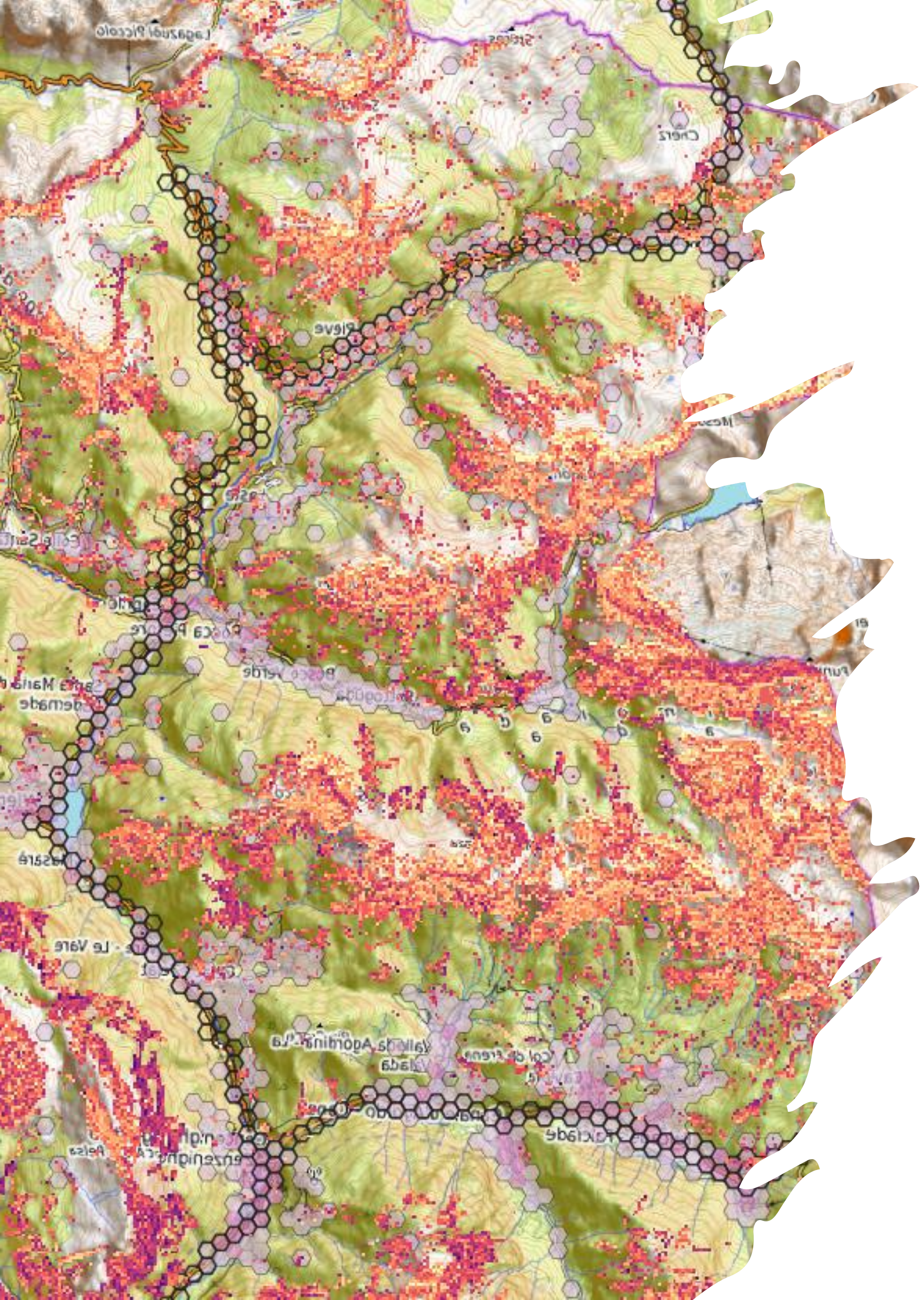


eurac research

Center for Climate Change and Transformation

Tessellated border-independent exposure analysis for operational climate and disaster risk preparedness applications

Chronicles from the DG-ECHO "TransAlp" project

Piero Campalani, Kathrin Renner, Massimiliano Pittore

0000-0002-1032-9825 0000-0001-7757-799X 0000-0003-4940-3444

17.10.2023

A Concepts and Context

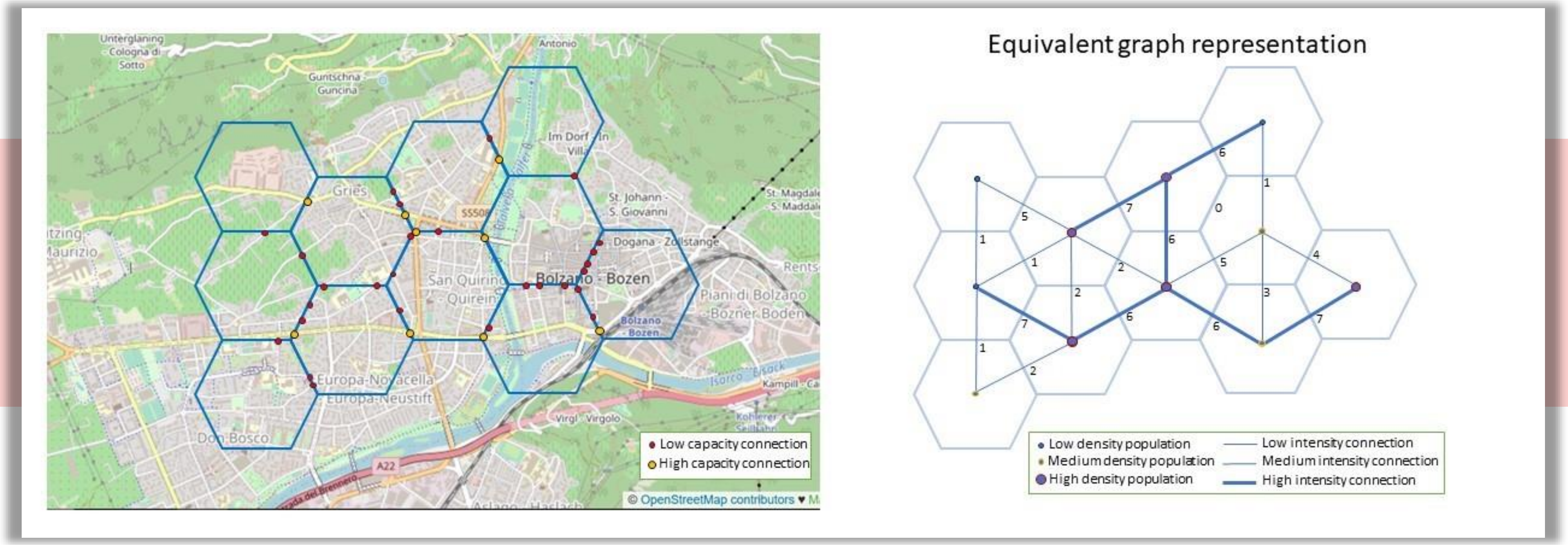
Q1 How to ease the life of DRR managers?

Available risk preparedness and prevention tools are increasingly lagging behind the growing threat of climate change, with multiple hazards often compounded causing cascaded and intertwined damages to society and the environment.

Q2 What about cross-border **exposure** data?

Transborder mountainous areas are especially vulnerable to such threats, given the susceptibility to natural hazards as well as remoteness of some settlements and the related importance of connectivity and accessibility.

Firstly, a simplified spatial support:



$$
\begin{cases}
T = \{l_i : i = 1, \dots, N\} \\
l_i \cap l_j = \emptyset, \forall i \neq j \\
\bigcup_{i=1}^{N} l_i = R
\end{cases}
$$

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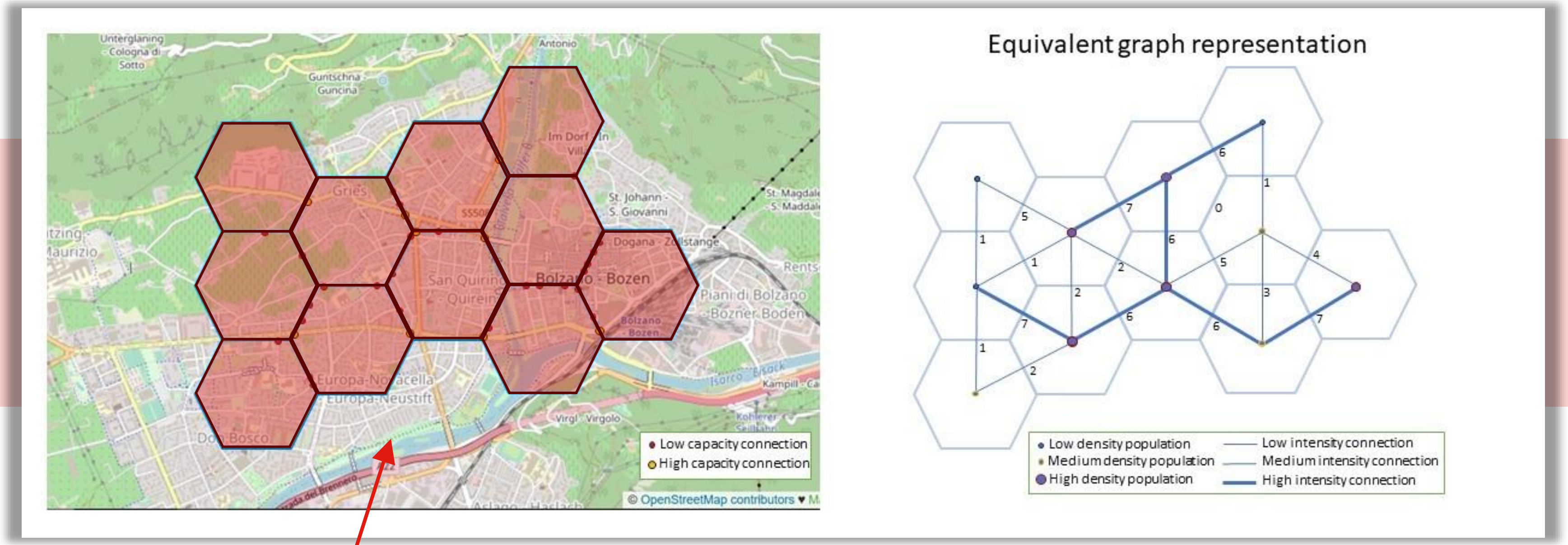

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HOMOGENEOUS PLANAR TESSELLATION

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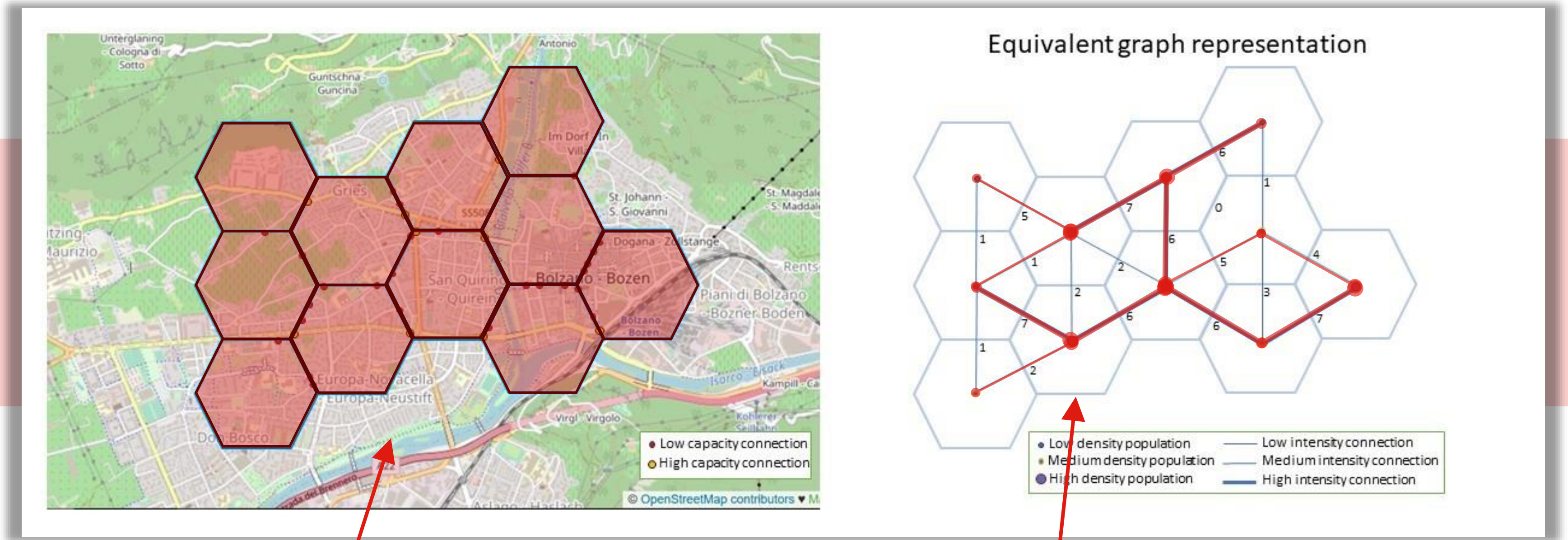

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DUAL-GRAPH REPRESENTATION

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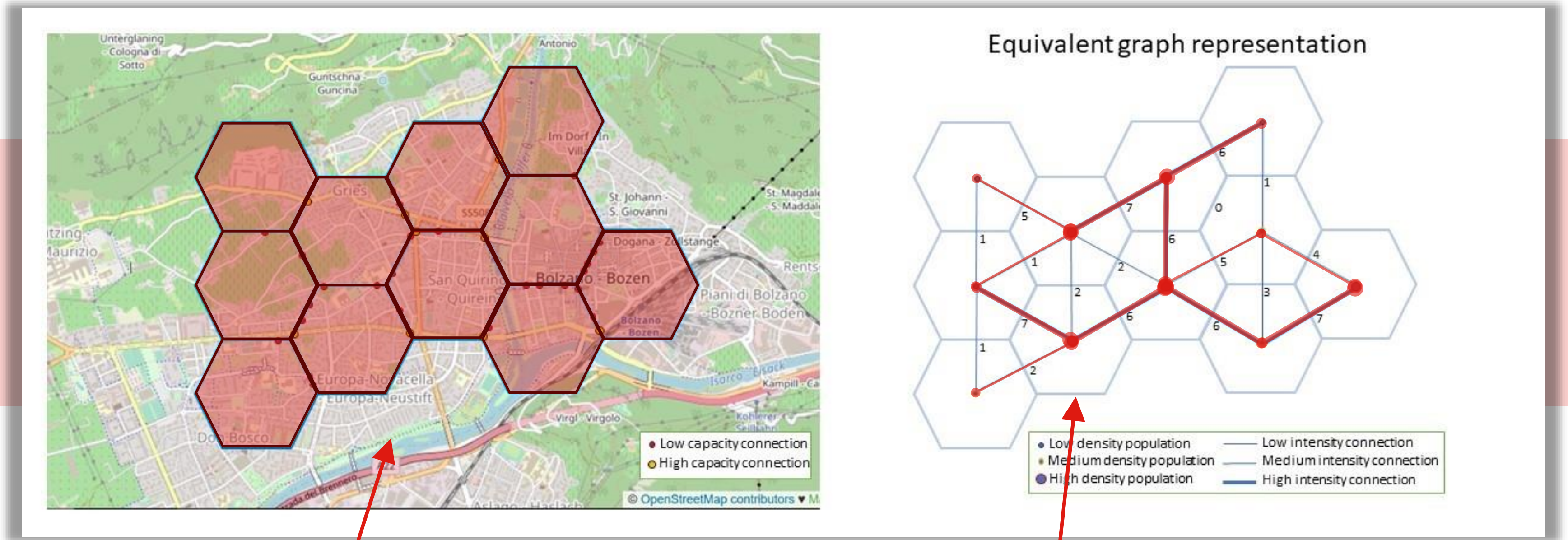

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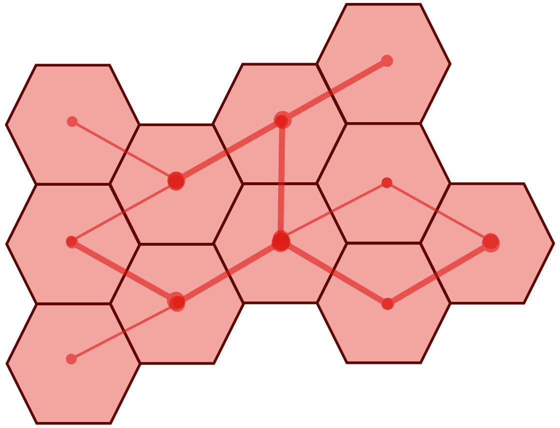
HOMOGENEOUS PLANAR TESSELLATION

DUAL-GRAPH REPRESENTATION

MULTIPLE RESOLUTION AGGREGATIONS ?

What is good:



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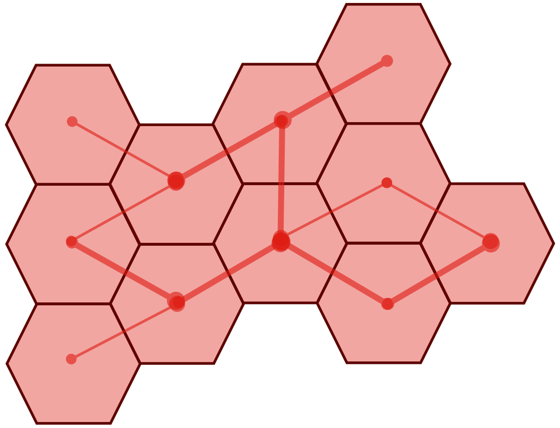

✓ **Simplified** view on map for e.g. pre-operational identification of hotspot areas

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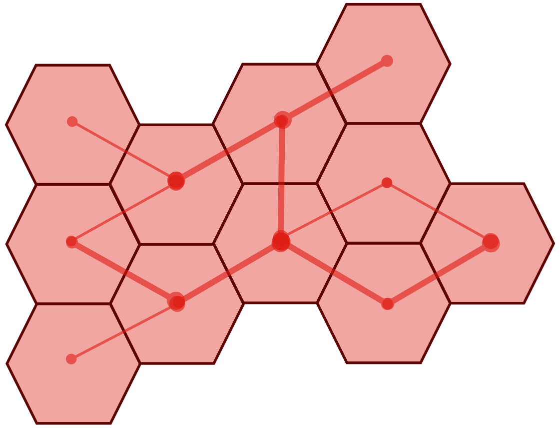

- ✓ **Simplified** view on map for e.g. pre-operational identification of hotspot areas
- ✓ Tessellation can naturally provide an **anonymization** shield for sensible data → opens to potentially more availability of data

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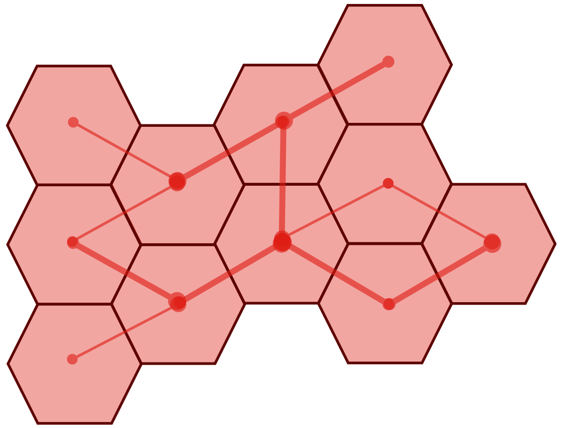

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✓ Hexagons reduce **sampling bias**, and improve spatial representativeness and topological expressivity

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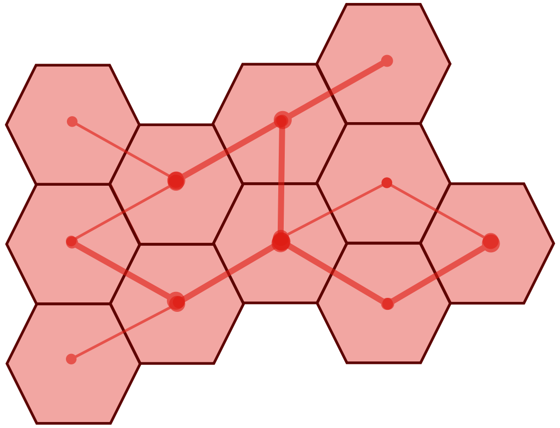

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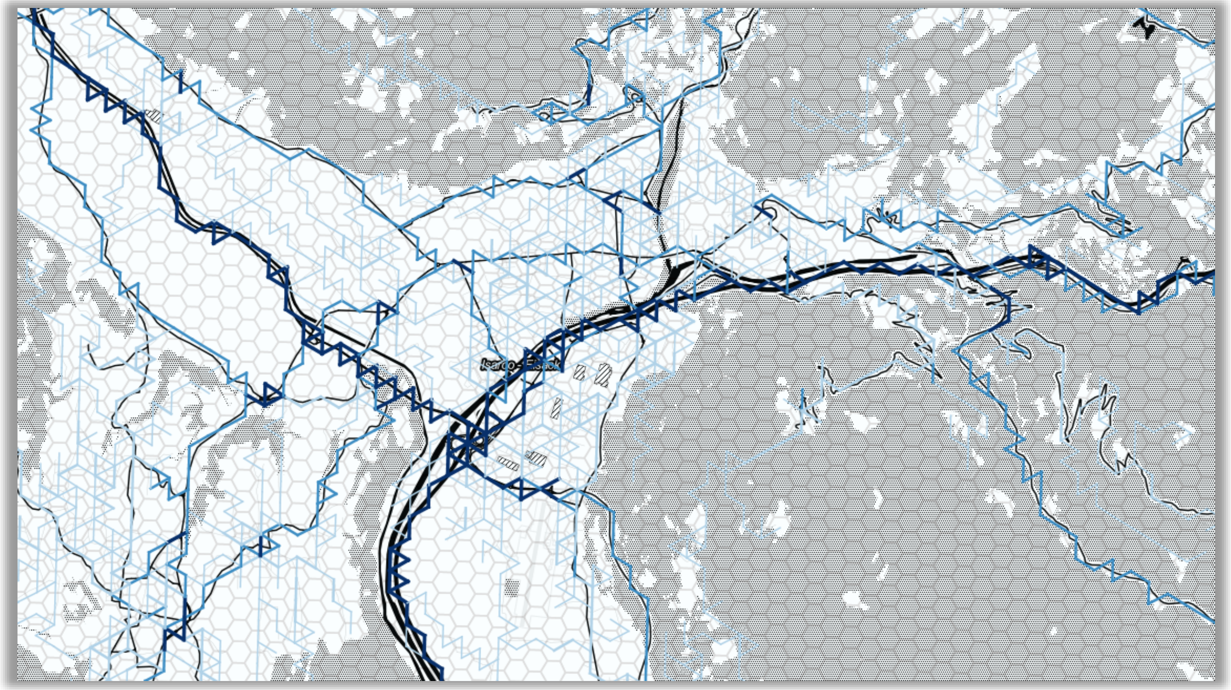
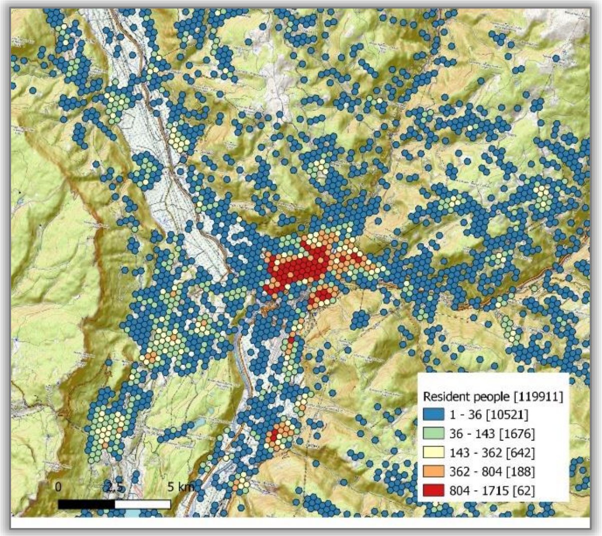
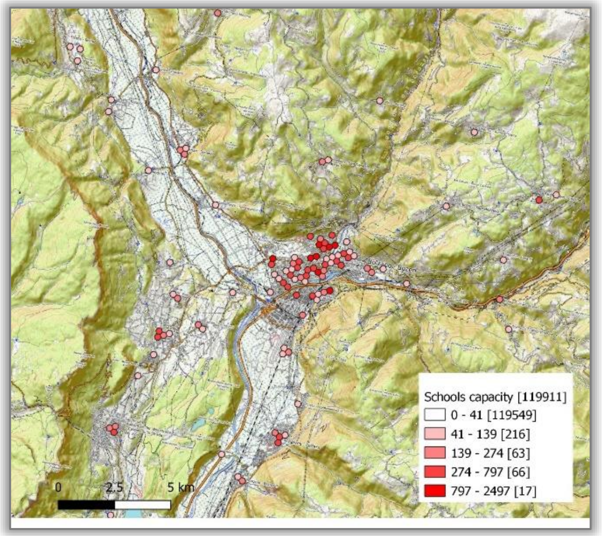
- ✓ Tessellation can naturally provide an **anonymization** shield for sensible data → opens to potentially more availability of data
- ✓ Hexagons reduce **sampling bias**, and improve spatial representativeness and topological expressivity
- ✓ **Duality** cells/graph to represent both area- and flow/connection-oriented data

Border-independent data collection and assimilation

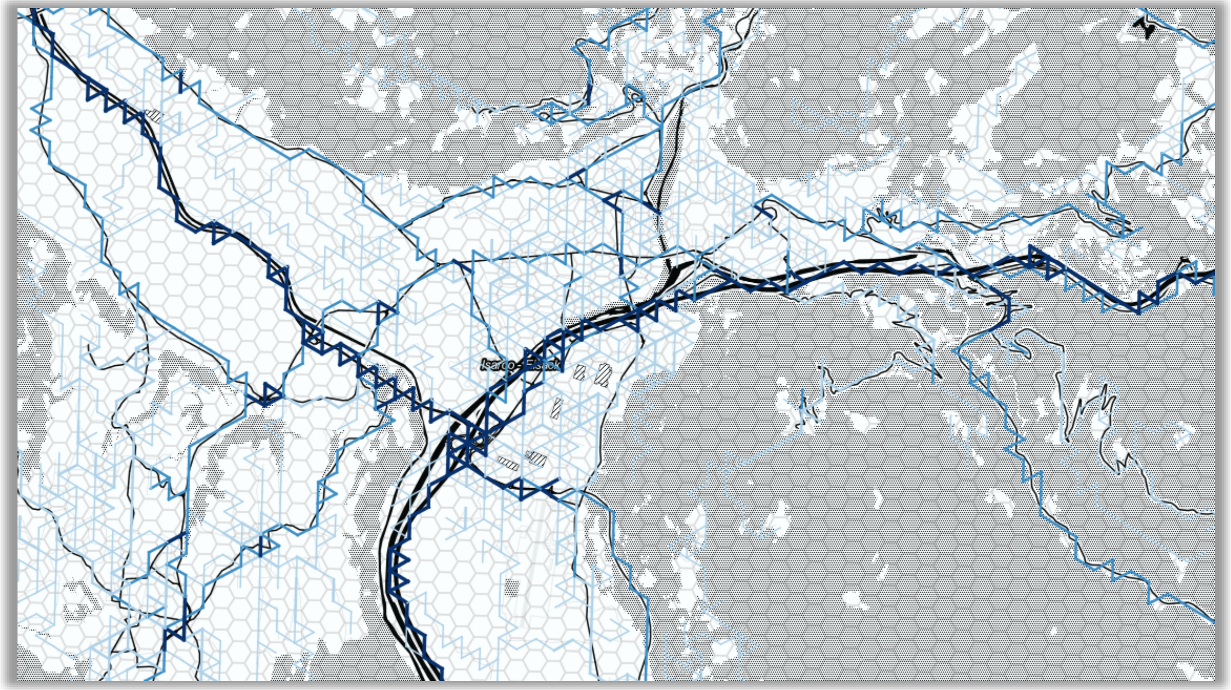


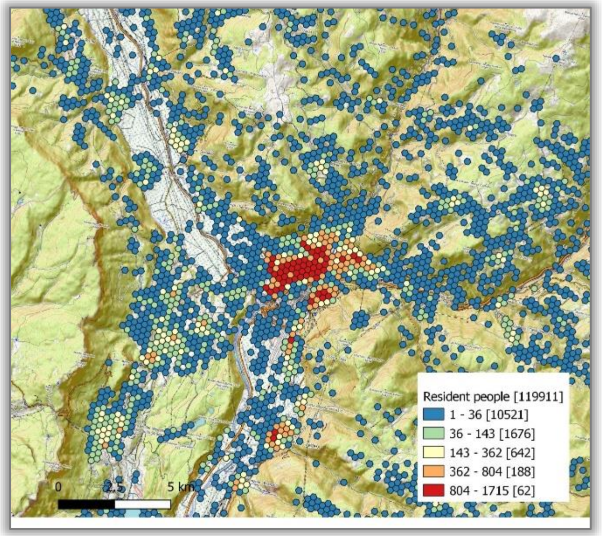


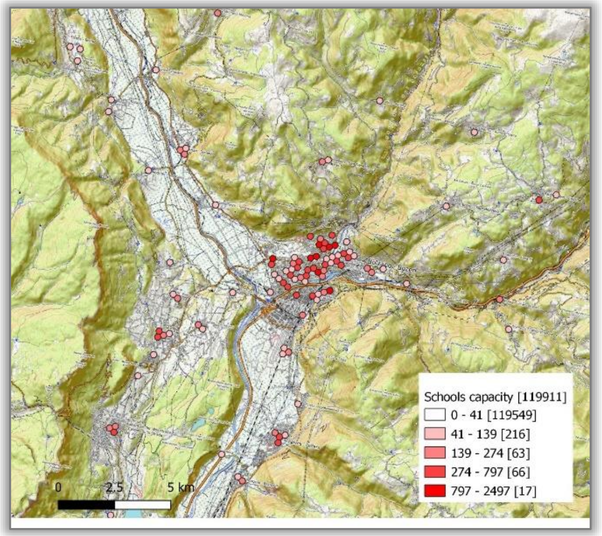


Border-independent data collection and assimilation

➢ **Define** a set of exposure assets to be included in the model







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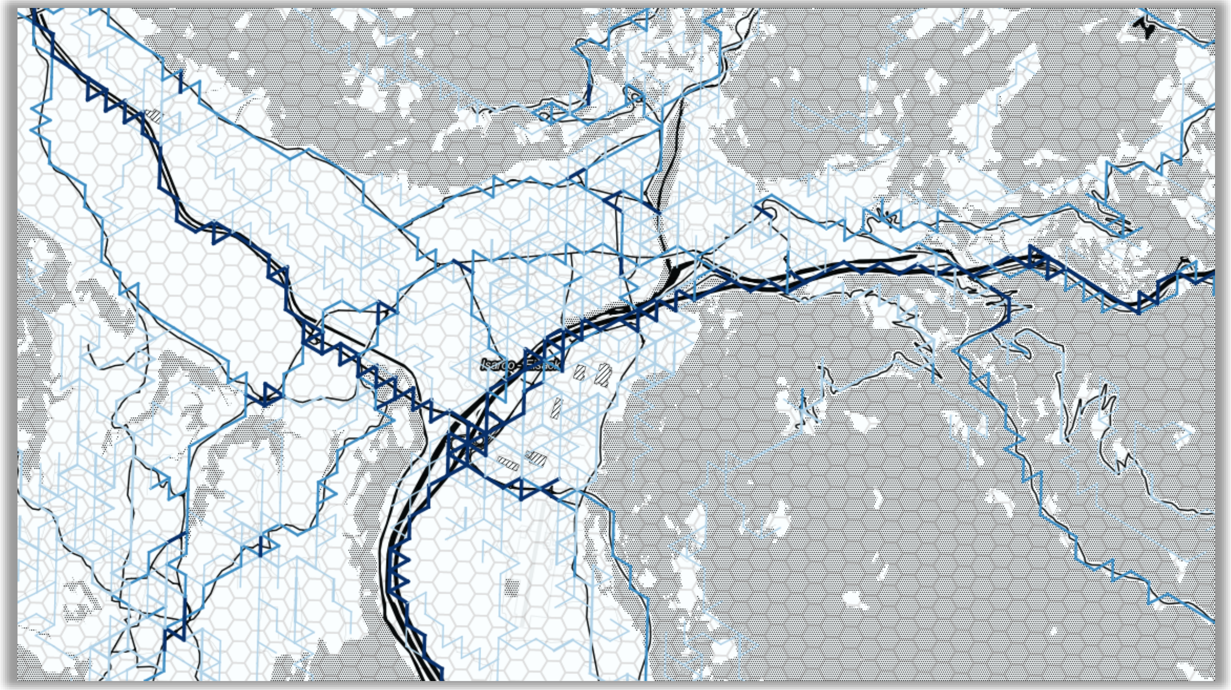

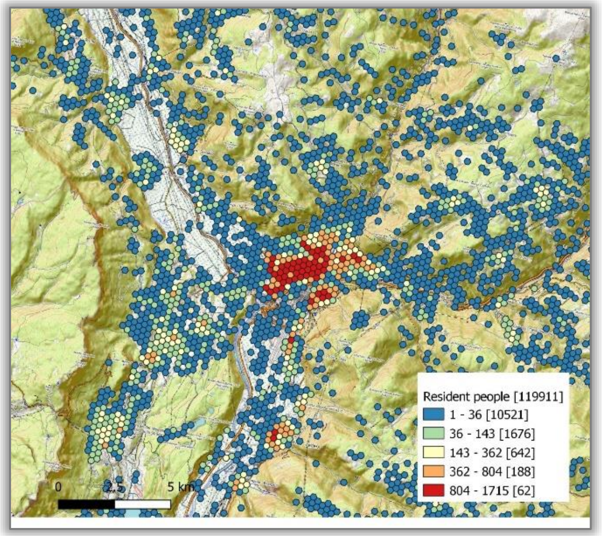

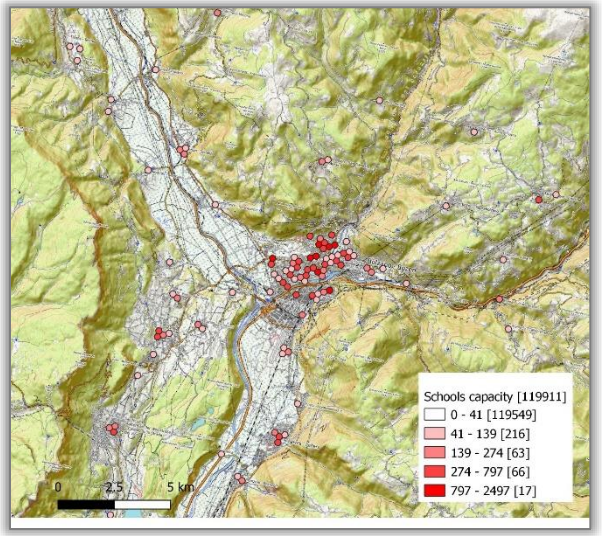

Border-independent data collection and assimilation

- **Define** a set of exposure assets to be included in the model
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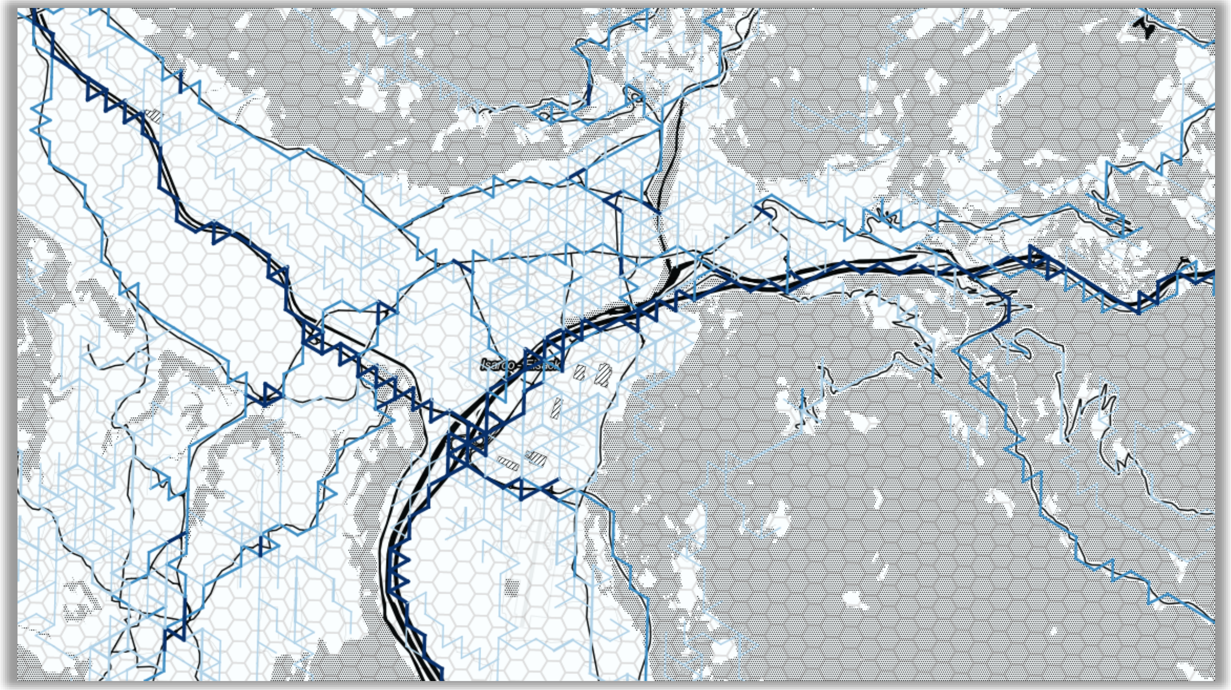
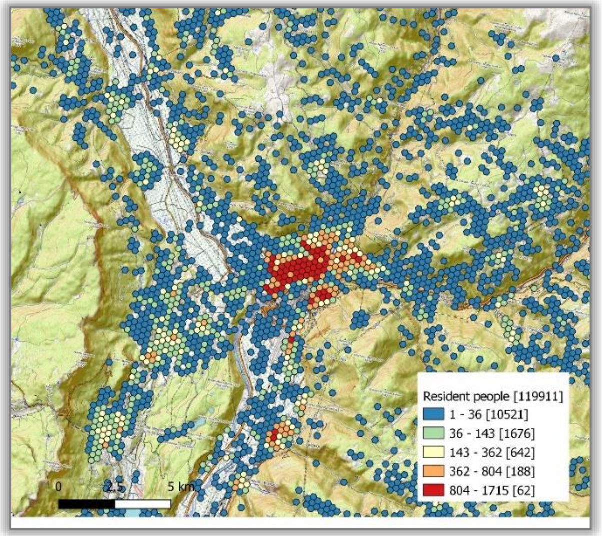
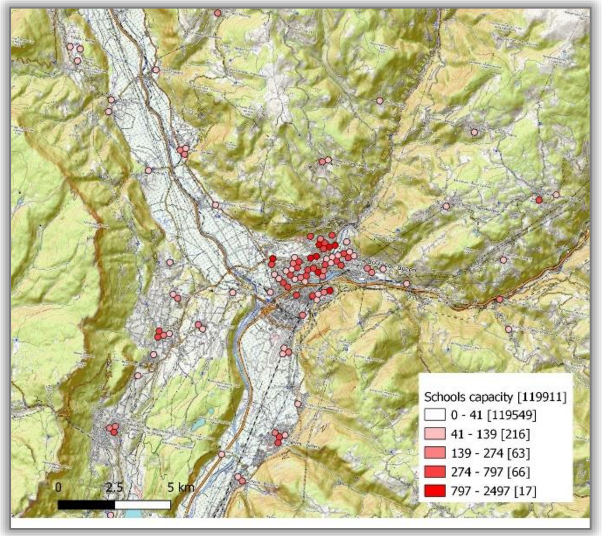
- **Assimilate**/simplify all datasets to the topology

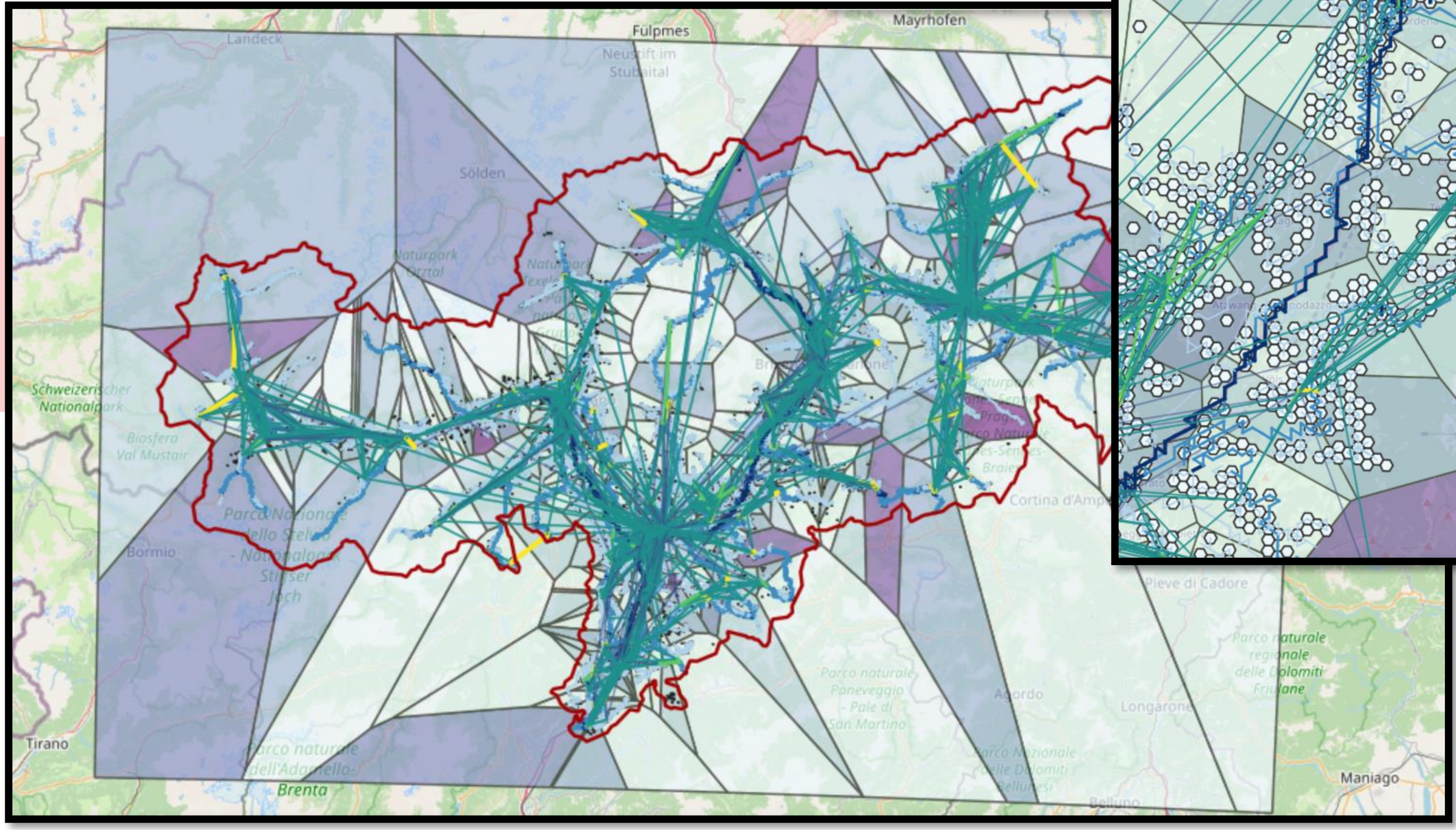


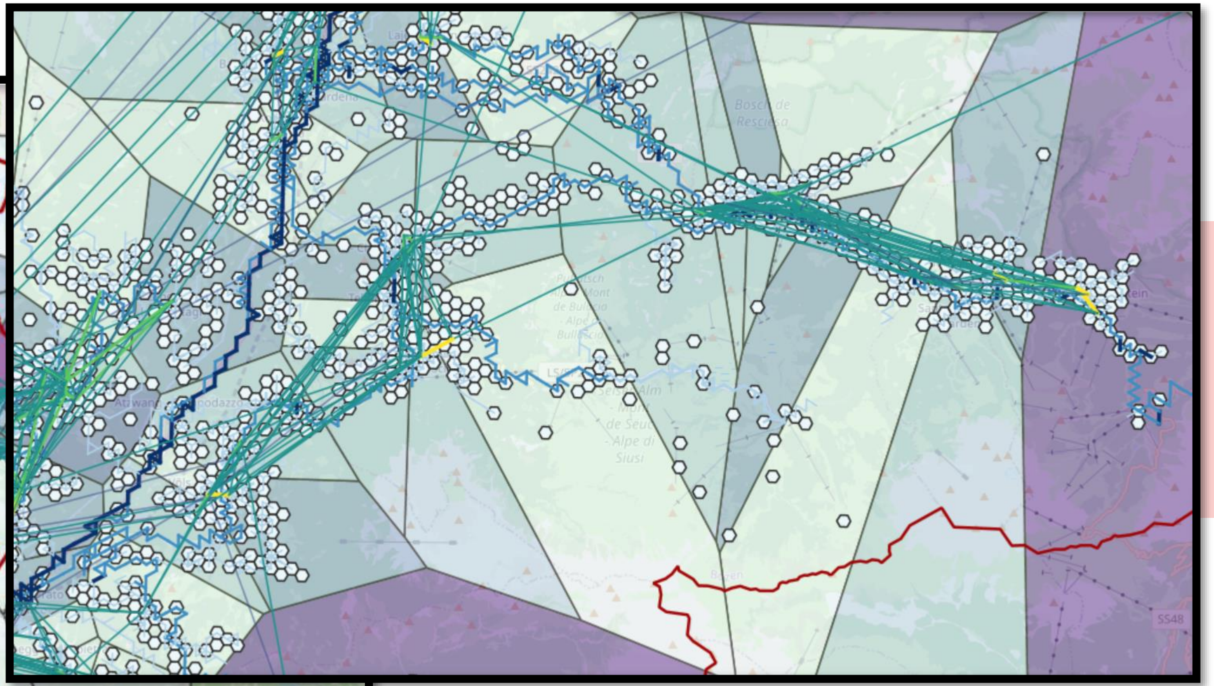




B Where is everybody?

Modelling the population flow:





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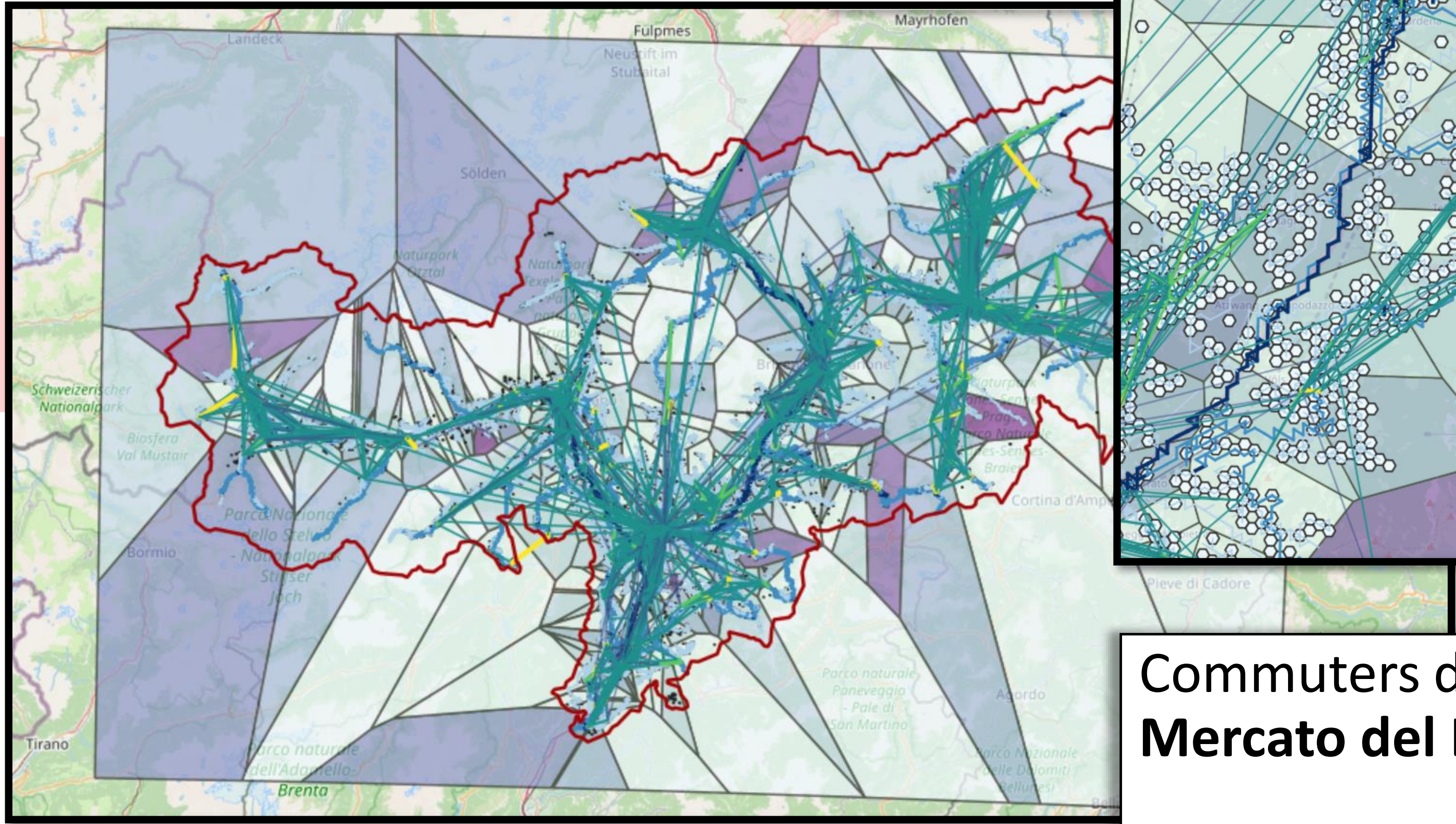
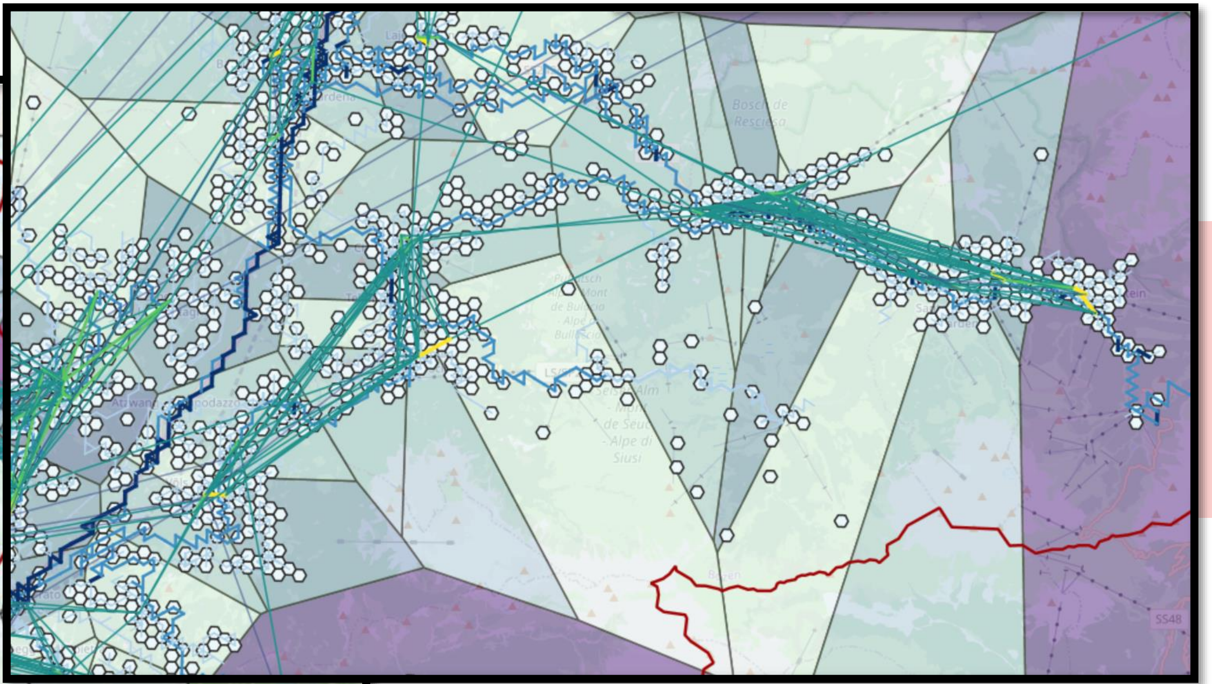
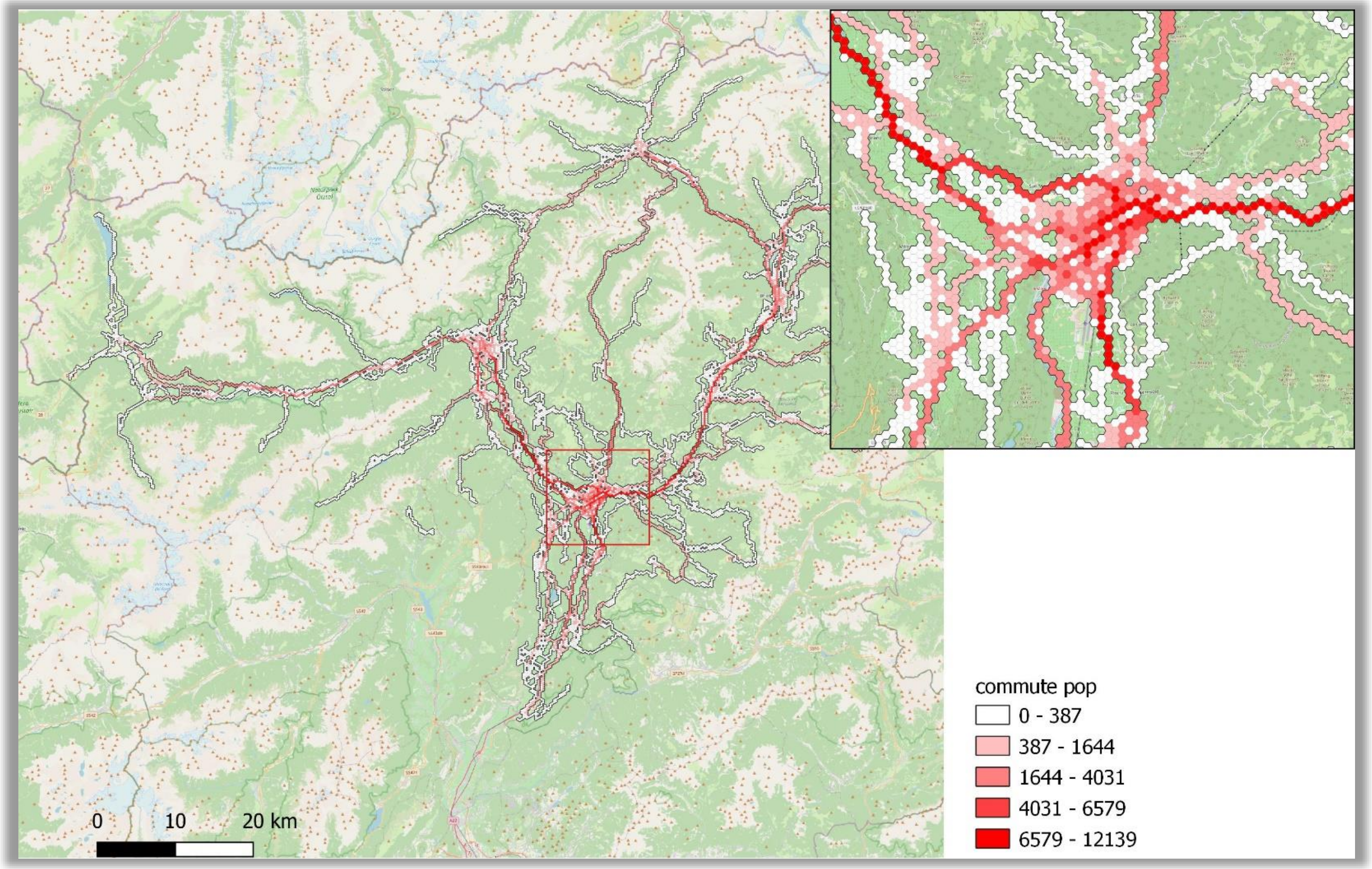




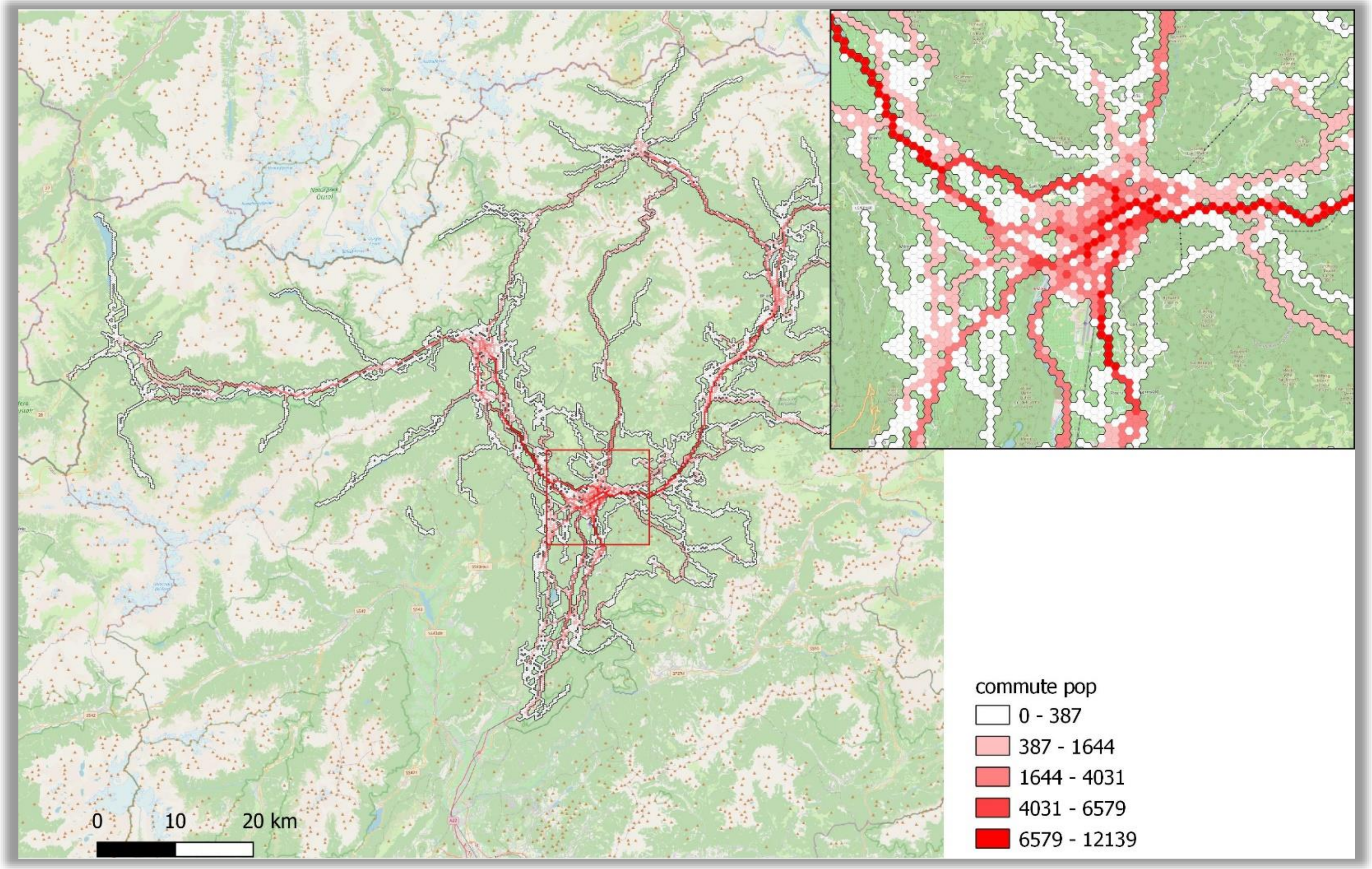
Commuters data from **Ufficio Osservazione Mercato del Lavoro** (South Tyrol, IT)

Need a flexible, border-independent solution



Need a flexible, border-independent solution

- **Dynamic best-effort**
  From basic to refined behaviour depending on data availability



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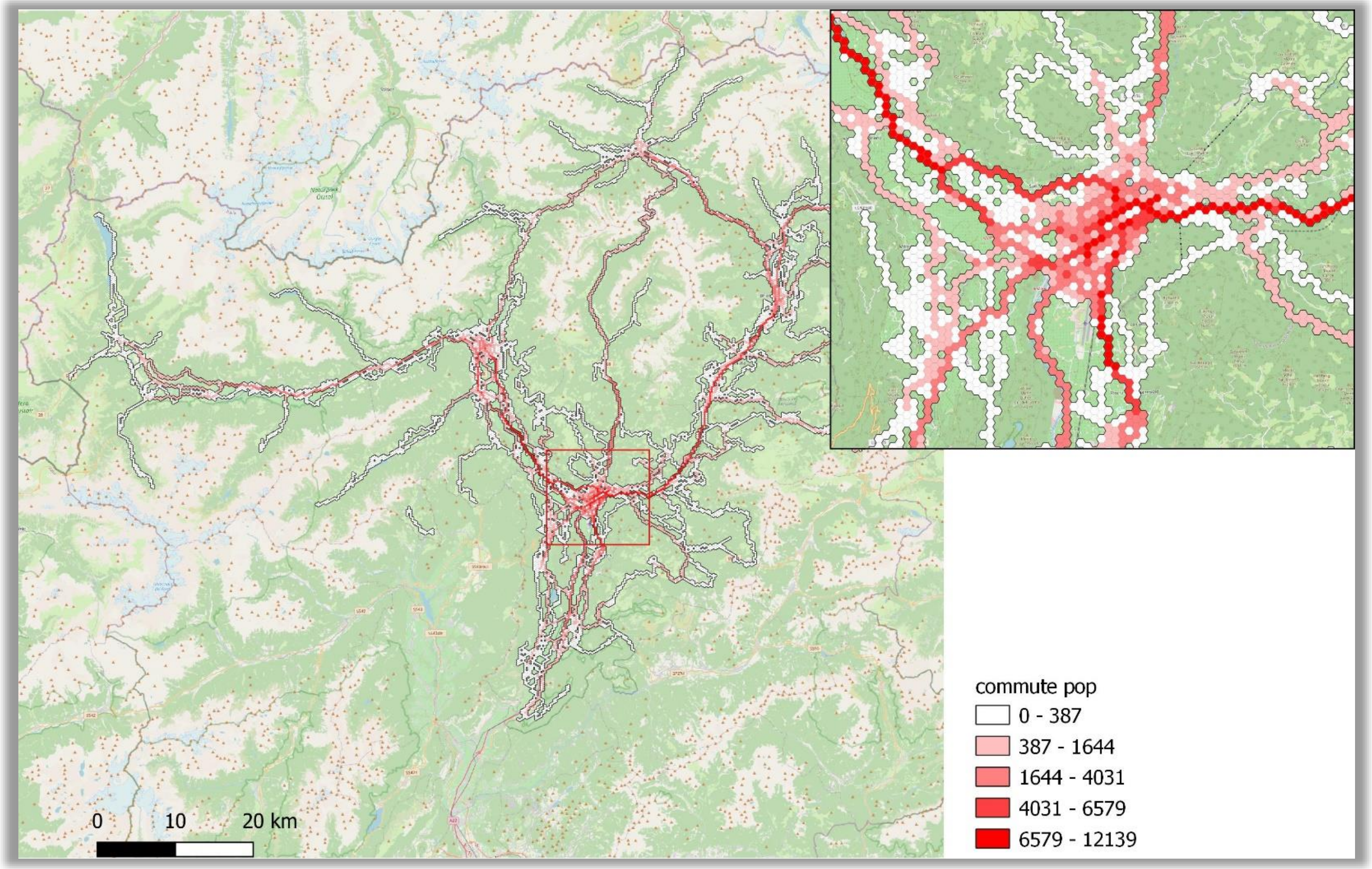

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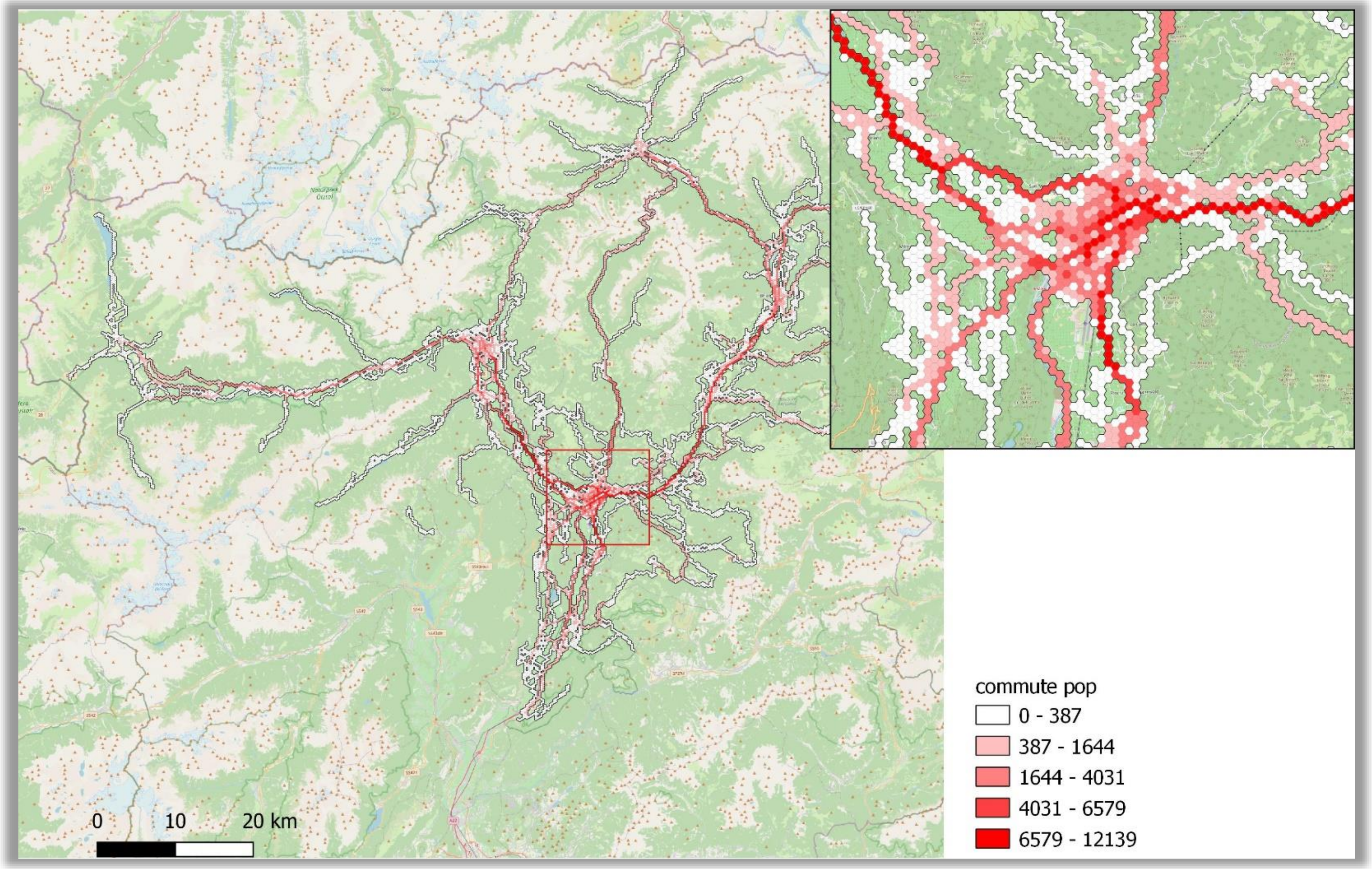
  Allow visual analysis at multiple scales (medium to small)



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- **Flexible training**
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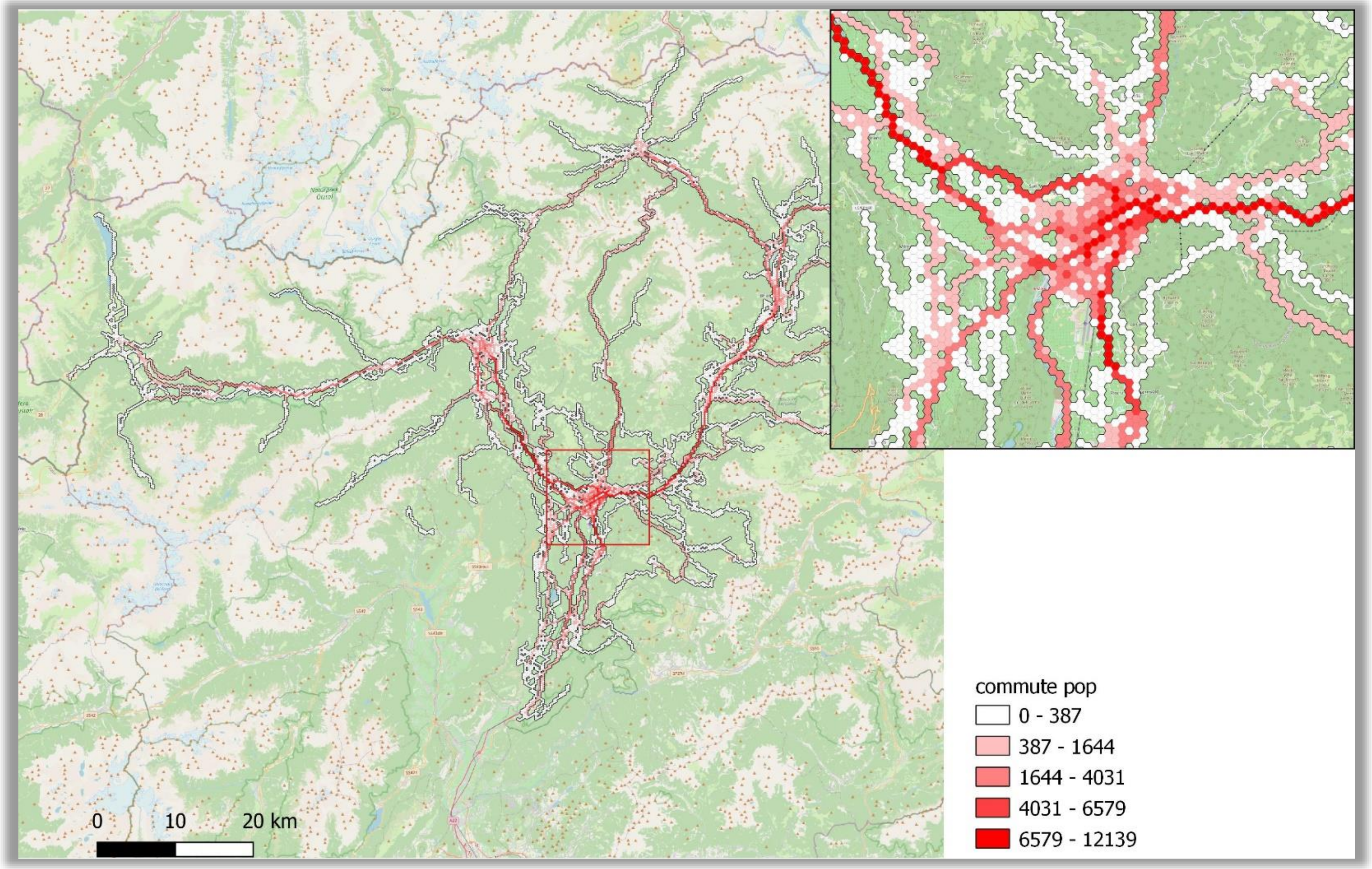
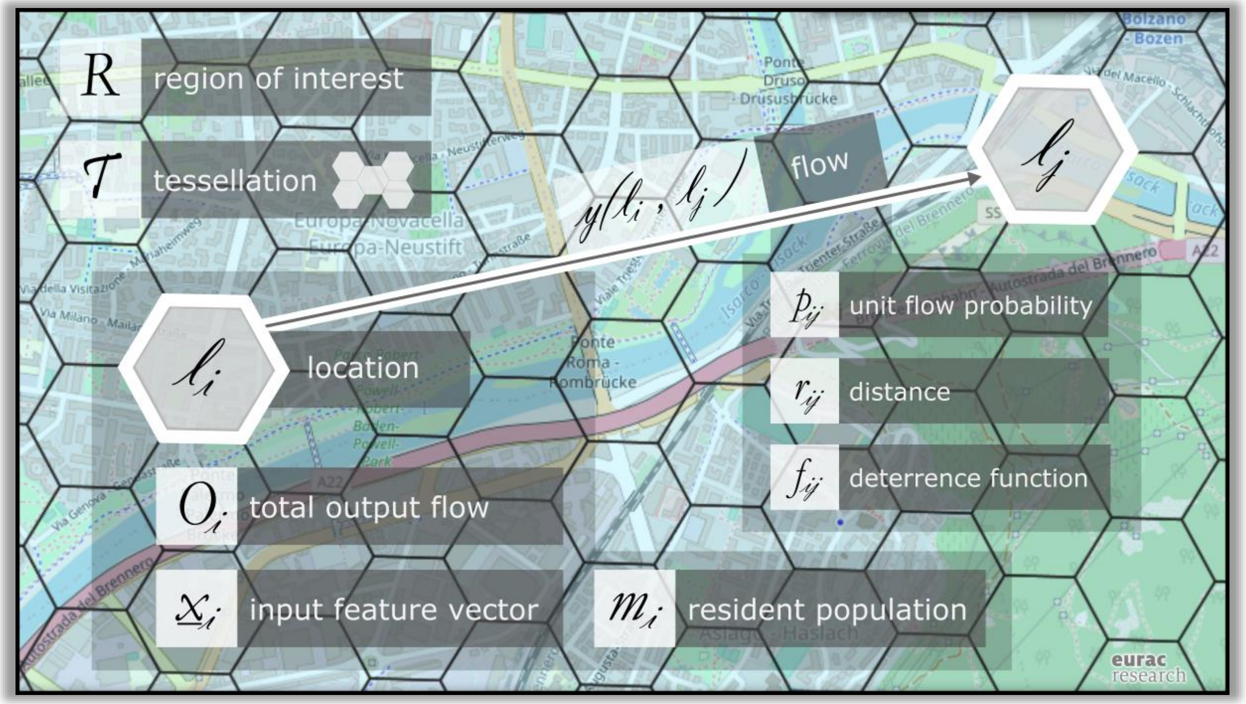
- **Multi-scale**
  Allow visual analysis at multiple scales (medium to small)
- **Re-compute easily**
  Pseudo real-time what-if scenarios visualizations



A gravity model ?

Asset / timeframe			Week days			Weekend and holidays		
			Morning	Afternoon	Night	Morning	Afternoon	Night
w_u	Land Use	w_u^1 : urban	$1/\oiint l$	$1/\oiint l$	$1/\oiint l$	$1/\oiint l$	$1/\oiint l$	$1/\oiint l$
		w_u^2 : industrial	$1/\oiint l$	$1/\oiint l$	$1/\oiint l$	0	0	0
		w_u^3: vegetated	$1/\oiint l$	$1/\oiint l$	0	$1/\oiint l$	$1/\oiint l$	0
		w_u^4 : crop/forest	0	0	0	$1/\oiint l$	$1/\oiint l$	0
		w_u^5 : water	0	0	0	$1/\oiint l$	$1/\oiint l$	0
w_n	Roads	w_n^1 : main	$1/\oint l$	$1/\oint l$	0	$1/\oint l$	$1/\oint l$	$1/\oint l$
		w_n^2 : residential	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$
		w_n^3 : pedestrian	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$
w_t	Transport	w_t^1 : stations	1	1	1	1	1	1
		w_t^2 : stops	1	1	0	1	1	0
		w_t^3 : parkings	1	1	1	1	1	1
w_h	Health	w_h^1 : hospitals	5	5	1	5	5	1
		w_h^2 : clinics	1	1	0	1	1	0
		w_h^3 : pharmacies	1	1	0	1	1	0
		w_h^4 : retirement	1	1	0	1	1	0
w_s	Education	w_s^1 : kita/schools	1	1	0	0	0	0
		w_s^2 : higher edu.	1	1	0	0	0	0
w_b	Food	w_b^1 : bars/cafes	1	1	0	1	1	0
		w_b^2 : restaurants	0	1	1	0	1	1
w_c	Retail	w_c^1 : malls	5	5	0	5	5	0
		w_c^2 : shops	1	1	0	1	1	0
w_a	Tourism	w_a^1 : hotels	1	1	1	1	1	1
		w_a^2 : attractions	1	1	1	1	1	1



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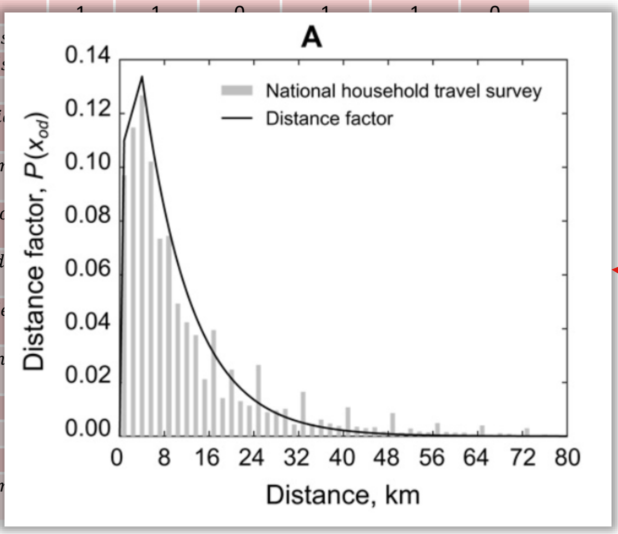
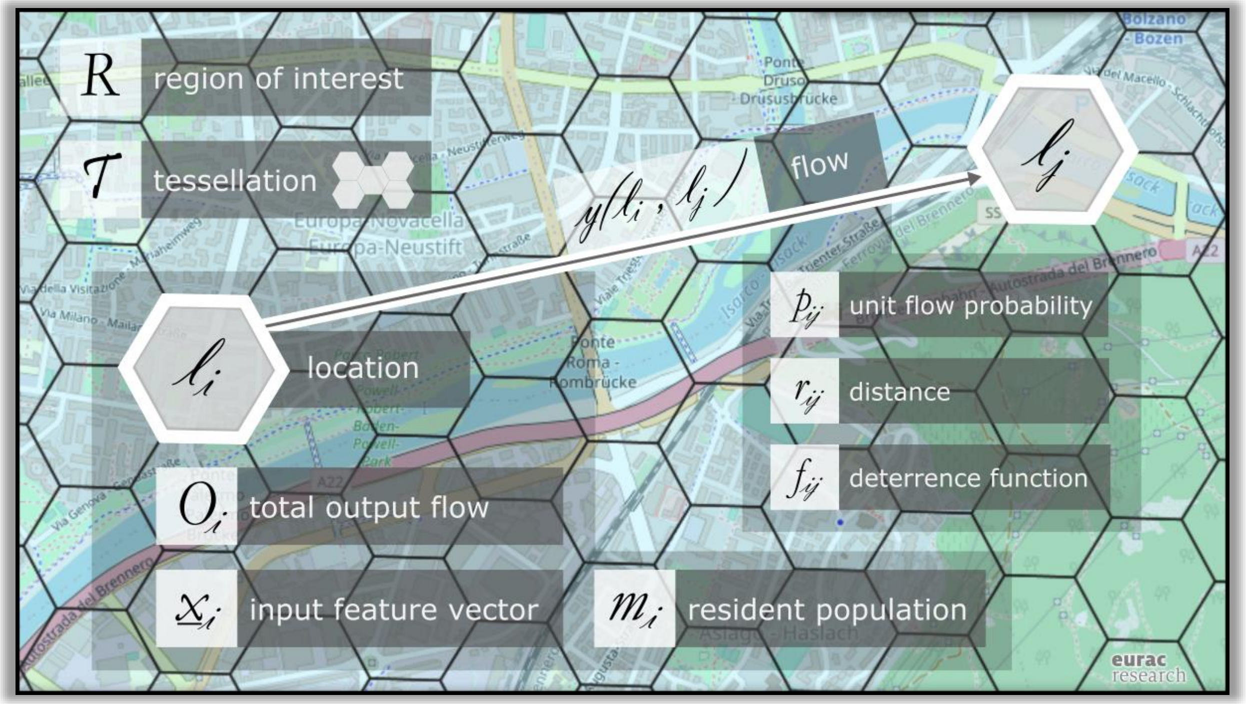
		w_u^2 : *industrial*	$1/\oiint l$	$1/\oiint l$	$1/\oiint l$	0	0	0
		w_u^3: *vegetated*	$1/\oiint l$	$1/\oiint l$	0	$1/\oiint l$	$1/\oiint l$	0
		w_u^4 : *crop/forest*	0	0	0	$1/\oiint l$	$1/\oiint l$	0
		w_u^5 : *water*	0	0	0	$1/\oiint l$	$1/\oiint l$	0
w_n	Roads	w_n^1 : *main*	$1/\oint l$	$1/\oint l$	0	$1/\oint l$	$1/\oint l$	$1/\oint l$
		w_n^2 : *residential*	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$
		w_n^3 : *pedestrian*	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$
w_t	Transport	w_t^1 : *stations*	1	1	1	1	1	1
		w_t^2 : *stops*	1	1	0	1	1	0
		w_t^3 : *parkings*						
w_h	Health	w_h^1 : *hospitals*						
		w_h^2 : *clinics*						
		w_h^3 : *pharmaci*						
		w_h^4 : *retiremen*						
w_s	Education	w_s^1 : *kita/schoo*						
		w_s^2 : *higher ed*						
w_b	Food	w_b^1 : *bars/cafe*						
		w_b^2 : *restauran*						
w_c	Retail	w_c^1 : *malls*						
		w_c^2 : *shops*						
w_a	Tourism	w_a^1 : *hotels*						
		w_a^2 : *attraction*						



Ganin et al. (2017)
doi:10.1126/sciadv.1701079



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$$A_i = \underline{w_i} \cdot \underline{x_i} = \sum_{k=1}^{N} w_i^k x_i^k = \sum_{k=1}^{N_u} w_{u,i}^k u_i^k + \sum_{k=1}^{N_n} w_{n,i}^k n_i^k + \sum_{k=1}^{N_t} w_{t,i}^k t_i^k + \sum_{k=1}^{N_h} w_{h,i}^k h_i^k + \sum_{k=1}^{N_s} w_{s,i}^k s_i^k + \sum_{k=1}^{N_b} w_{b,i}^k b_i^k + \sum_{k=1}^{N_c} w_{c,i}^k c_i^k + \sum_{k=1}^{N_a} w_{a,i}^k a_i^k$$

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		w_u^2 : industrial	$1/∯ l$	$1/∯ l$	$1/∯ l$	0	0	0
		w_u^3: vegetated	$1/∯ l$	$1/∯ l$	0	$1/∯ l$	$1/∯ l$	0
		w_u^4 : crop/forest	0	0	0	$1/∯ l$	$1/∯ l$	0
		w_u^5 : water	0	0	0	$1/∯ l$	$1/∯ l$	0
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		w_n^3 : pedestrian	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$	$1/\oint l$
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		w_h^2 : clinics						
		w_h^3 : pharmaci						
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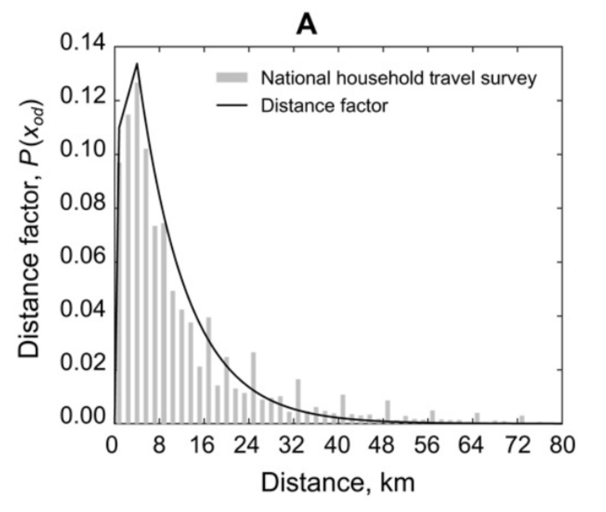

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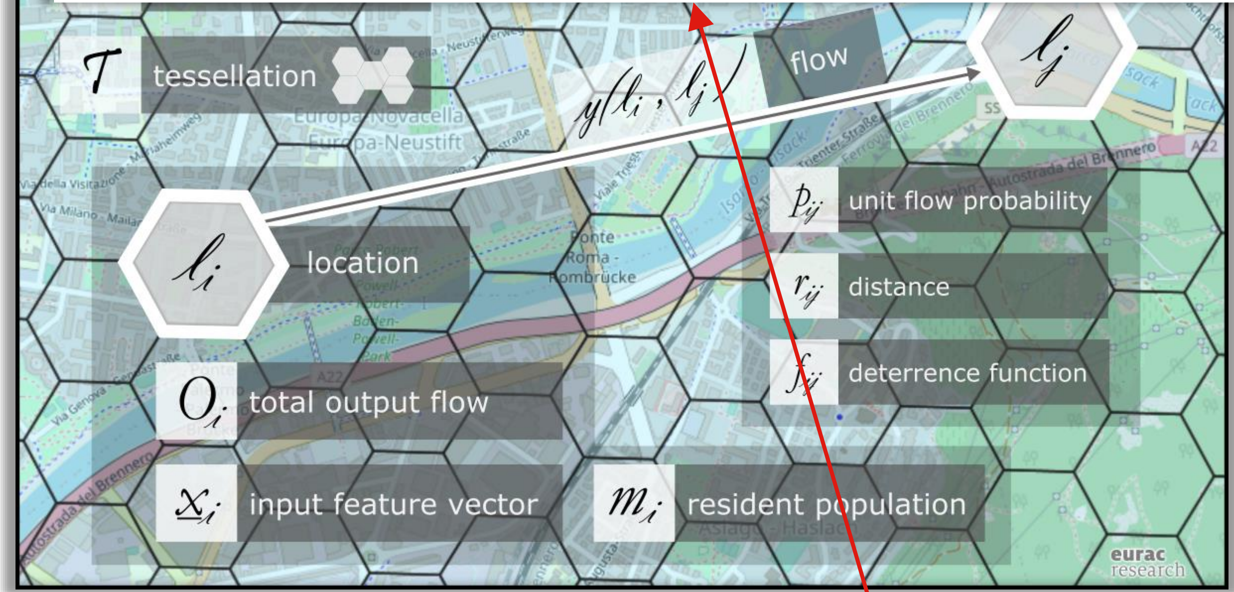

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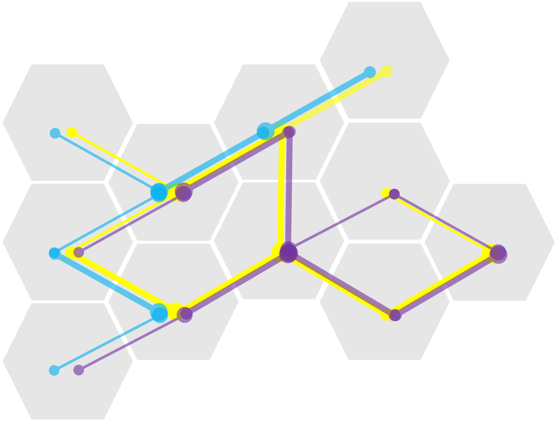
- Daily commuters
- Tourists
- Trucks
- External
- …



Ghatee, Mehdi & Hashemi, S. Mehdi. (2014)

C Output of the *TransAlp* project

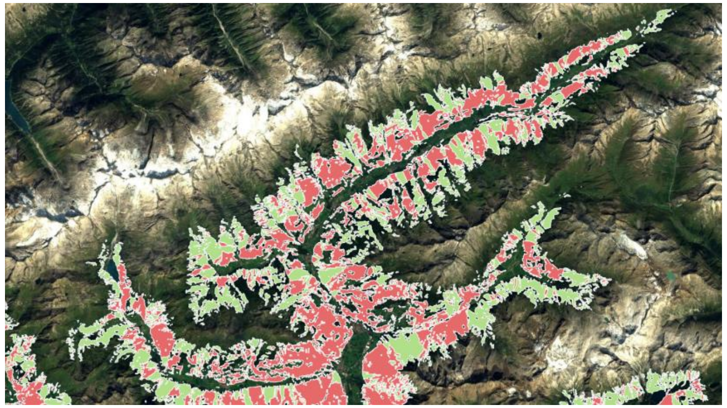
Exposure

Cross-border harmonization of assets

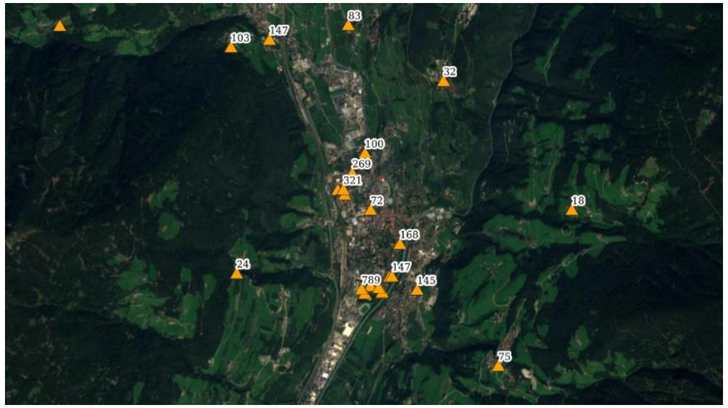
roads network

human settlements

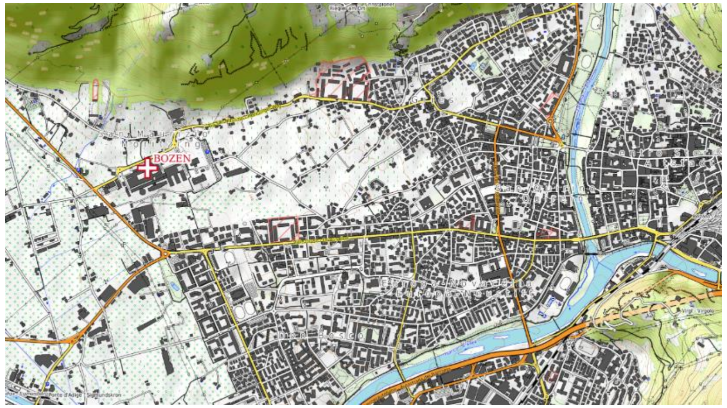
protection forest



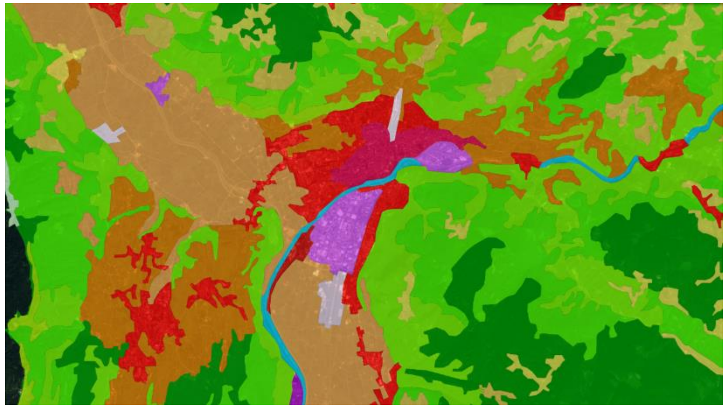
schools / kindergarten



hospitals / daycare



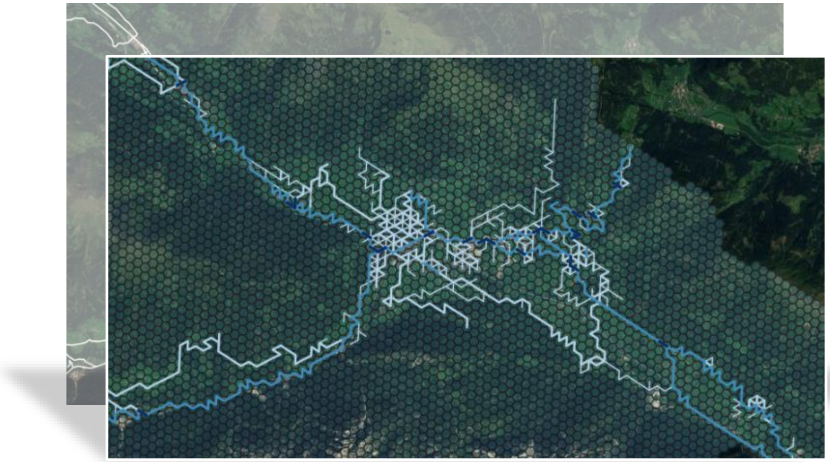
land cover



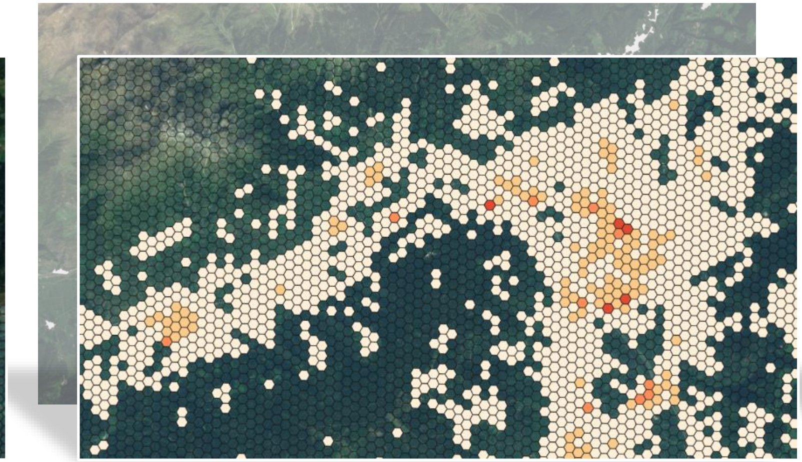
Exposure

Cross-border harmonization of assets

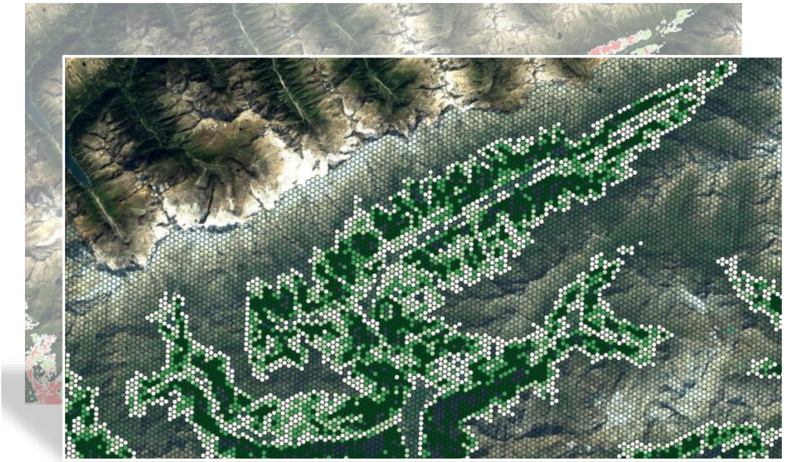
roads network



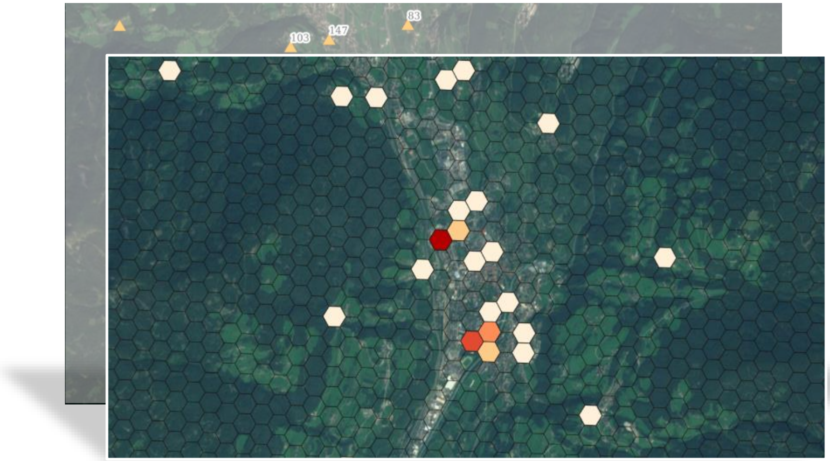
human settlements



protection forest



schools / kindergarten



hospitals / daycare

land cover

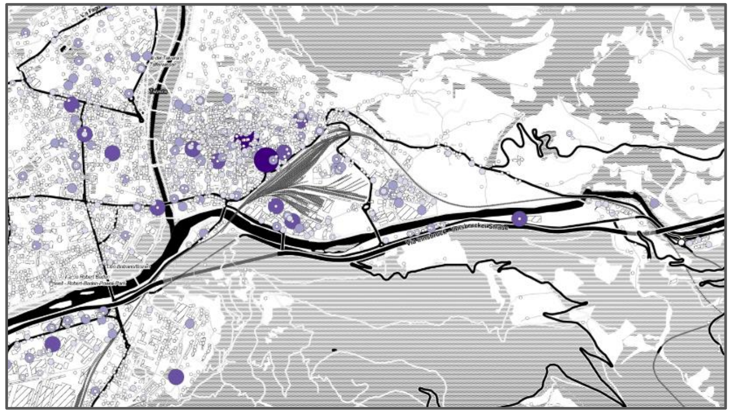
Exposure

Predicting dynamic population flow

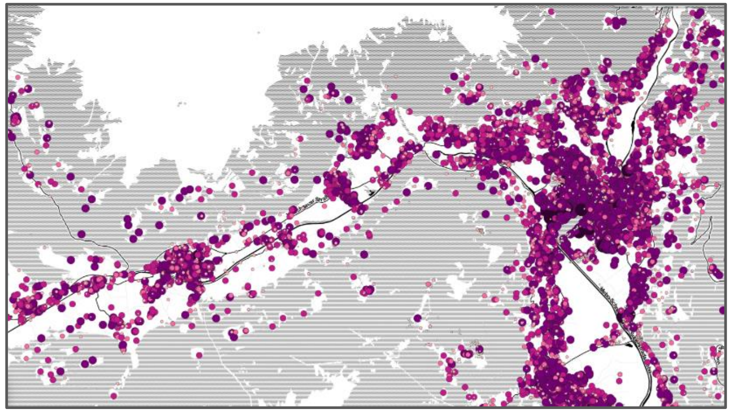
eurac research TransAlp

13 dec 2022 – Final Meeting

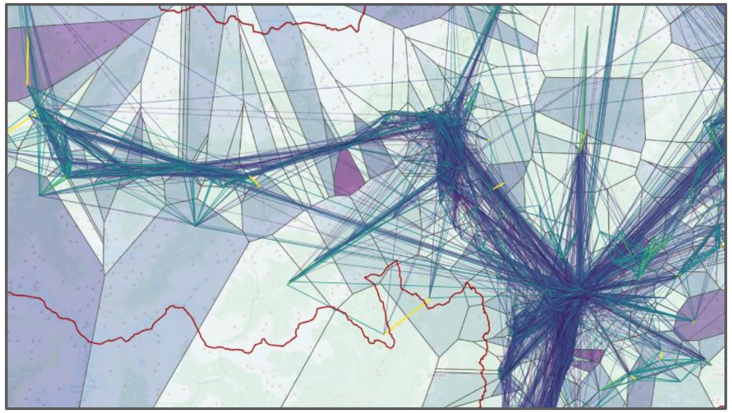
employees



residents



commuting trips

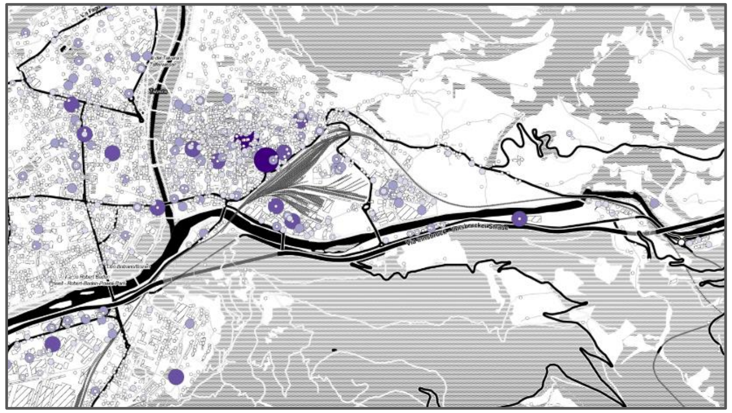


Exposure

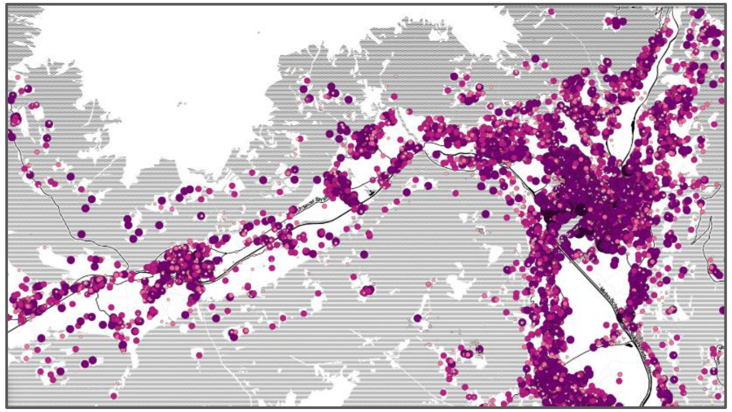
Predicting dynamic population flow

13 dec 2022 – Final Meeting

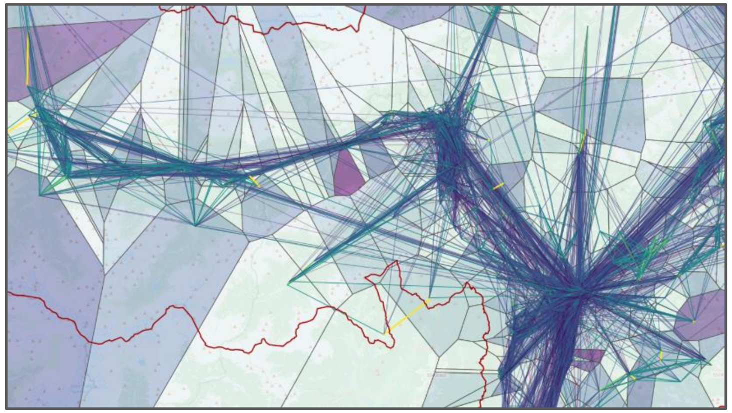
employees



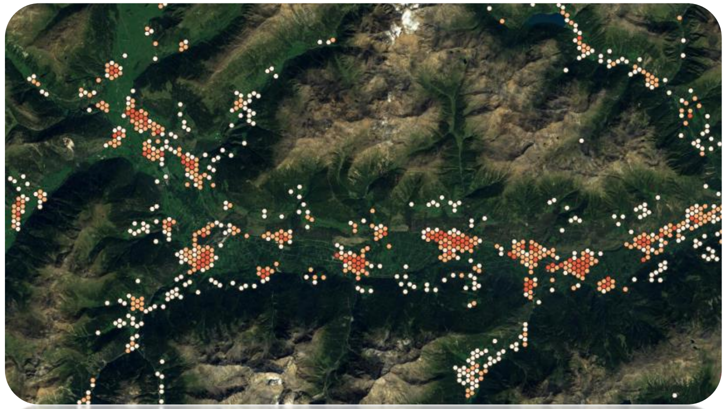
residents



commuting trips



daytime pop.



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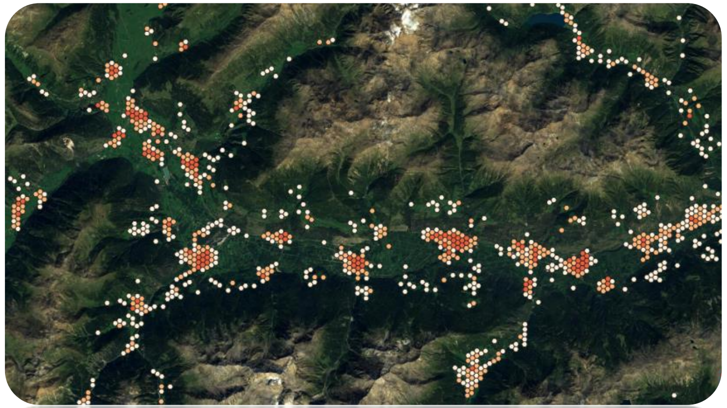
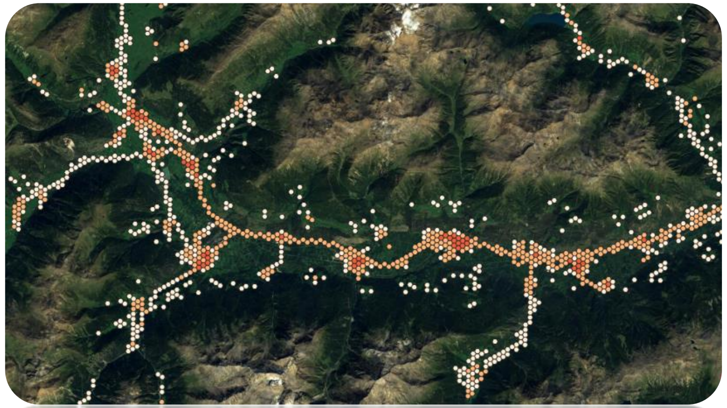
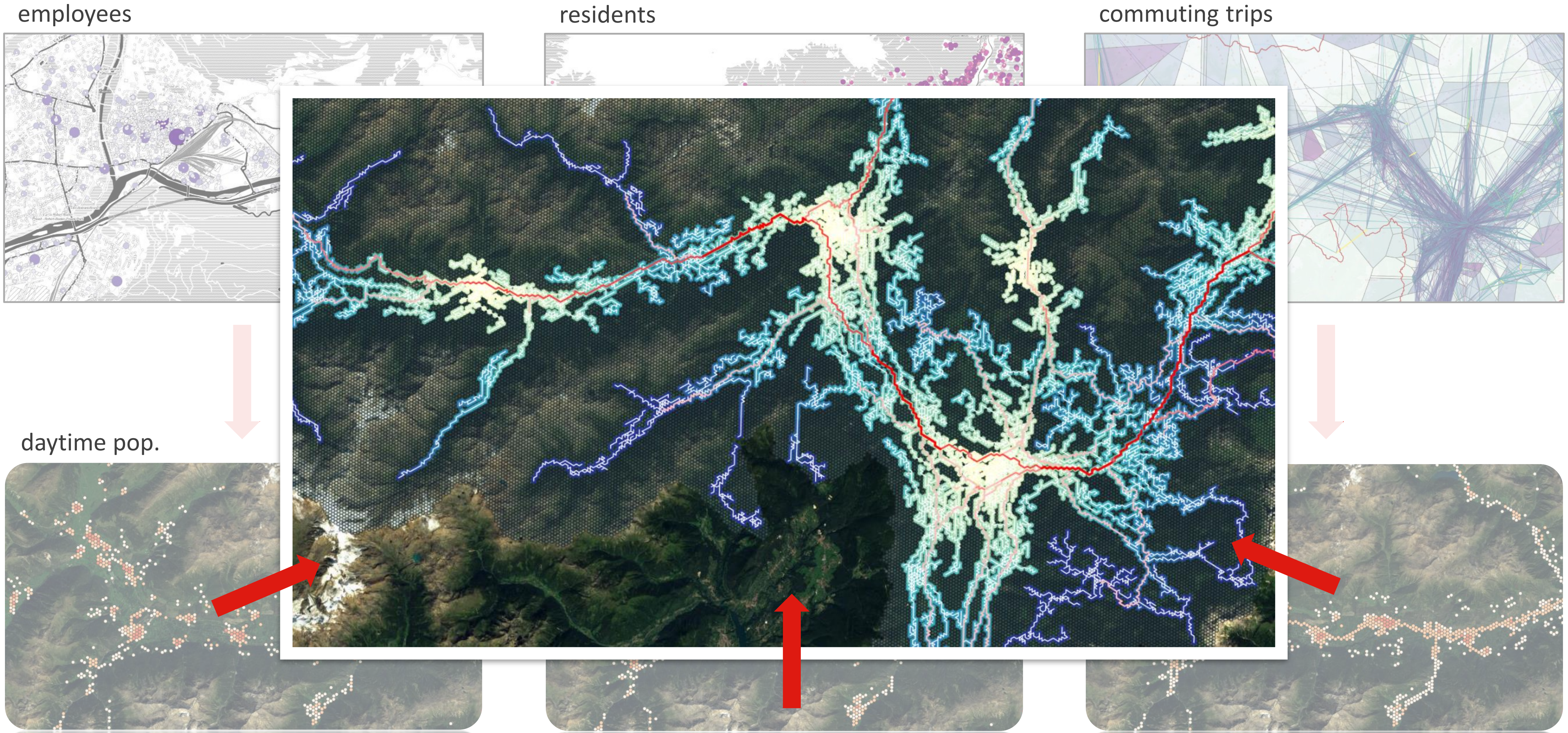


commuting pop.



Exposure

Predicting dynamic population flow



Exposure

Putting it all together: towards an impact forecasting tool

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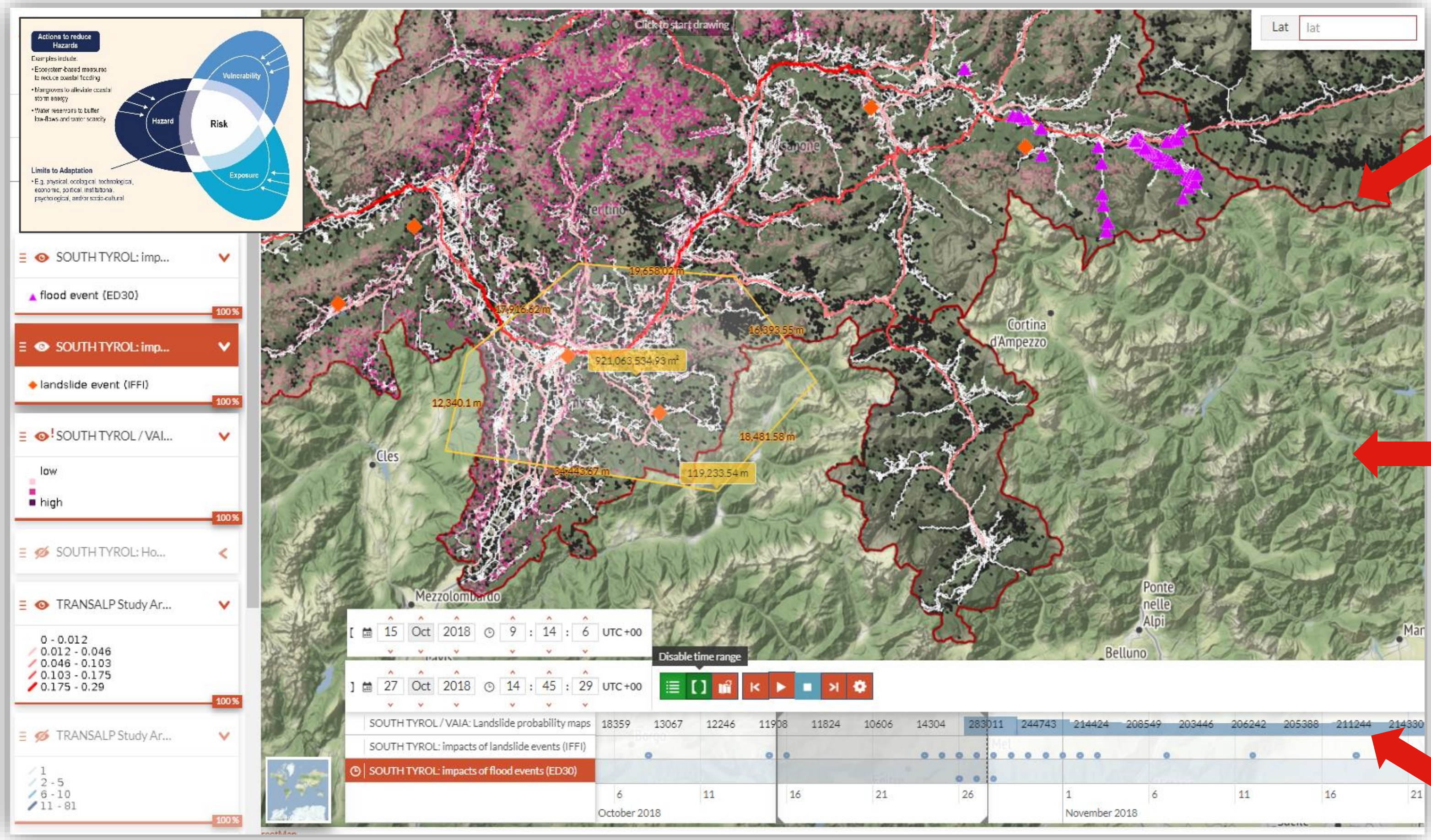
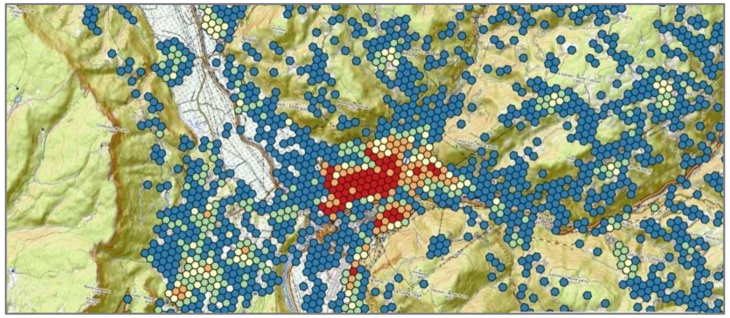
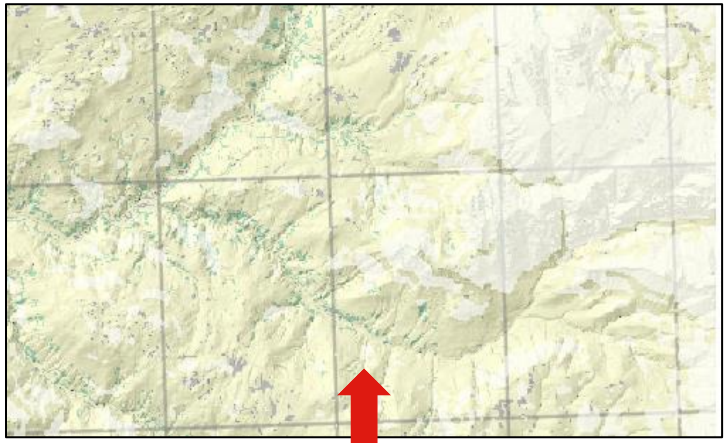
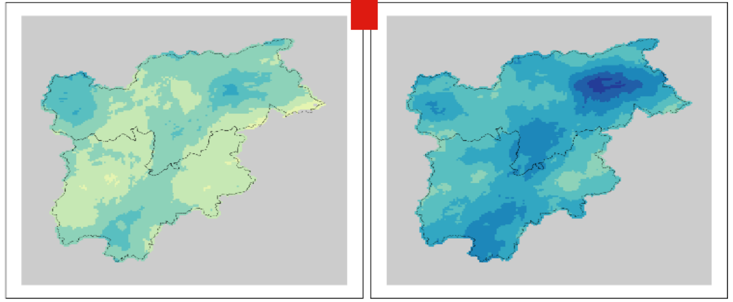


https://maps.eurac.edu/maps/1274

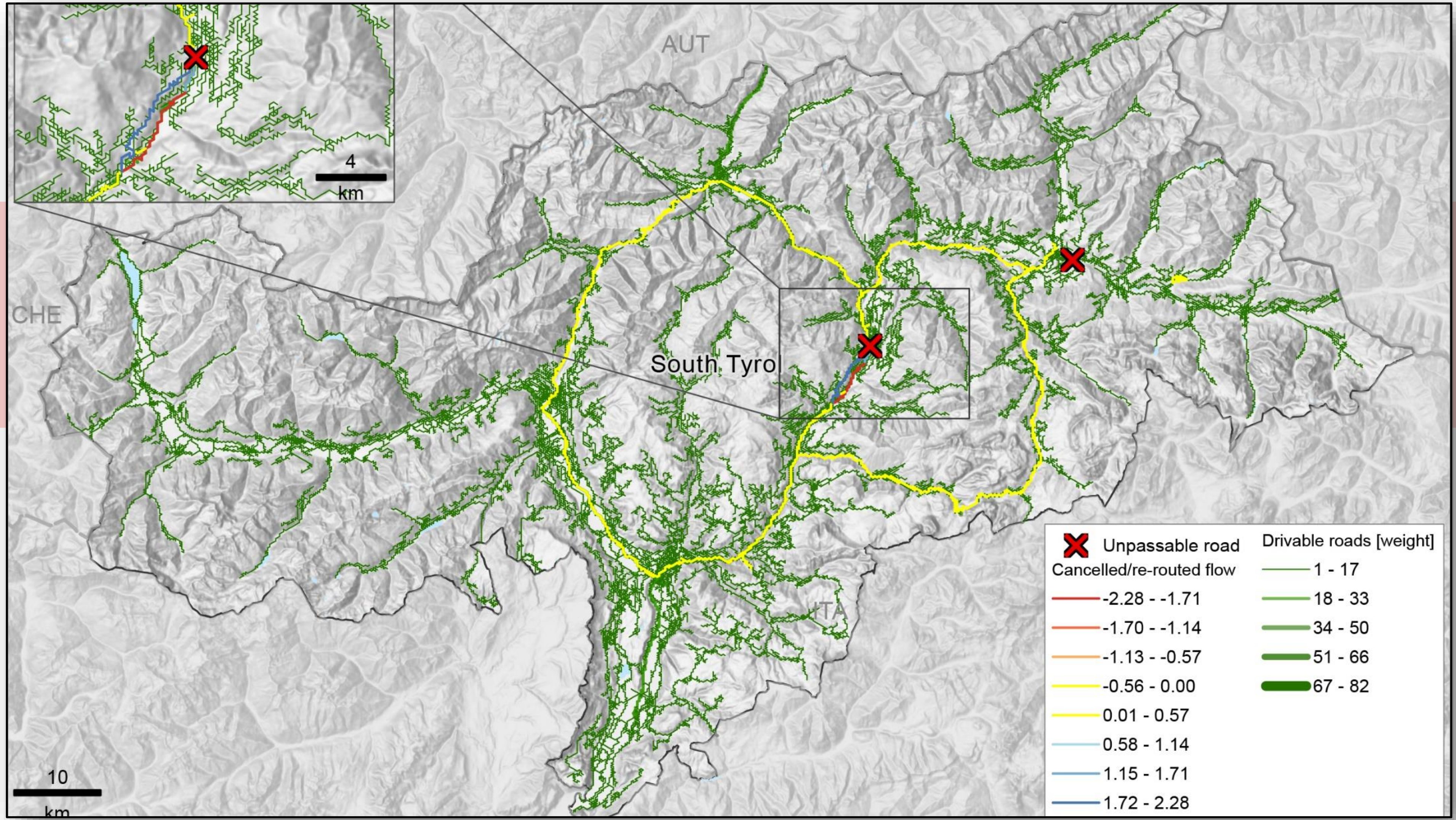




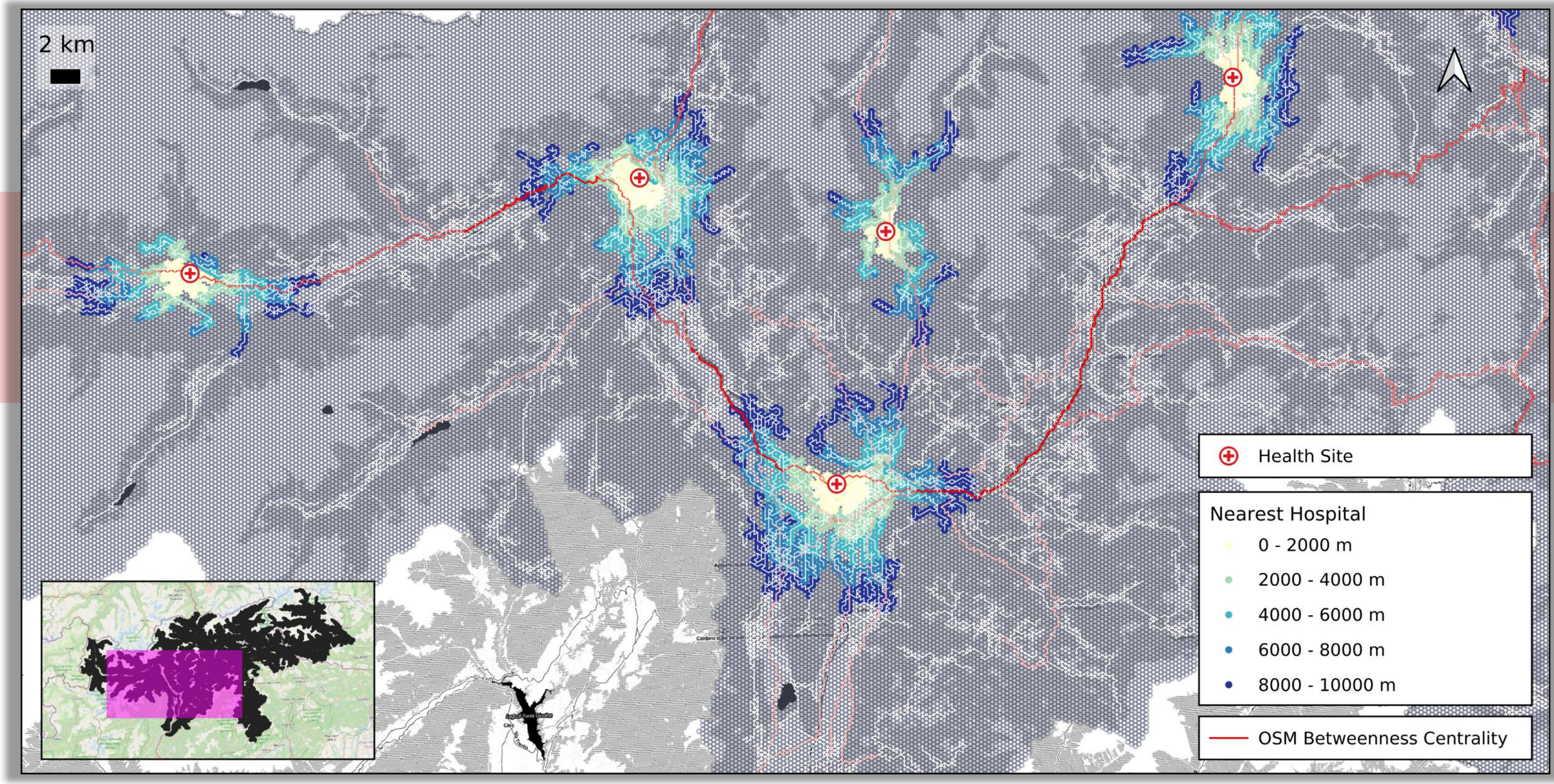


D Forward looking

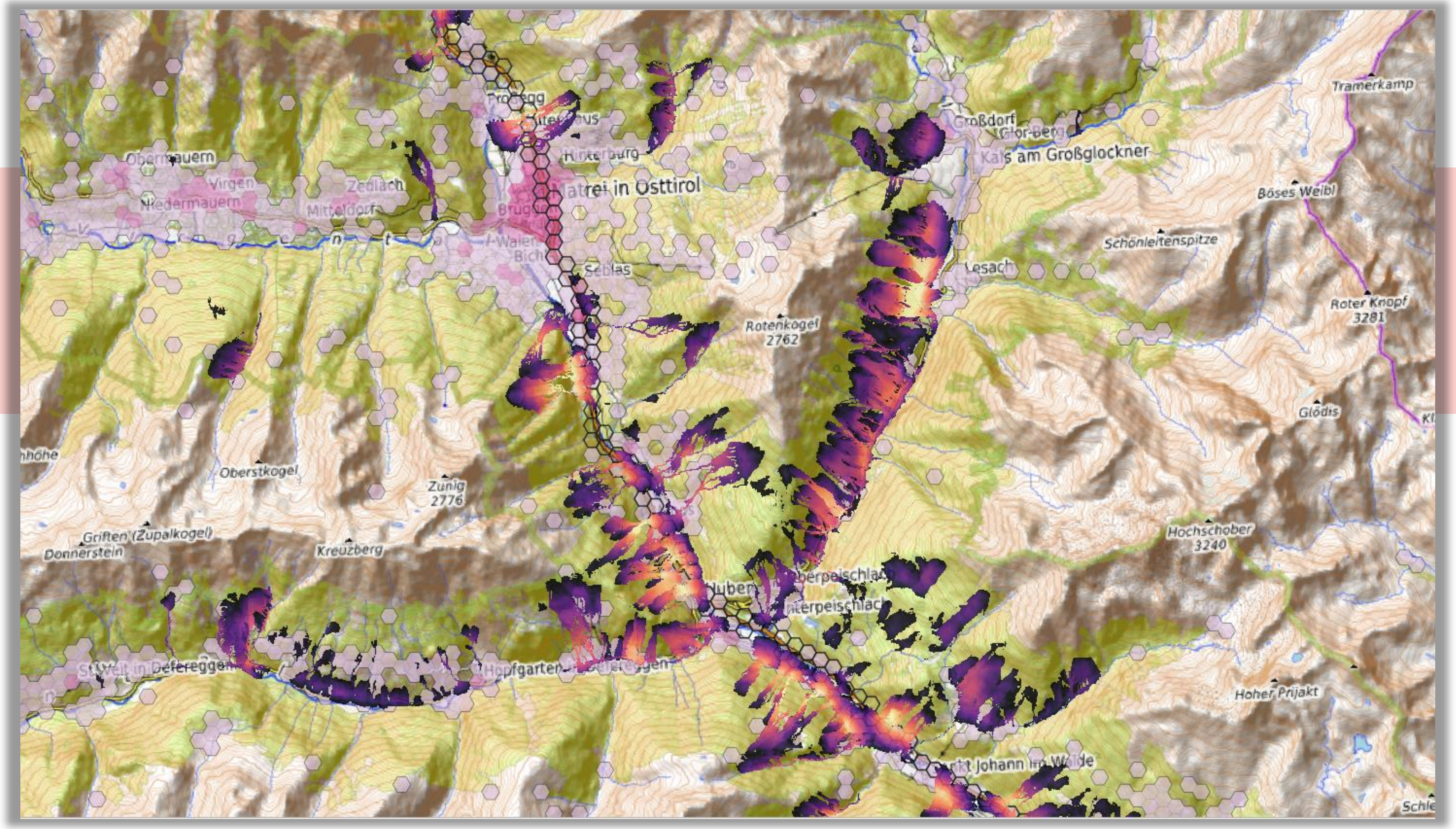
Resilience and efficiency in transport networks



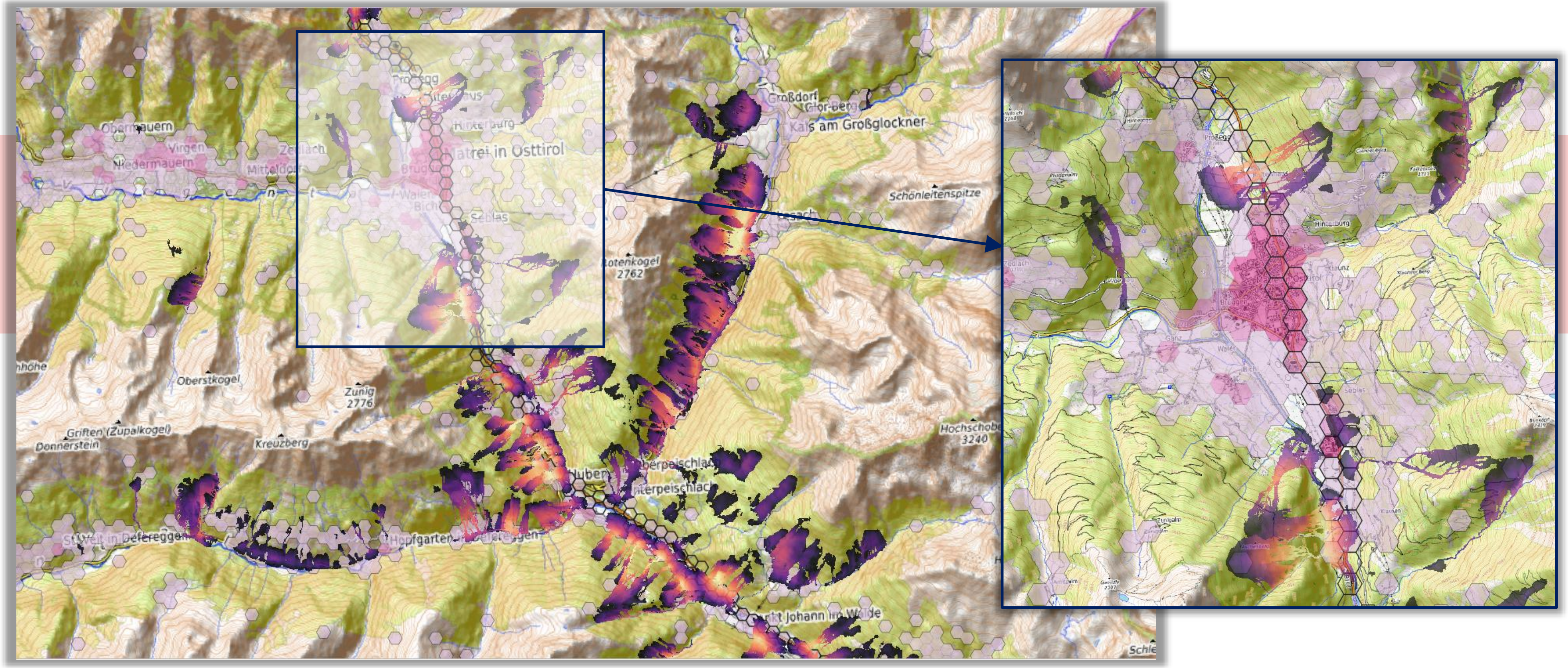
From exposure to vulnerability



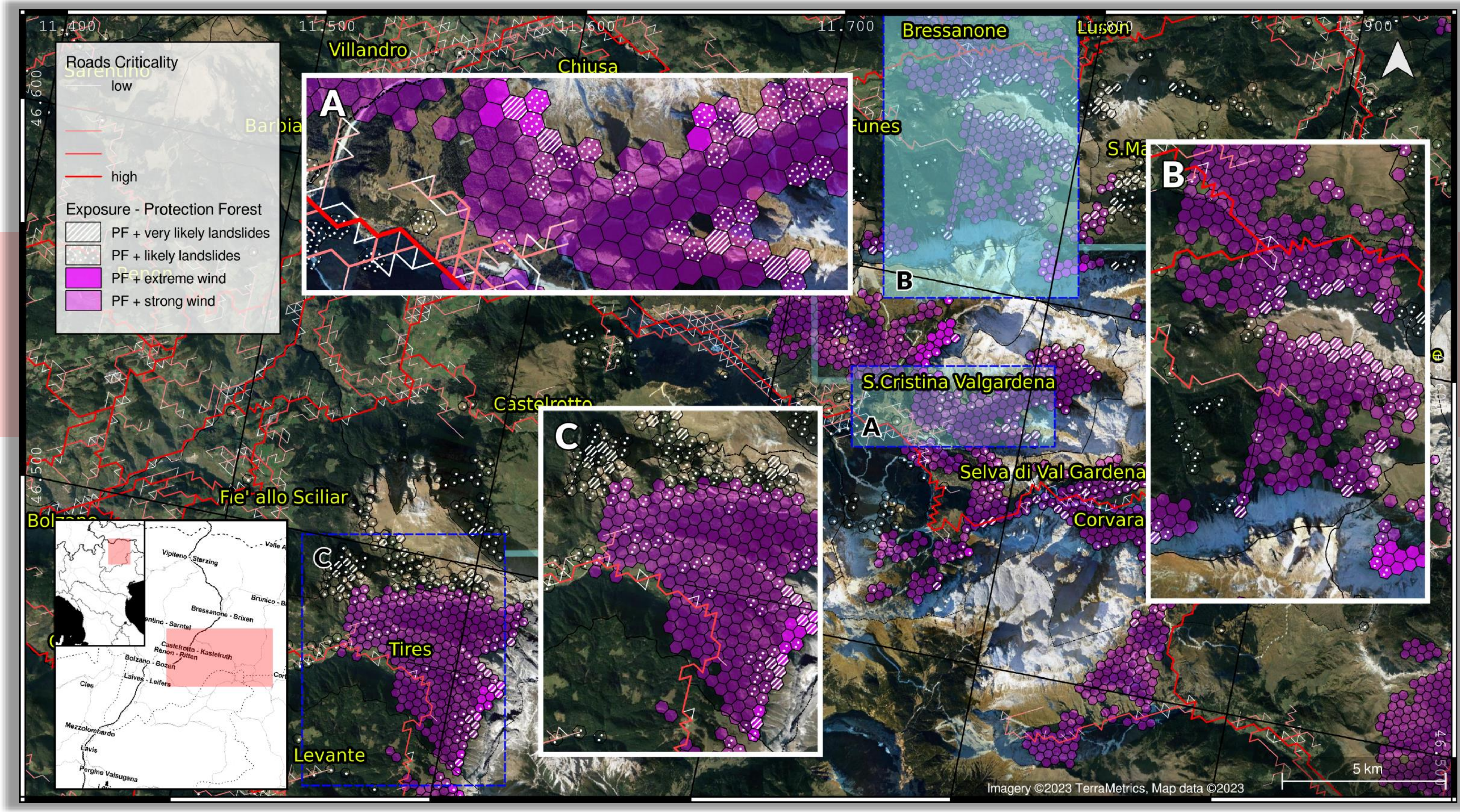
Large-scale hazard risk simulations



Large-scale hazard risk simulations



Multi-hazards risk nowcasting



Links

- The *TransAlp* Project

  https://project-transalp.eu/en/

  https://www.linkedin.com/in/trans-alp-project-5b0437217/

- WebGIS/Maps from *TransAlp*

  https://maps.eurac.edu/maps/?group__group_profile__slug__in=trans-alp-project-public

- Pittore, M., Campalani, P., Renner, K. et al. “Border-independent multi-functional, multi-hazard exposure modelling in Alpine regions”. *Natural Hazards* (2023)

  https://doi.org/10.1007/s11069-023-06134-3 eurac research

https://ror.org/01xt1w755

Thank you!

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