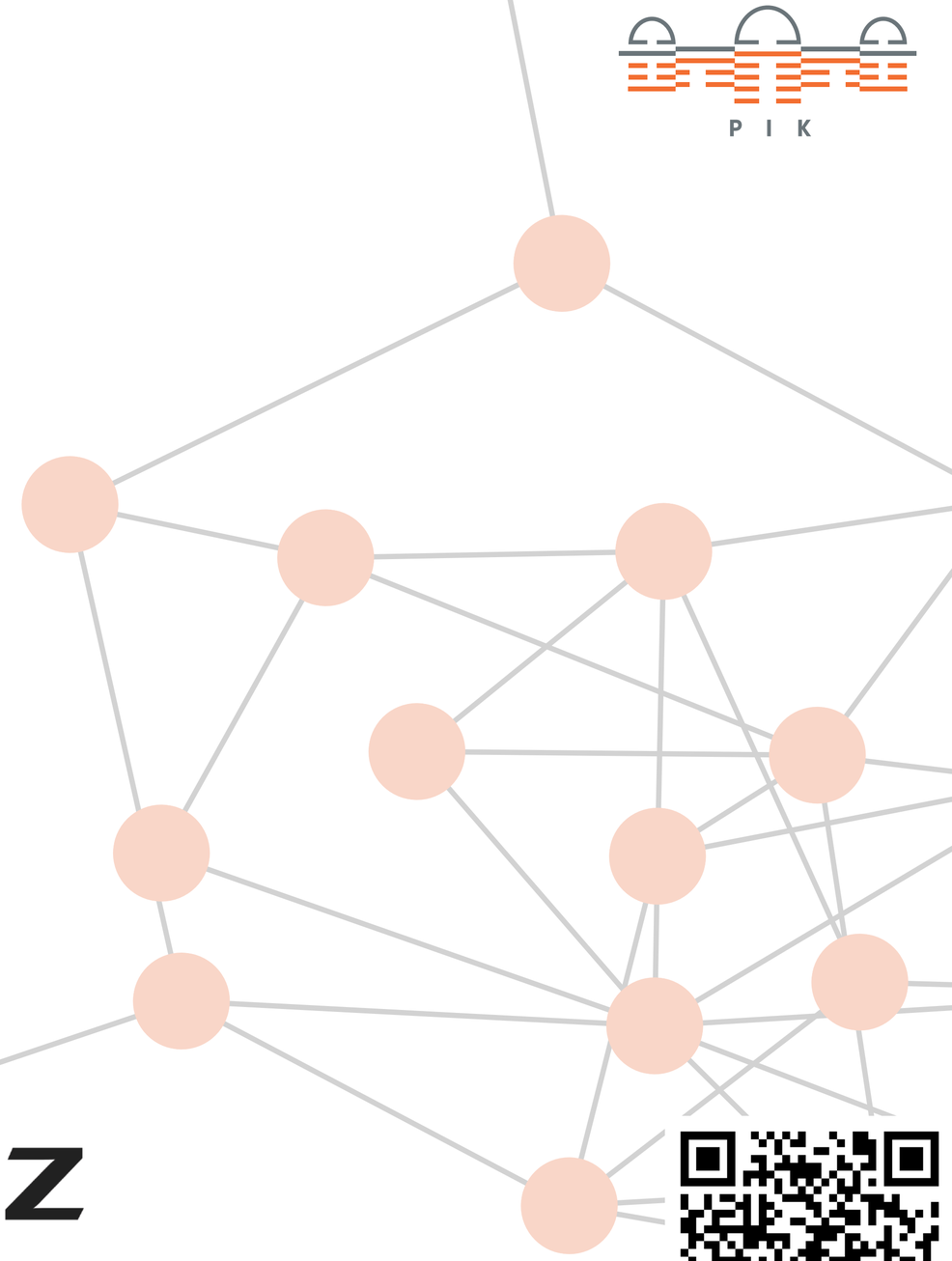
26.05.2022

EGU22, NH9.5

Jonas Wassmer
Co-authors: Norbert Marwan & Bruno Merz

Resilience of emergency infrastructure networks after flooding events



Natural Hazards and Risks in a Changing World

Universität Potsdam

GFZ Helmholtz-Zentrum Potsdam

Infrastructure after the Ahrvalley flood

Rail bridge, Ahrvalley,
by Heather Murdock, November 2021

Vier Wochen nach der Flut: Krankenhaus Maria Hilf in Bad Neuenahr nimmt wieder Patienten auf

Der stationäre Betrieb hatte am Freitag nach der Flutnacht vom 14. Juli schließen müssen, weil die reguläre Strom- und Wasserversorgung sowie die Abwasserentsorgung zusammengebrochen waren.

Von Frank Bugge | 13. August 2021, 8:00 Uhr | Lesezeit: 3 Minuten

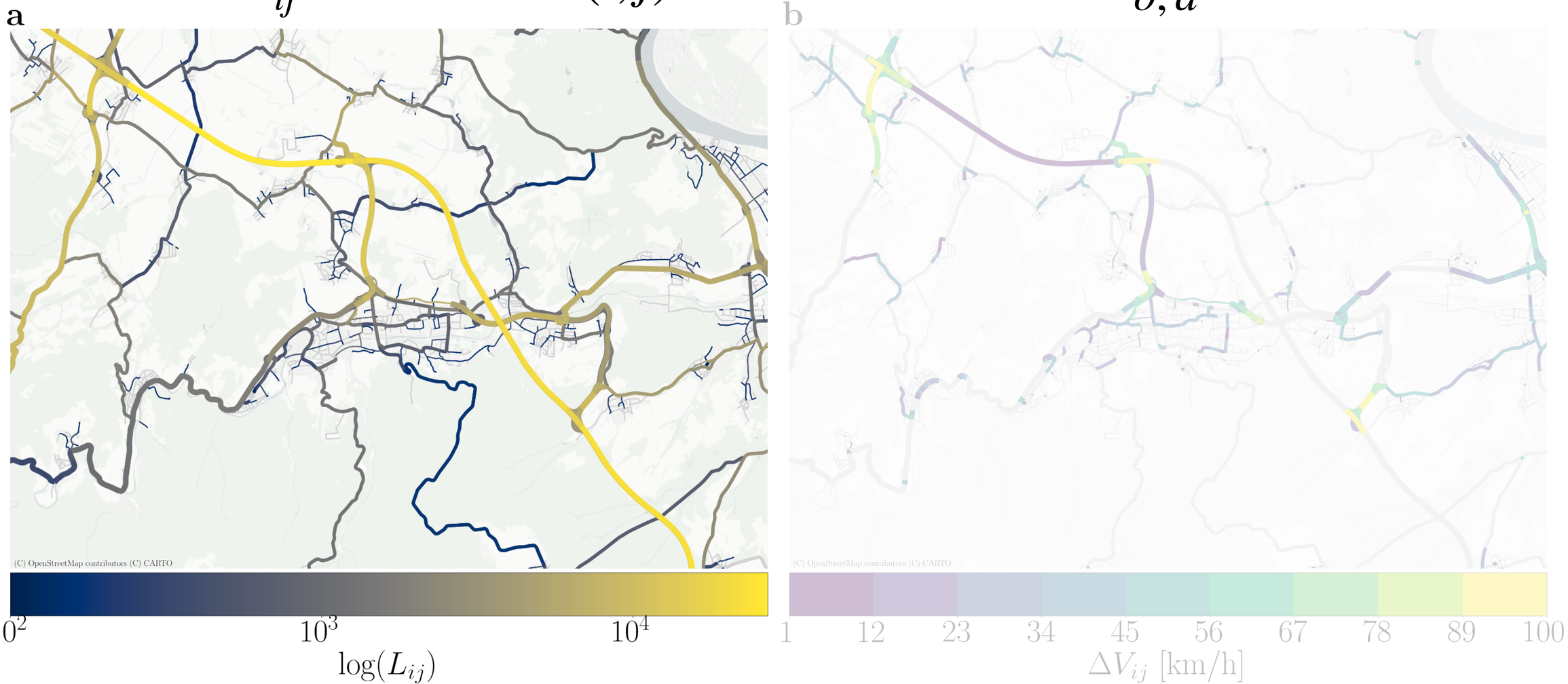
Source: Rhein-Zeitung

- Understand evacuation patterns
- Analyse accessibility to emergency services

The gravity model of traffic

$$L_{ij} = \sum_{o,d} F_{od}\,\theta_{od}(ij)$$

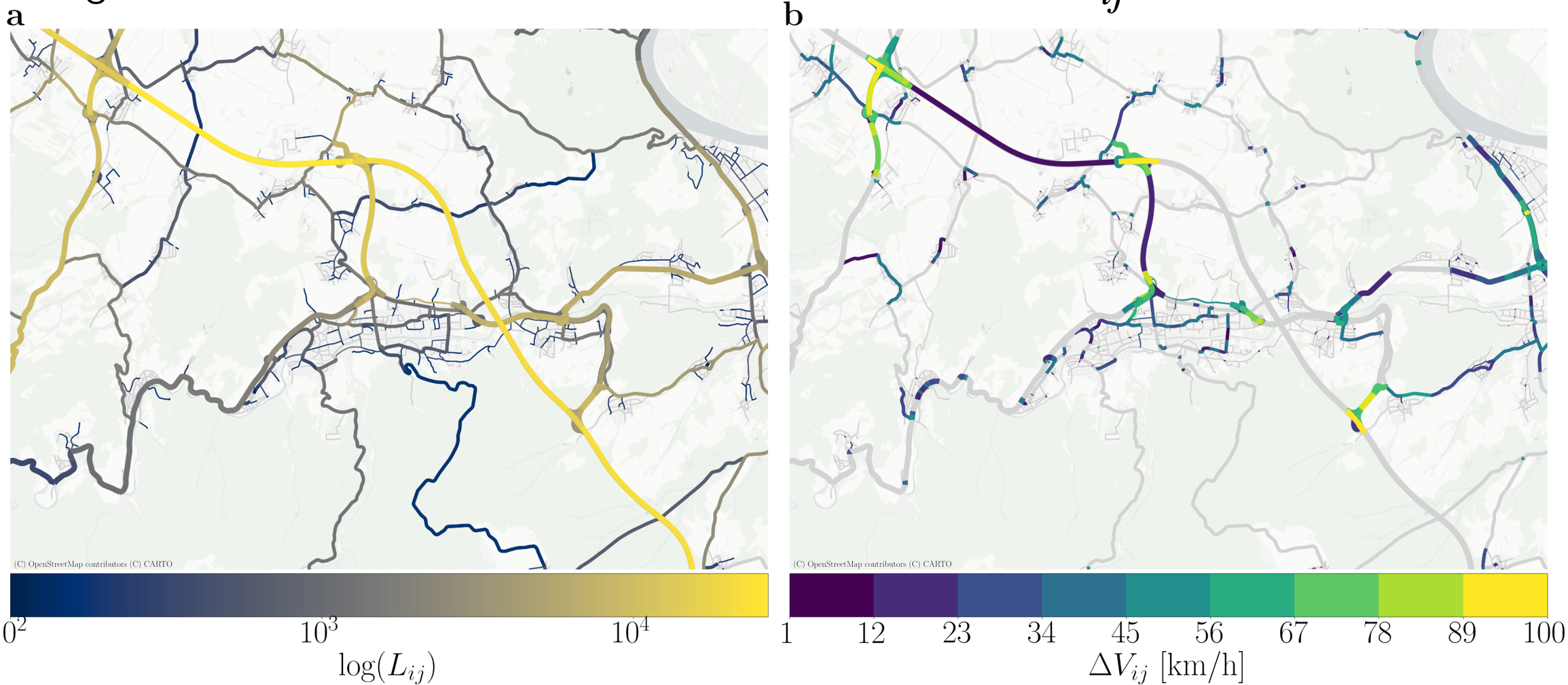
- Traffic load L_{ij} on roads $\ell = (i,j)$



The gravity model of traffic

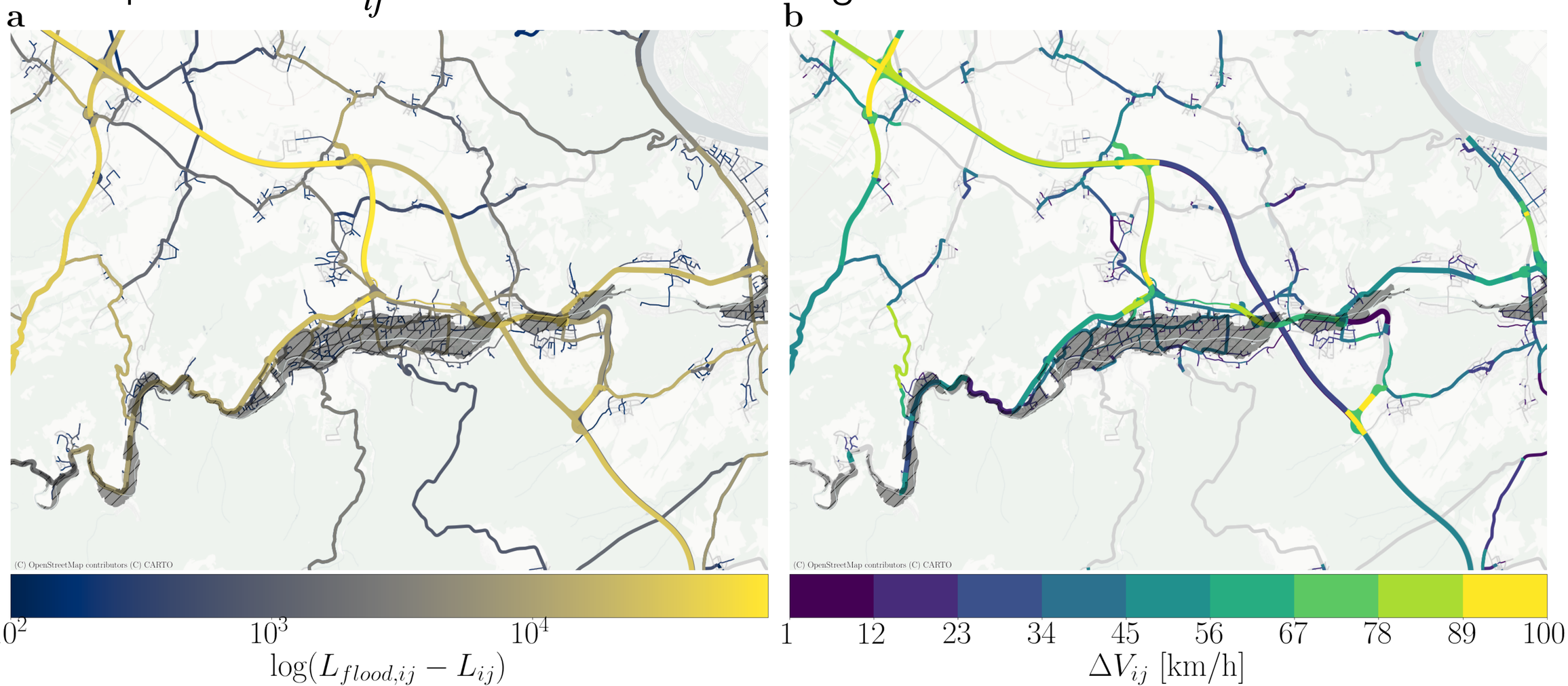
$$V_{ij} \propto \frac{l_{ij} m_{ij}}{L_{ij}} \in [V_{min}, V_{max}]$$

- Daganzo method



Traffic simulation after Ahr flooding

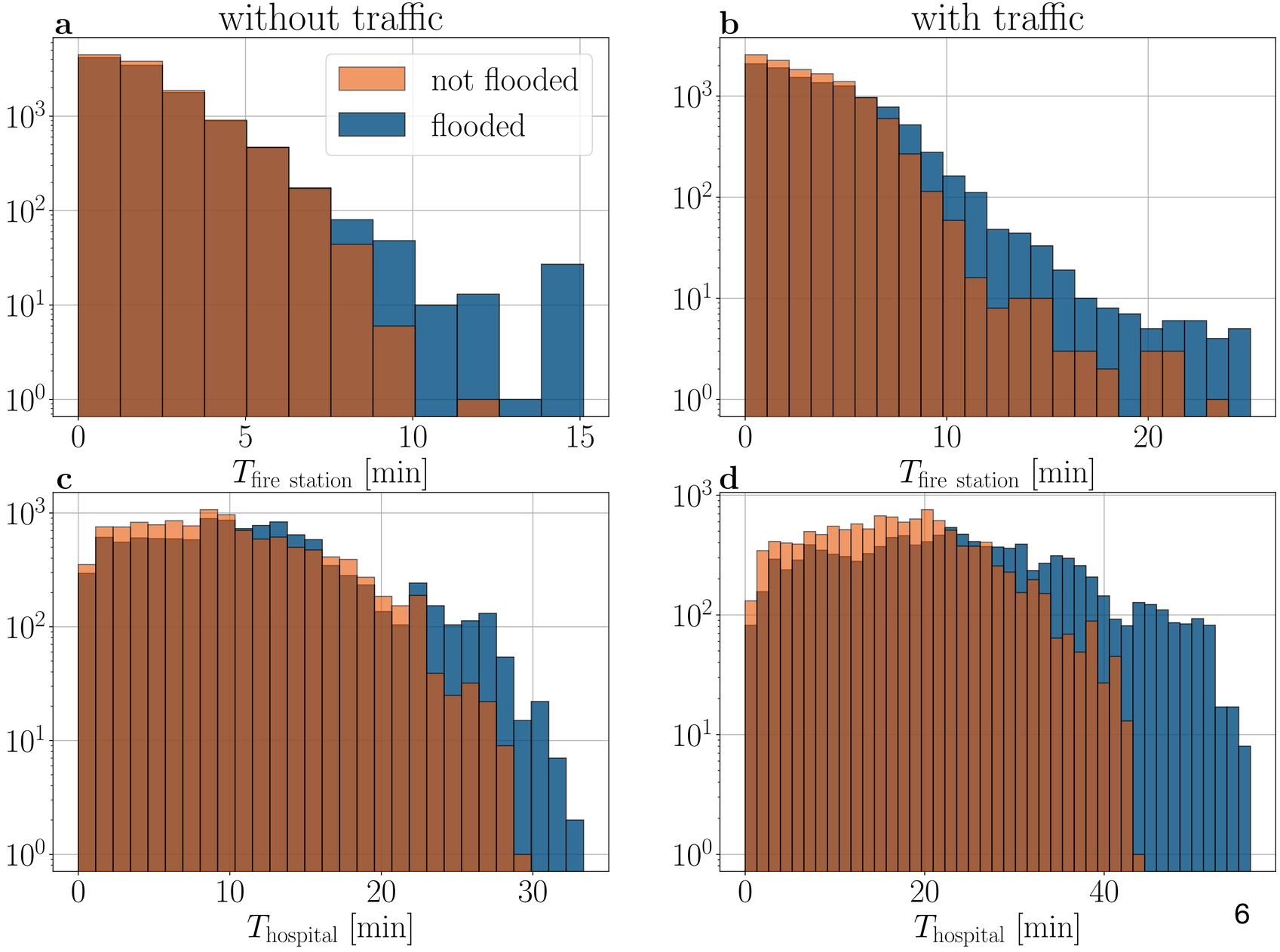
- Compute loads L_{ij} before and after flooding



Accessibility of emergency services

- speed v_{ij}, length l_{ij}, shortest paths sp_{od}

⇒ Time to emergency services T



Take home messages

Severe congestions
⇒ Optimise evacuation patterns

Reachability of emergency services hindered
⇒ Enhance accessibility

Sweeped car, Ahrvalley,
by Heather Murdock, November 2021

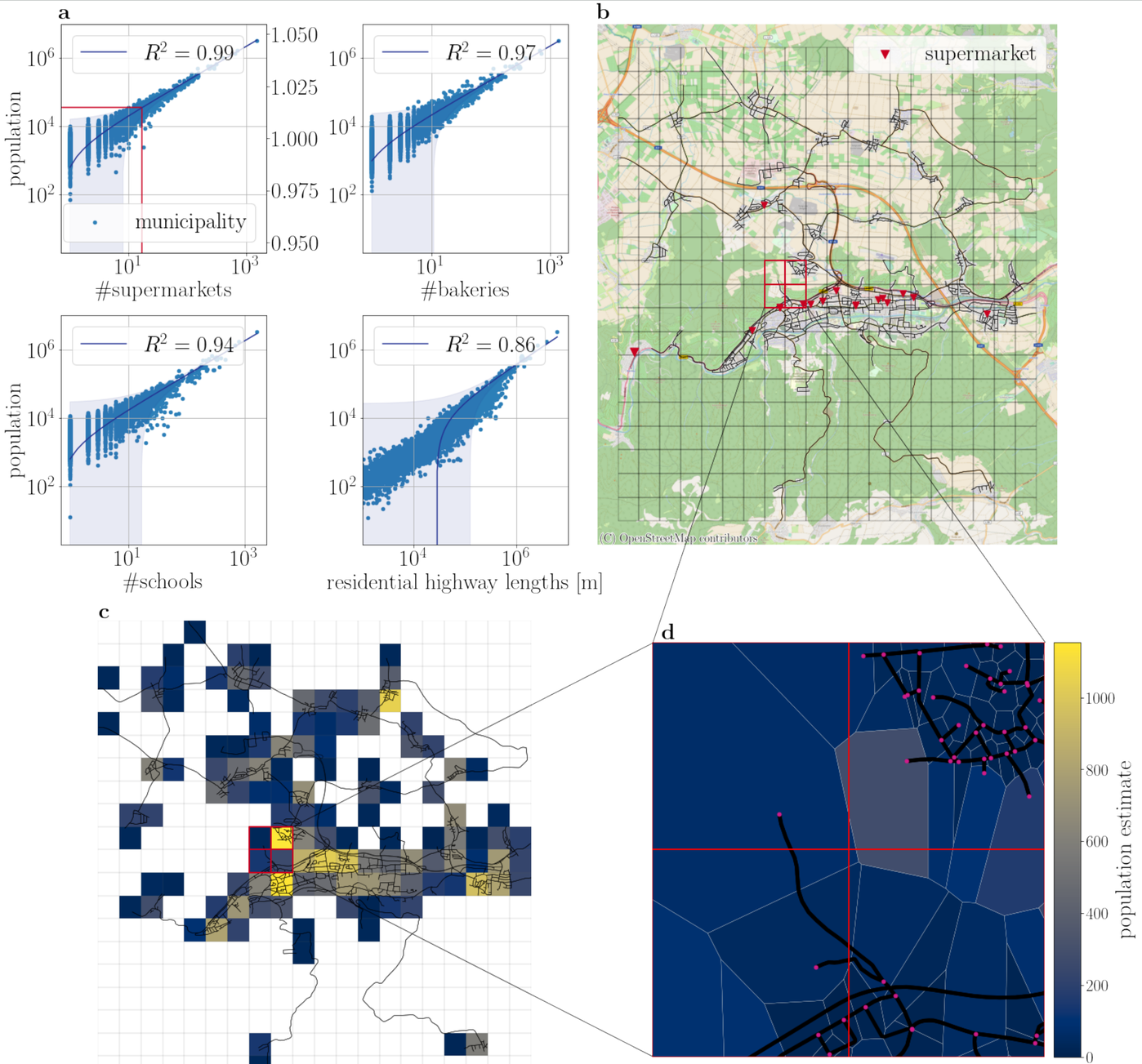
Appendix

The gravity model of traffic

- Traffic flow F_{od} between origin o and destination d

$$F_{od} = N_o \frac{N_d P(x_{od})}{\sum_k N_k P(x_{ok})}$$

- Estimate nodal population N_k

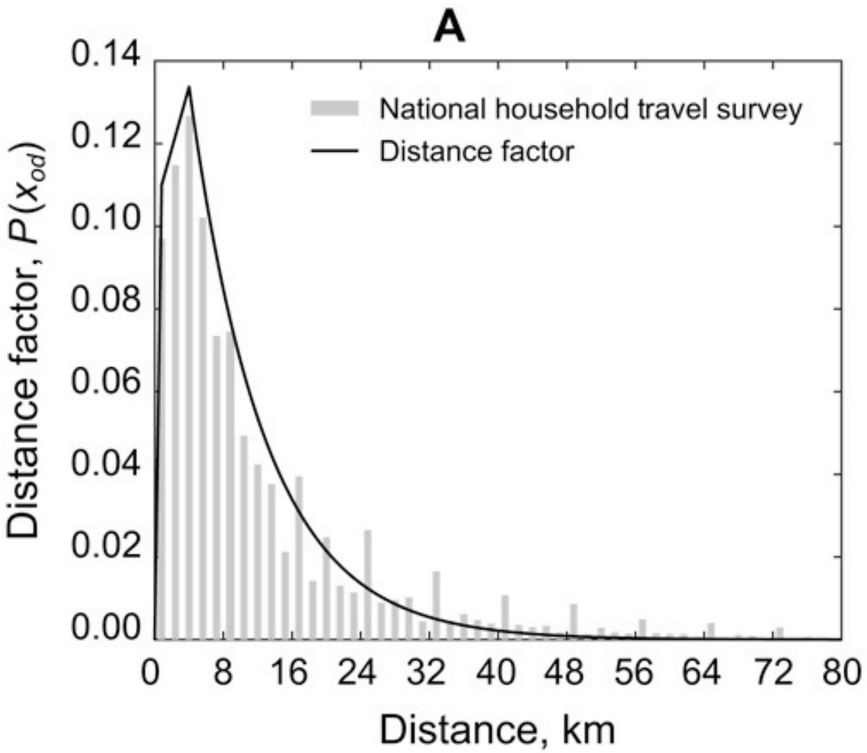


Choosing a distance function

Exponential decay of travels with respect to distance

In extreme weather scenarios this is not sufficient!

⇒ Need to include ‘distance to event’ information



Ganin et. al., Science Adv. (2017)

Choosing a distance function

Exponential decay of travels with respect to distance

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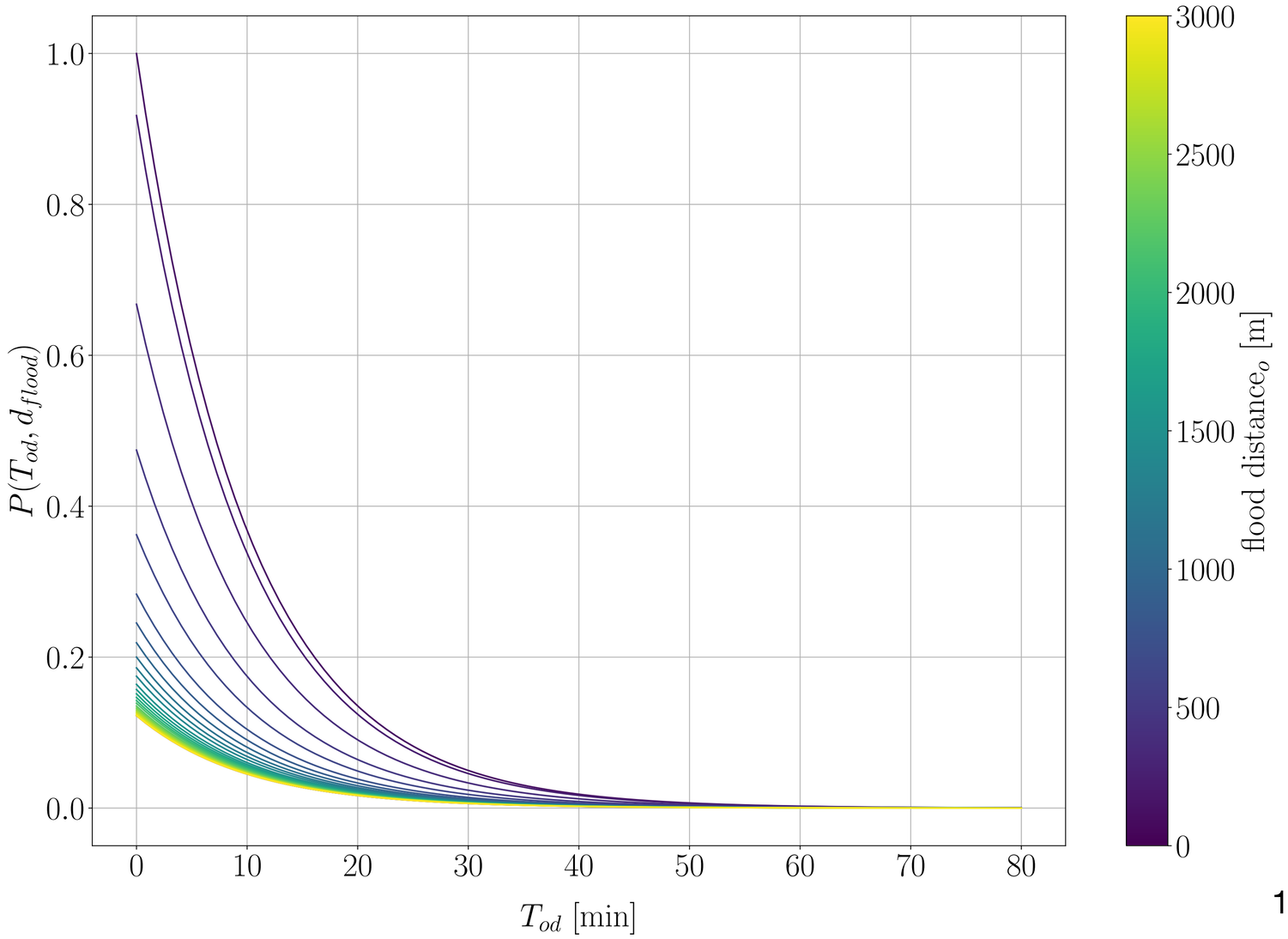
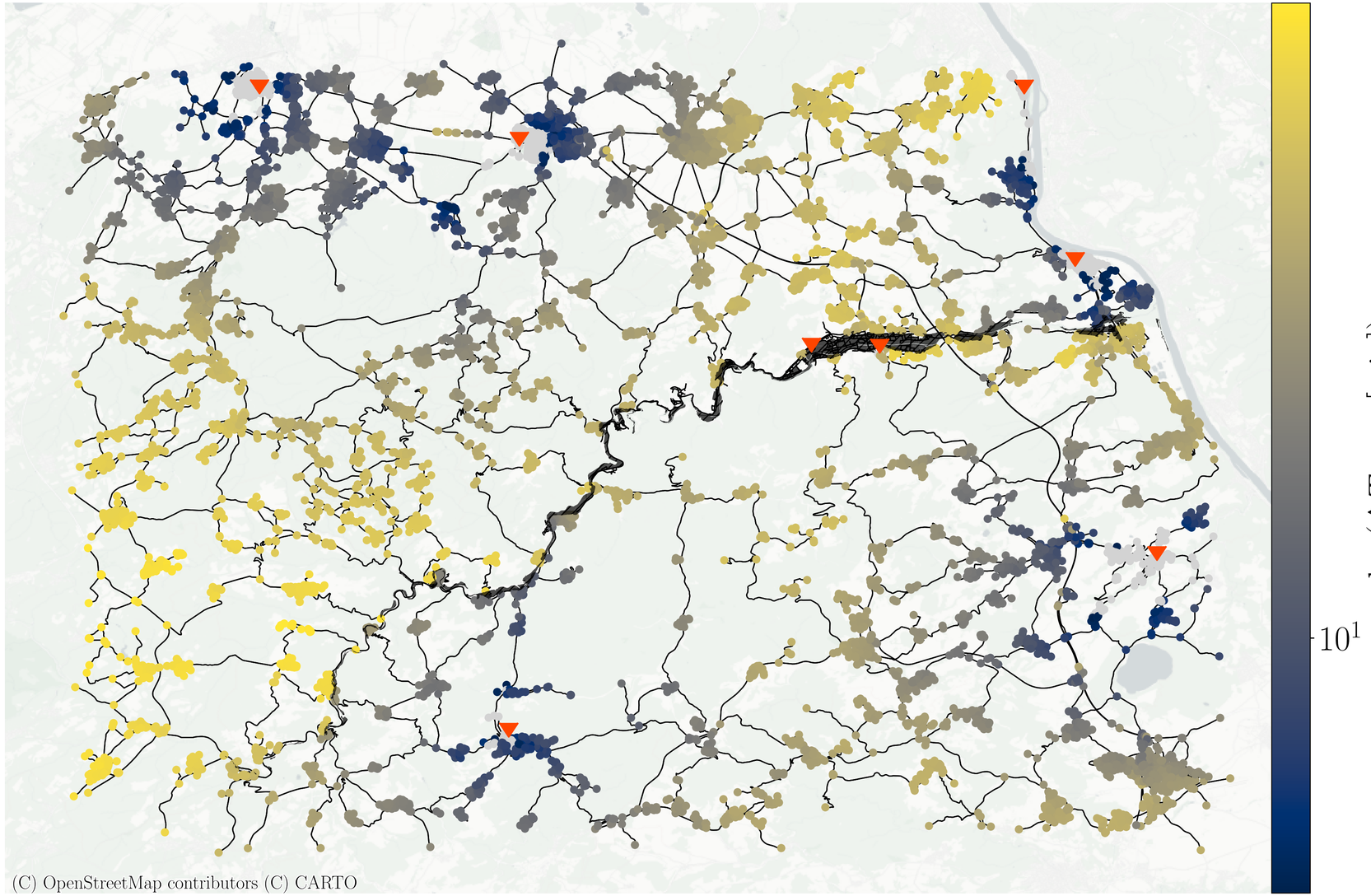
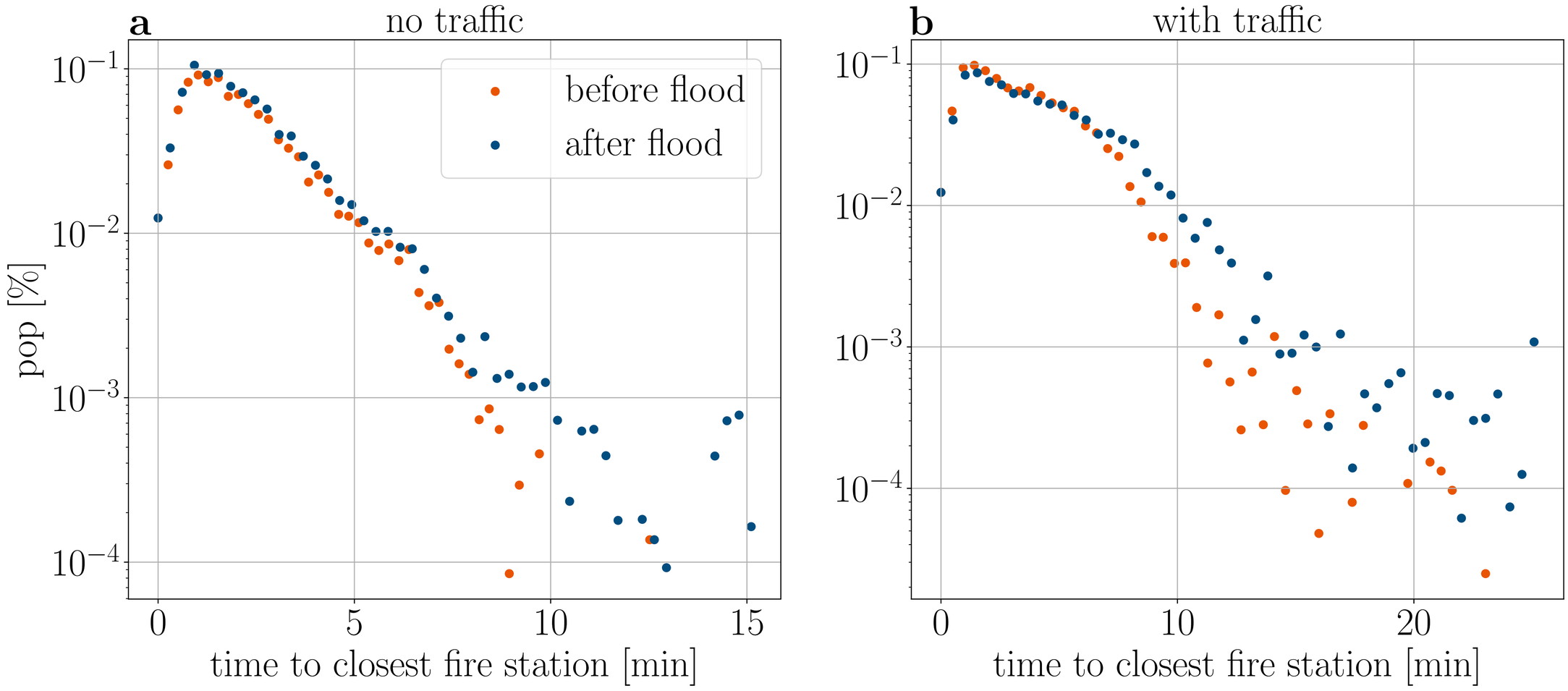


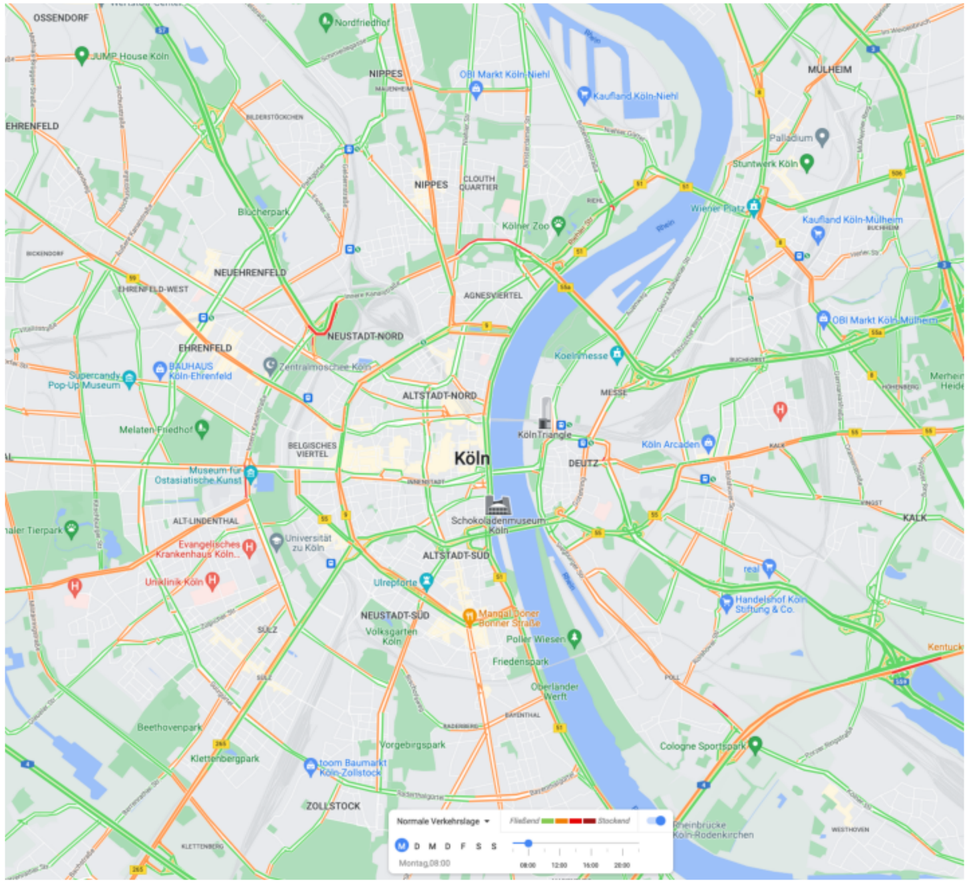
Time to hospitals after flooding



Time to fire stations is scale free



Cologne traffic Google comparison



Literature

- Ganin, A. A., Kitsak, M., Marchese, D., Keisler, J. M., Seager, T., & Linkov, I. (2017). Resilience and efficiency in Transportation Networks. *Science Advances*

- Yuqin Jiang, Zhenlong Li & Susan L. Cutter (2021): Social distance integrated gravity model for evacuation destination choice, International Journal of Digital Earth