  - 22 person groups with mobility between different cells
- 6633 traffic cells
- > 1 Mio routes for street-bound traffic
- Mapping of traffic only between cells
- Time interval: 24h
- Combination with data extracted from OpenStreetMap (OSM) to generate activities



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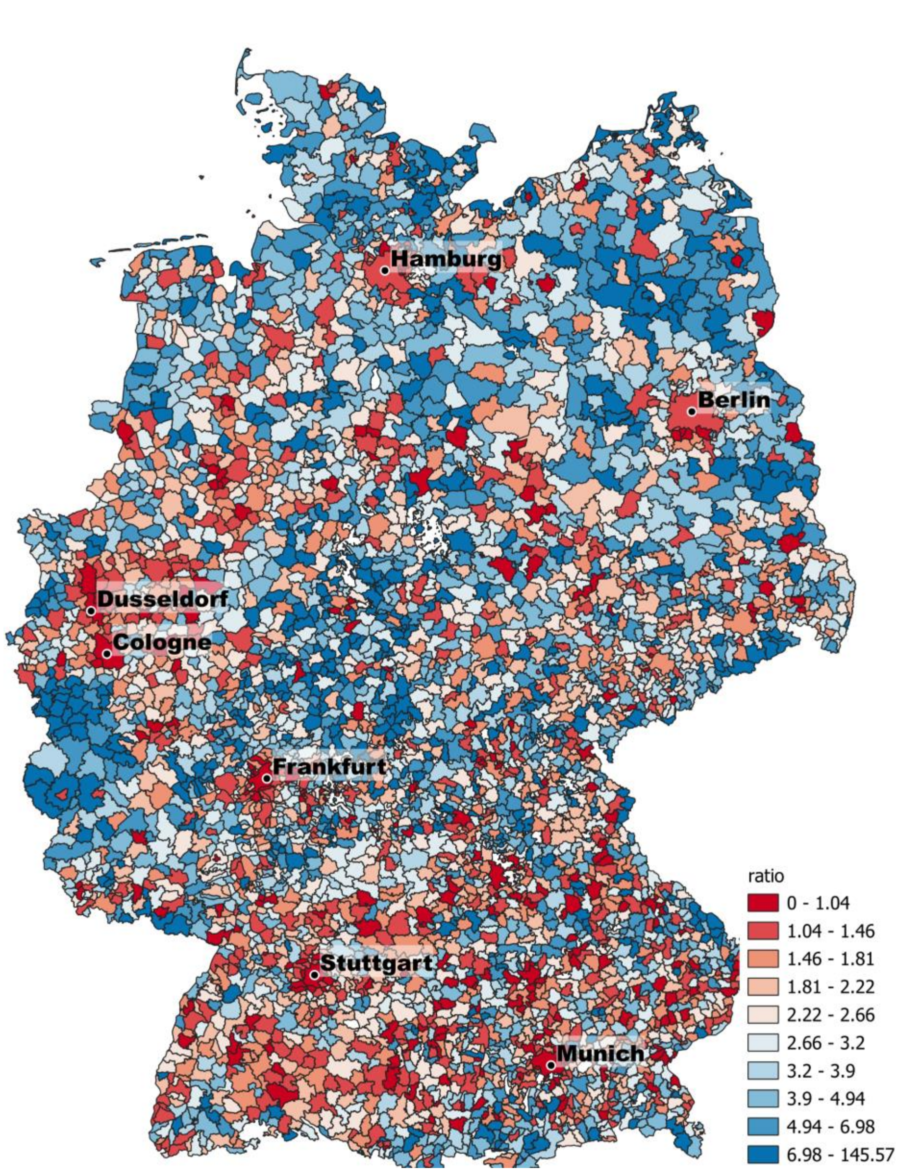
Validation of work places

- Aggregated community values
- Comparison with official statistics
  - “sozialversicherungspflichtig” [excludes ~30 %]
- Capacity often larger
  - Higher estimates in rural counties



J. L. Malkus, M. L. Díaz, A. Schengen, T. Mocanu, M. J. Kühn *An OpenStreetMap-based approach for generating capacity-restricted POIs for activity-based travel demand modeling. Procedia Computer Science (2024), 238:420-427*

OSM (2024)

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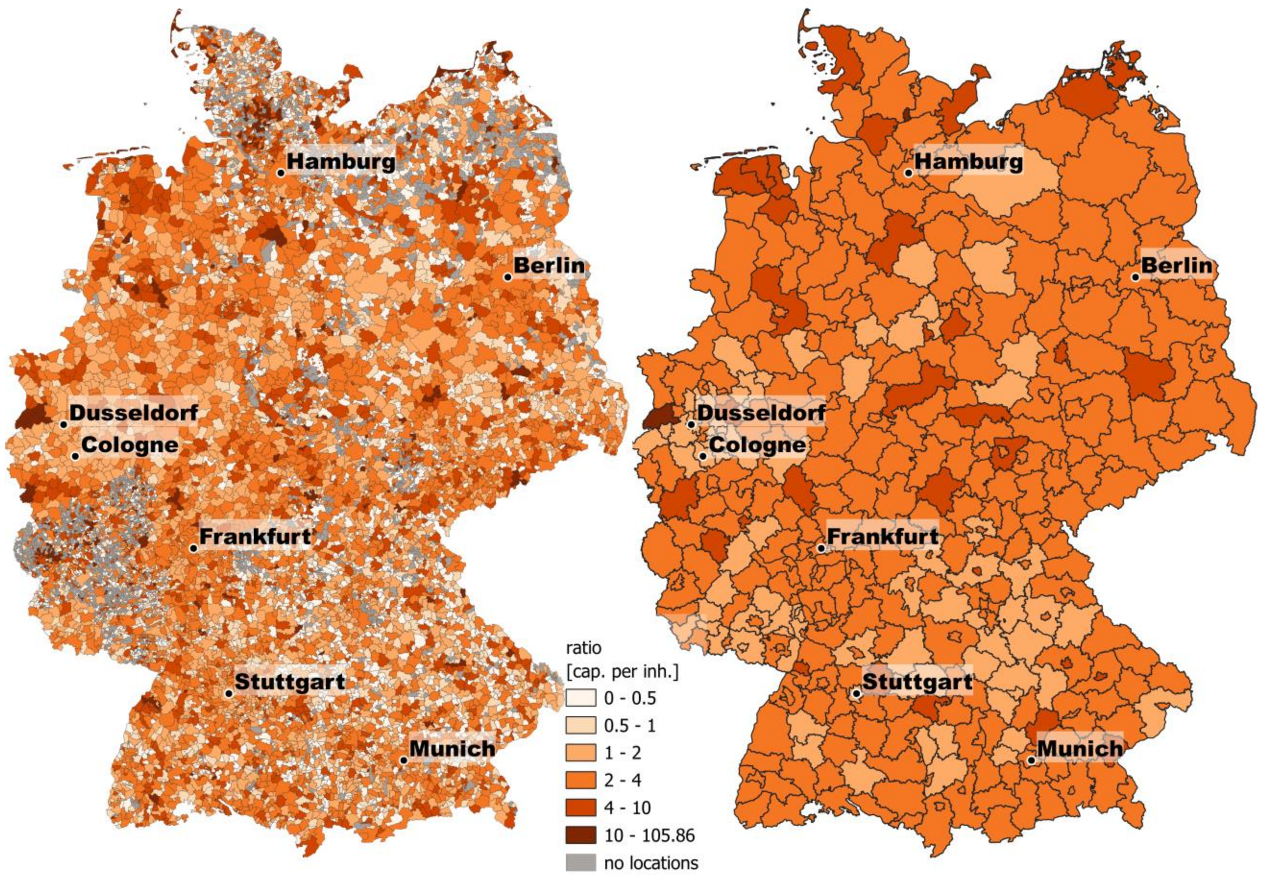
Validation of shopping

- Aggregated on community (left) and county (right)
- Comparison (factor) against population
- High variability between communities
- More homogeneous on county scale

OSM (2024)



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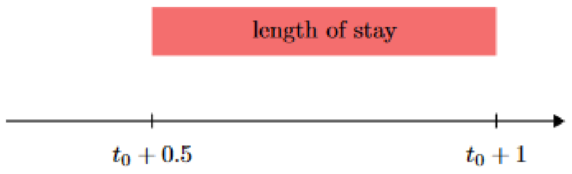
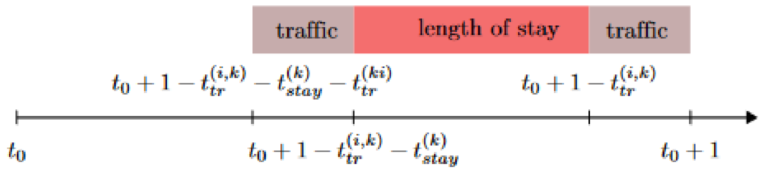
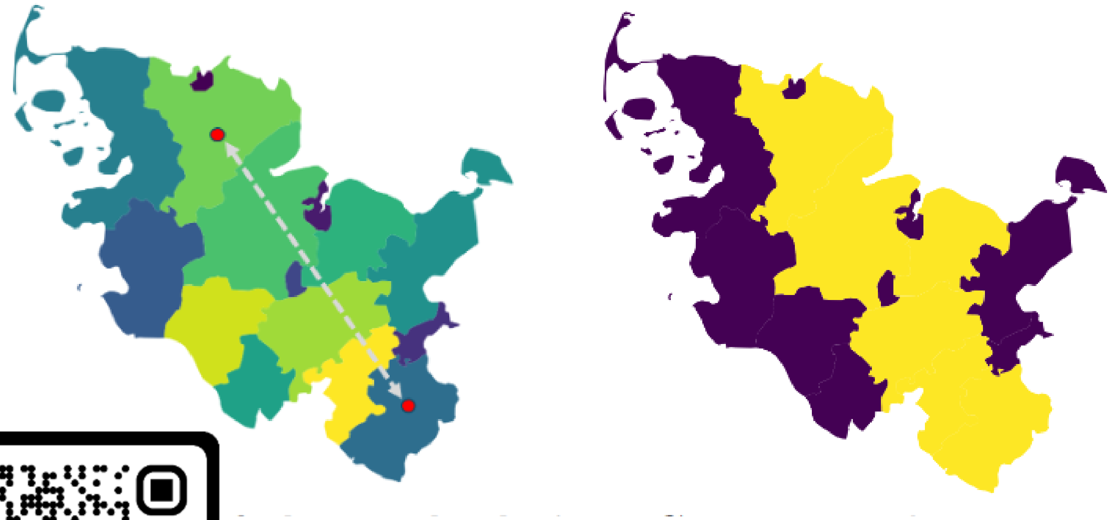
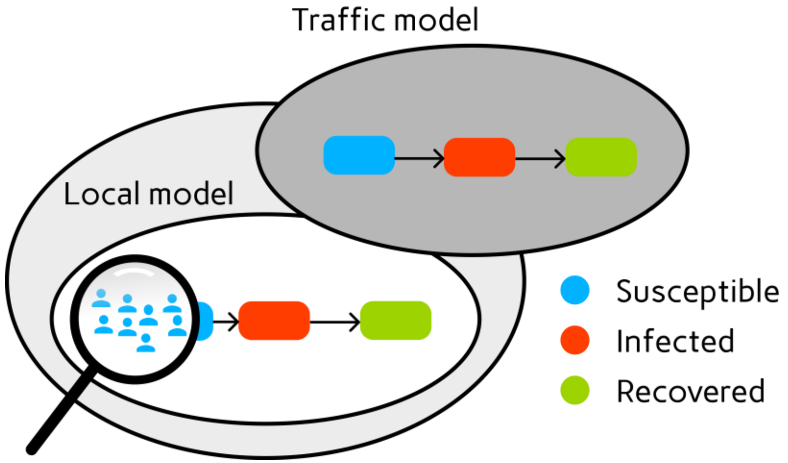
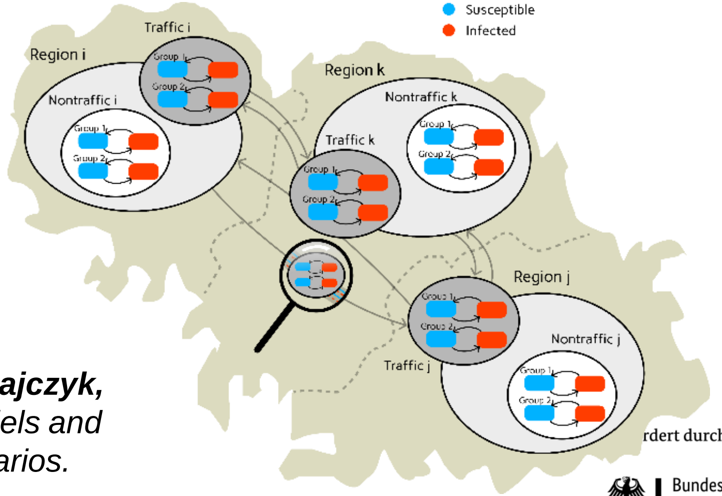
Novel travel-time aware metapopulation models











Metapop (2024)

H. Zunker, R. Schmieding, D. Kerkmann, A. Schengen, S. Diexer, R. Mikolajczyk, M. Meyer-Hermann, M. J. Kühn *Novel travel time aware metapopulation models and multi-layer waning immunity to assess late-phase epidemic and endemic scenarios. PLOS Computational Biology 20(12): e1012630 (2024).*

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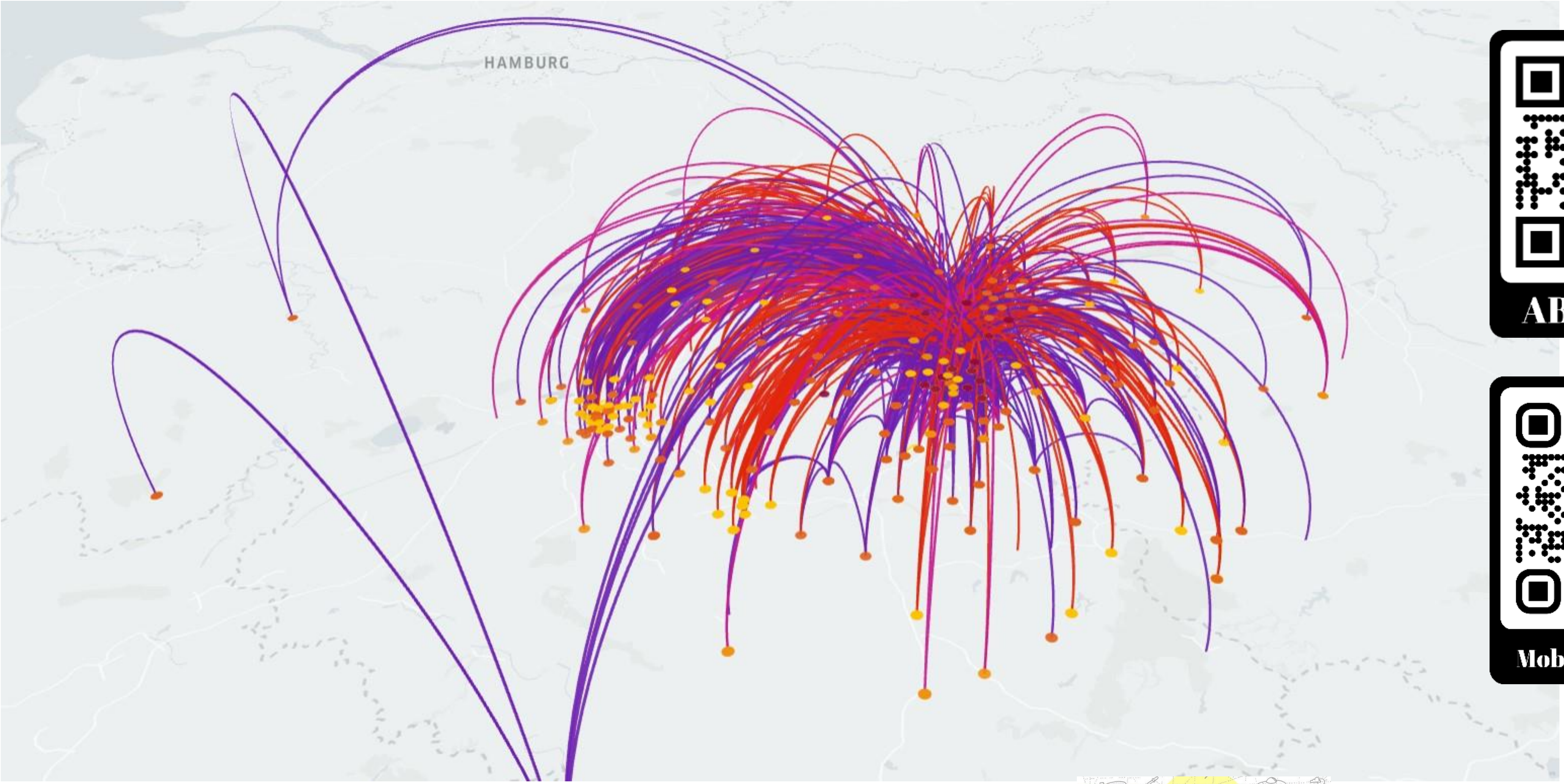
aufgrund eines Beschlusses des Deutschen Bundestages

Agent-based model for Brunswick



ABM (2024)

Mobility BS (2024)

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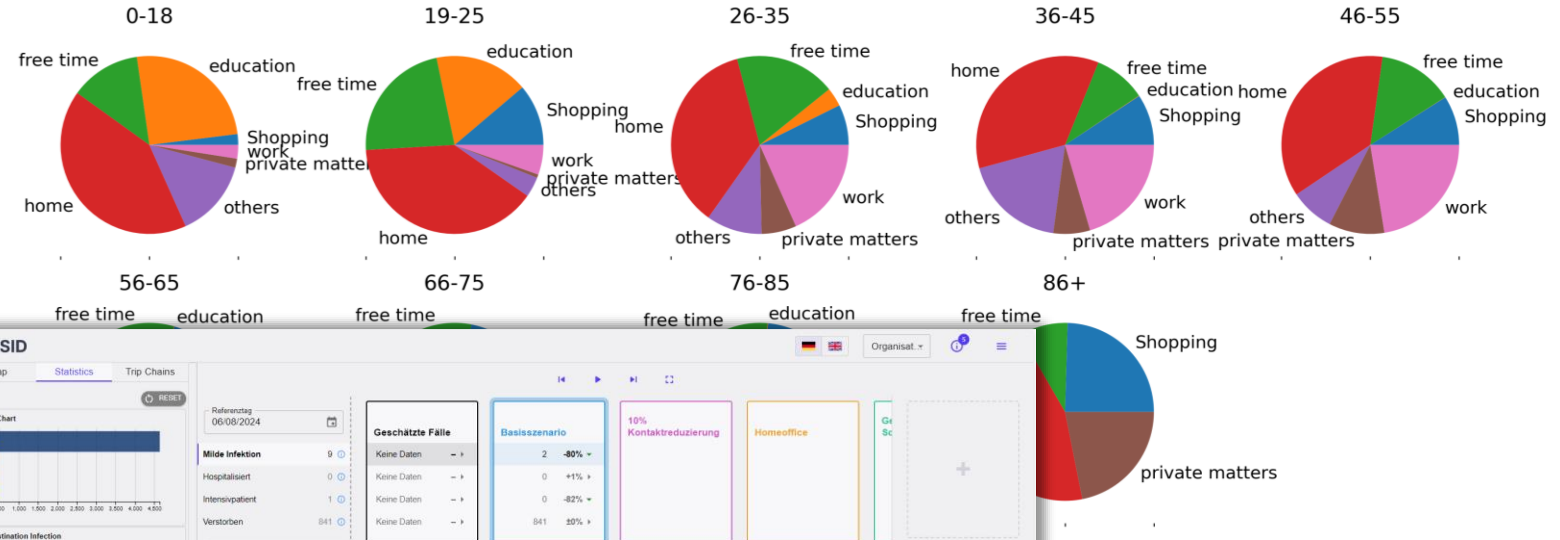
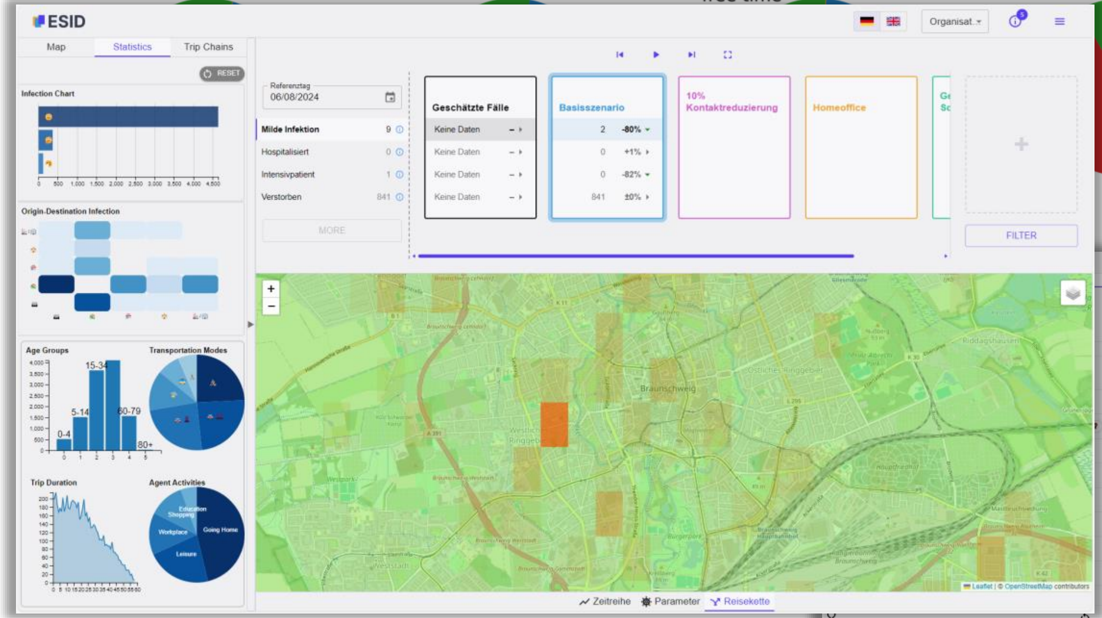
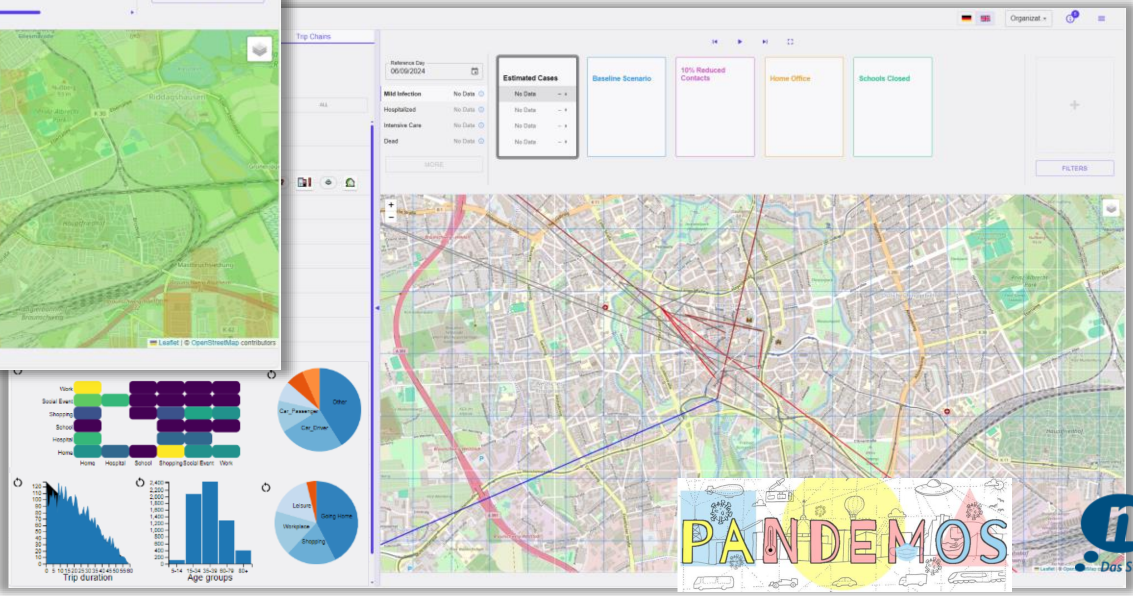
Agent-based model for Brunswick







ABM (2024)

Mobility BS (2024)

ESID

https://github.com/DLR-SC/ESID/

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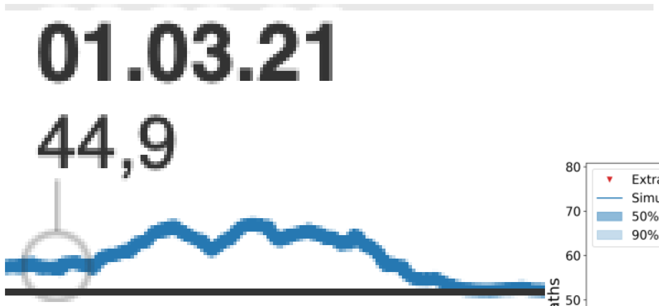
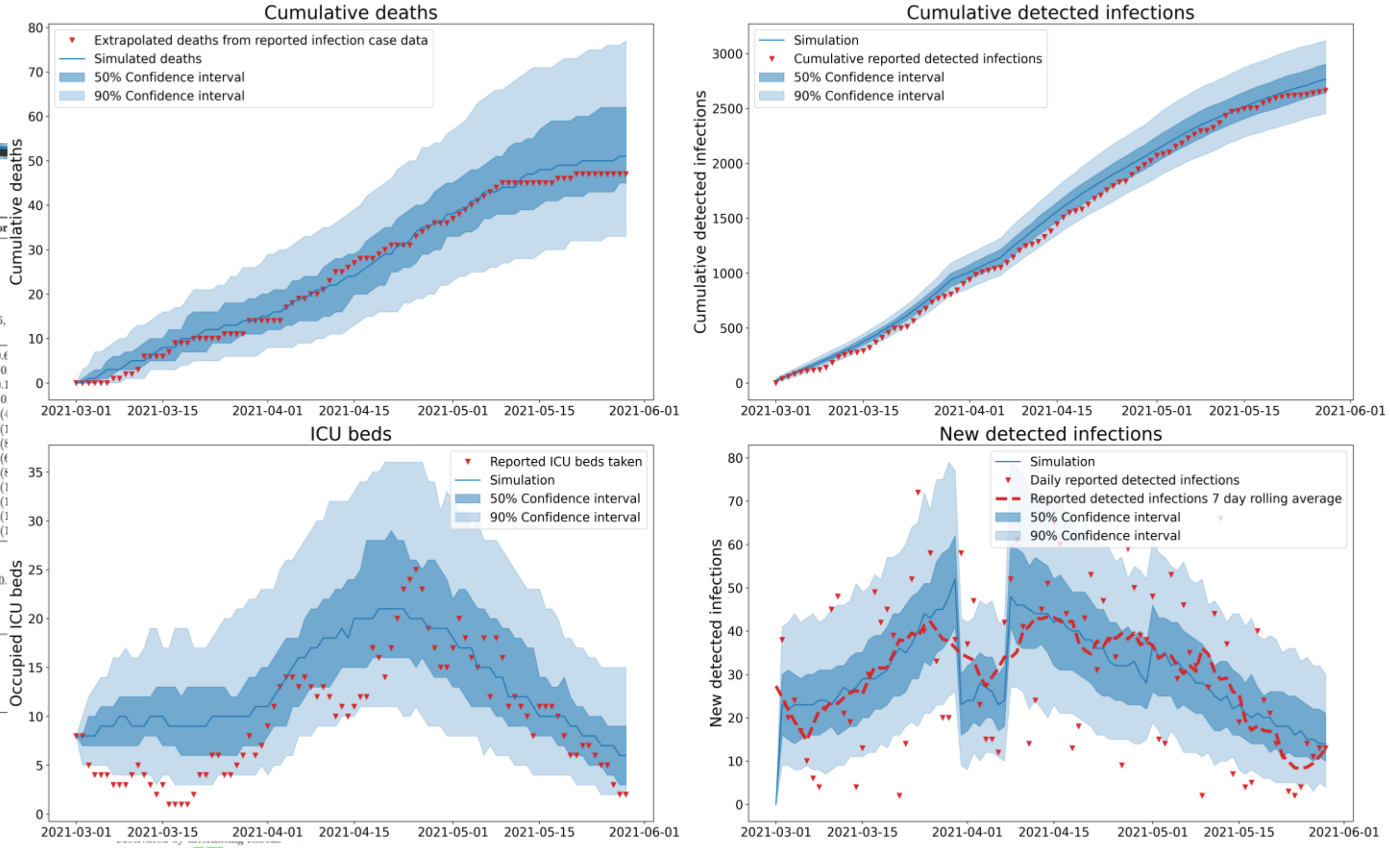
Agent-based model for Brunswick

D. Kerkmann, S. Korf, K. Nguyen, D. Abele, A. Schengen, C. Gerstein, J. H. Göbbert, A. Basermann, M. J. Kühn, M. Meyer-Hermann *Agent-based modeling for realistic reproduction of human mobility and contact behavior to evaluate test and isolation strategies in epidemic infectious disease spread. Computers in Biology and Medicine 193 (2025): 110269.*



Variable	Description	Value(s) or	
v_P	Viral load peak	8.1	
v_I	Viral load incline	2	
v_D	Viral load decline	−0.17	
α	Viral shed parameter	−7	
β	Viral shed parameter	1	
s_f	Viral shed factor	Gamma(1.6,	
λ	Infection rate from viral shed	1.596	
p_{Sym}	Chance to develop symptoms from an infection	$\{0.5, 0.55, 0.6$	
p_{Sev}	Chance to develop severe symptoms from a symptomatic infection	$\{0.02, 0.03, 0.$	
p_C	Chance to develop critical symptoms from a severe infection	$\{0.1, 0.11, 0.1$	
p_D	Chance to die from a critical infection	$\{0.12, 0.13, 0.$	
t_E^N	Time from Exposed to nonsymptomatic	LogNormal(4	
t_N^{Sym}	Time to develop symptoms after infection in case of a symptomatic infection	LogNormal(1	
t_N^R	Time to recover in case of an asymptomatic infection	LogNormal(8	
t_{Sym}^{Sev}	Time to develop severe symptoms in case of a severe infection	LogNormal(6	
t_{Sym}^R	Time to recover in case of a symptomatic infection	LogNormal(8	
t_{Sev}^C	Time to develop critical symptoms in case of a critical infection	LogNormal(1	
t_{Sev}^R	Time to recover in case of a severe infection	LogNormal(1	
t_C^D	Time to die in case of death	LogNormal(1	
t_C^R	Time to recover in case of a critical infection	LogNormal(1	
m_r	Mask protection factor for the receiving person	0.25	
m_t	Mask protection factor for the transmitting person	0.25	
m_c	Overall mask compliance per location type	$\{0, -0.1, -0.$	
p_f	Protection from vaccination against severe infection	0.8	
q_e	Quarantine efficiency	0.5	
q_d	Quarantine length	10	
	Test Sensitivity	0.71	
	Test Specificity	0.996	
p_s	Testing probability for symptomatic agents	0.02472	
μ_{ns}	Testing ratio symptomatic to nonsymptomatic agents	4.83	
	Relative increased testing ratio during lockdown	0.2	
d	Initial dark figure	4.171	
r_L	Relative contact reduction during lockdown	0.2725	
	Reduced trips during lockdown (Basic Shop, Social Event)	0.5	
	Reduced trips factor during lockdown (Work)	0.7	
	Reduced trips factor during lockdown (School)	0.0	
	Relative contact reduction after lockdown	0.5	
	Reduced trips factor after lockdown (Basic Shop, Social Event)	0.8	
	Reduced trips factor after lockdown (Work)	0.75	
	Reduced trips factor after lockdown (School)	0.5	
ψ	Seasonality factor April	0.95	Motivated by [5, 66] and manual adaptation
ψ	Seasonality factor May	0.85	Motivated by [5, 66] and manual adaptation
r_E	Percentage of the population celebrating Easter	0.2	Motivated by [69] and manual adaptation



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Data and software

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Published data sets

- Makroskopische bundesweite Verkehrsströme, Mobilithek, 2025 https://mobilithek.info/offers/573360269906817024

- Microscopic trip chains for Brunswick (Germany) region, zenodo, 2024, 10.5281/zenodo.13318435

Mobility BS (2024)

Software

- MEmilio a high performance Modular EpideMIcs simuLatIOn software, v1.3.0, 2024 10.5281/zenodo.10412634. https://github.com/SciCompMod/memilio

- ESID Epidemiological Scenarios for Infectious Diseases https://github.com/DLR-SC/ESID/

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Outlook: Modeling backend

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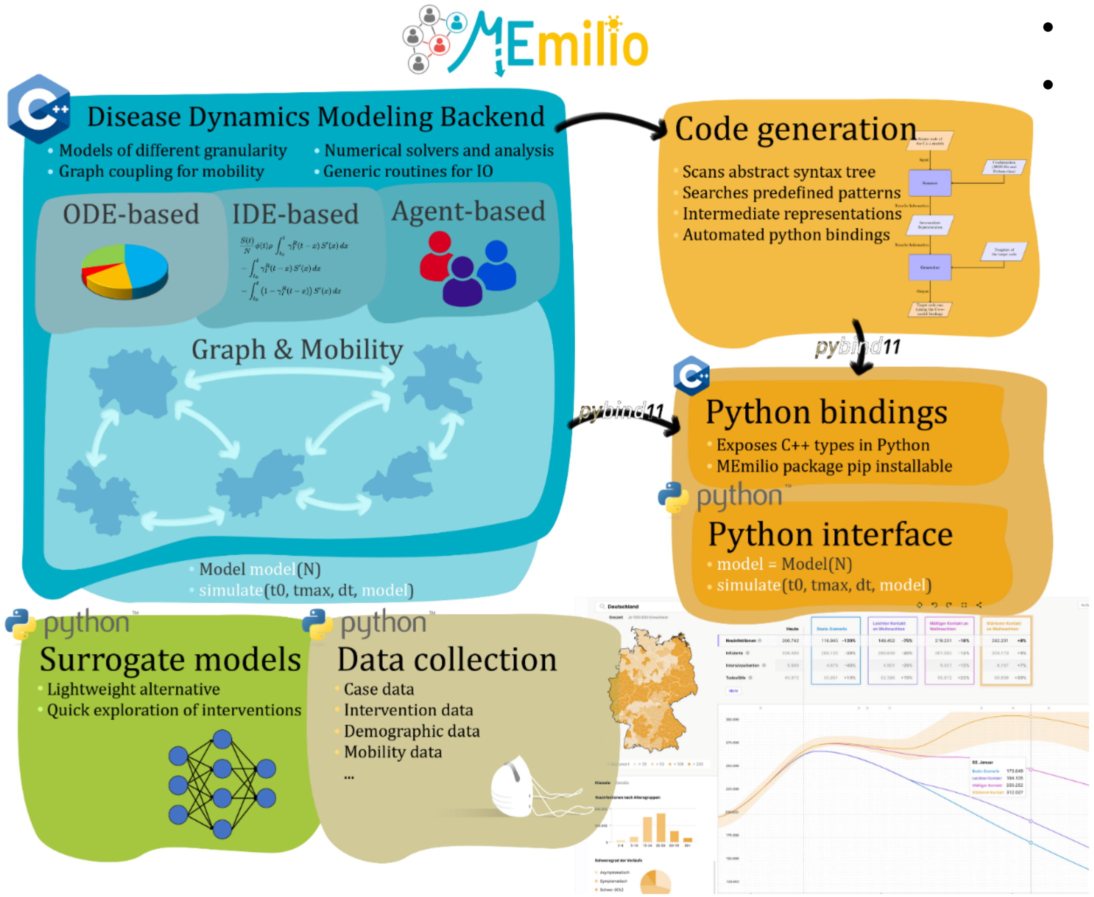
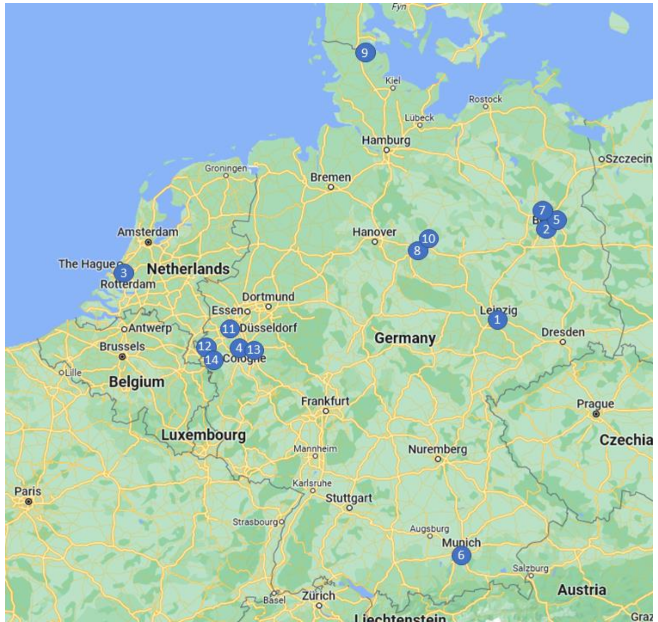
Modular design for intermodel comparisons and extensions



Activity (on main) September 2024

- 14 active pull requests (10 merged)
- 16 active issues (9 closed)
- 14 active authors

„Research Software Quality Assured and Re-usable“
→ Further funding to extend backend



Questions?