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Dynamic flood hazard maps based on traffic flow forecasts using mobile phone data

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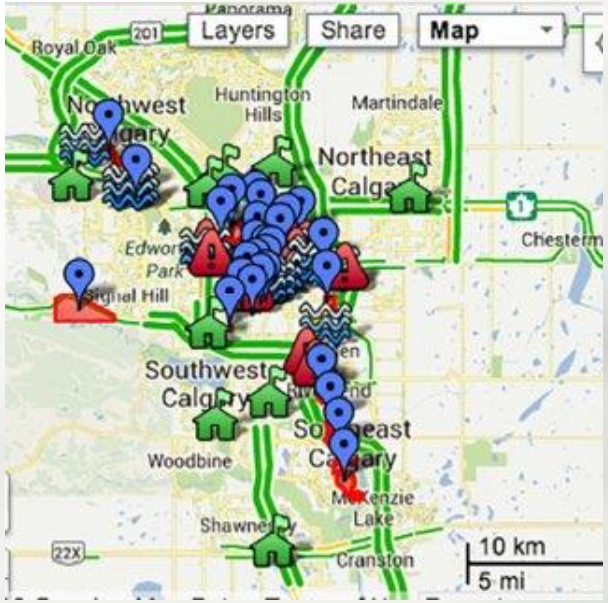
Non-structural practices for risk mitigation

Risk reduction can be achieved by acting on the individual components:

- ✓ Exposure and vulnerability can be effectively acted upon by means of non-structural measures. In particular, the vulnerability of exposed persons can be significantly limited through emergency management plans that are timely and effective.
- ✓ The degree of preparation of citizens and civil protection bodies could be significantly improved by **a more precise knowledge of the crowding of exposed people** and the space-time dynamics of their mobility.

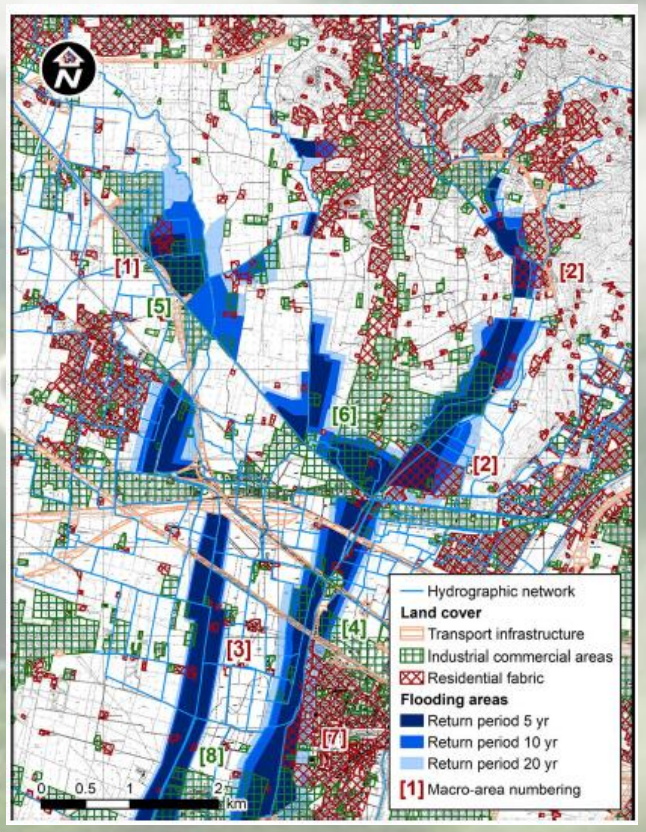
The main scope of this research??

- In this work, we aim to develop flood risk maps using the hydrological flood modelling at a local scale with a combination of “real time” traffic flows using mobile phone data



Dynamic exposure maps

- ✓ Crowding maps related to characteristic Spatio-temporal patterns could provide a valuable tool to enhance emergency managers' preparedness.
- ✓ The suitability of mobile phone data to derive crowding maps is discussed with reference to a test case identified in a strongly urbanized area, subject to frequent floodings and located in the western outskirt of Brescia town (northern Italy).
- ✓ The dramatic sprawl of urban settlements along with the conveyance capacity impairment of the secondary hydrographic network yield an unacceptable high level of flood exposure, even for medium-low return periods (5-20 years).



Balistrocchi, Carpita, Metulini, Ranzi, NHESS, 2020
https://doi.org/10.5194/nhess-2020-201

Material and methods

Mobile phone data

- ✓ In this work we aim at proposing a time series modelling strategy to obtain “real time” traffic flows prediction.
- ✓ Mobile phone origin-destination signals on the flow of Telecom Italia Mobile (TIM) users among different census areas (ACE of ISTAT, the Italian National Statistical Institute) were used, and for the MoSoRe Project 2020-2022 and recorded on an hourly basis from September 2020 to August 2021.
- ✓ For this area a year long dataset of TIM users’ geo-localizations is available (Erlang measures). TIM users’ geo-referenced spatial distributions are reproduced every 15 minutes by using a raster with 150 meters spatial resolution.
- ✓ Data analysis was carried out by a time series modelling strategy for traffic flow prediction based on Harmonic Dynamic Regression (HDR, Hyndman, Athanasopoulos, 2021)

Material and methods

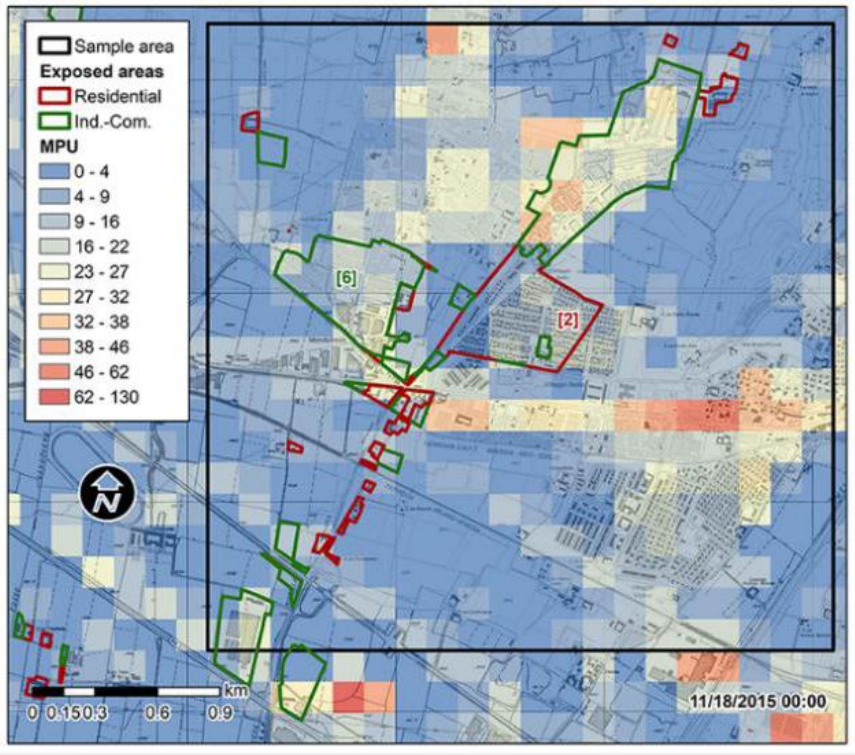
Flood propagation model

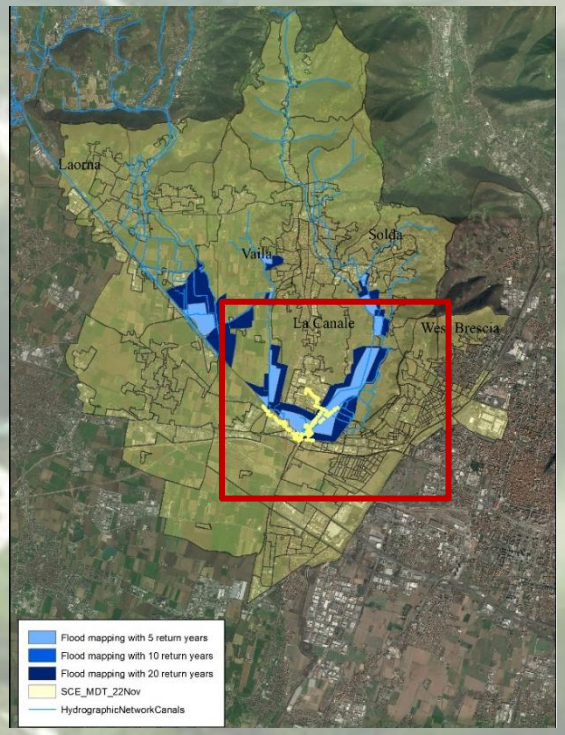
- To simulate flood propagation, obtained hydrograph from HEC-HMS hydrologic modeling system was utilized in the HEC-RAS model.
- Flood processes, especially in the small catchment, are mainly caused by intense **localized precipitation** and **plane features**.

  - ✓ To describe the effects of land use on the basin response to storm rainfall, the elevation of 350 critical points in the flood plain area were obtained by GNSS technology, and a combination of DEM and field surveying in critical points to present topography is used

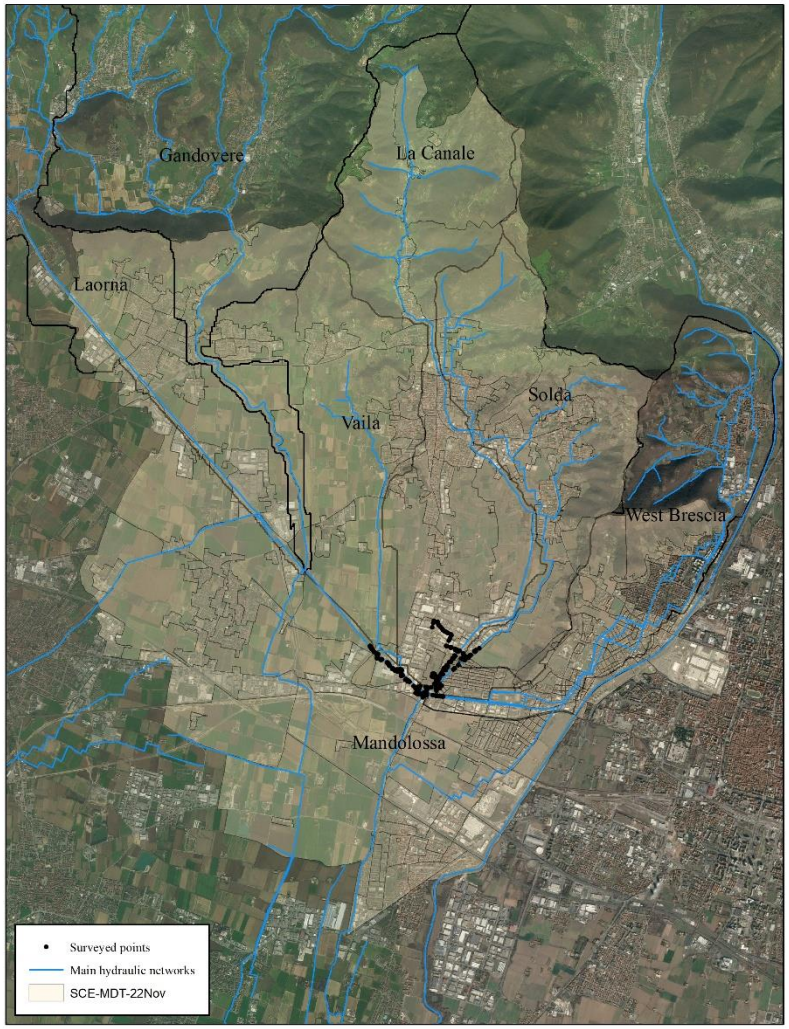
Results

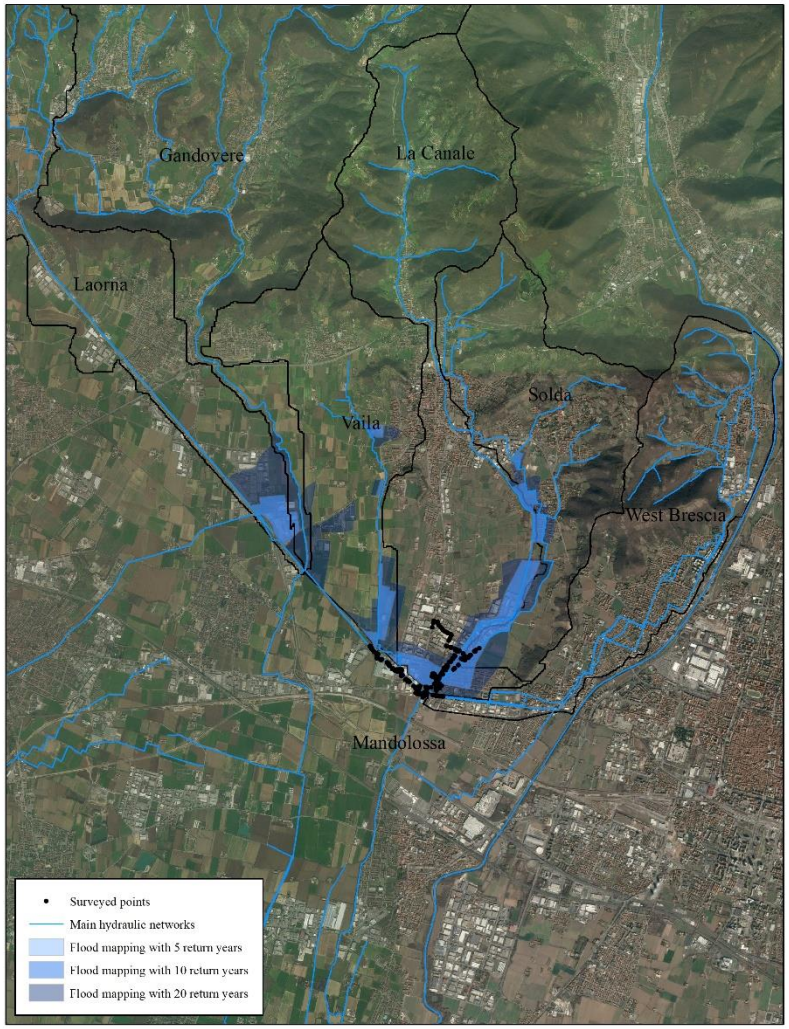
The following figures present estimated dynamic flood exposure risk maps, which show exposed people obtained from mobile phone data and processed with the HDR model by combining flood hazard maps at different storm return periods.



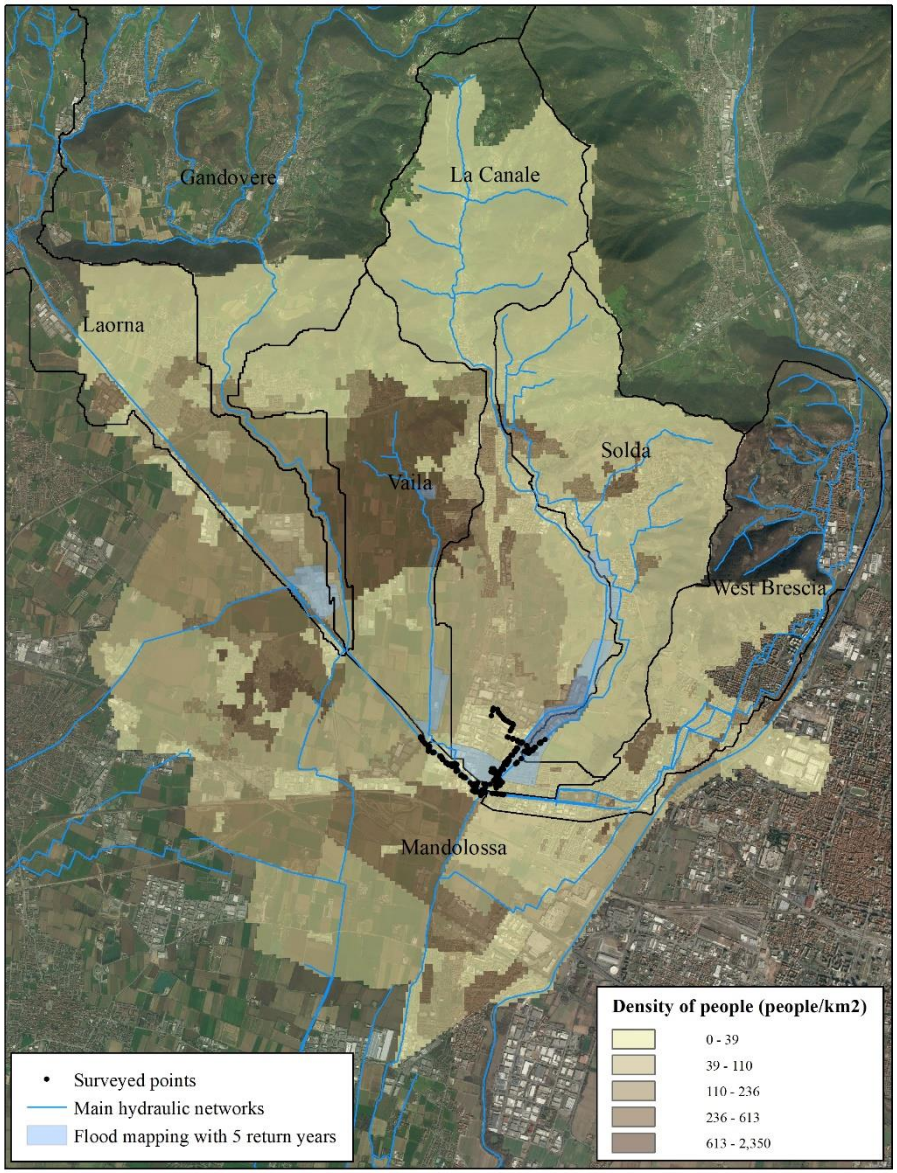


Density from mobile phone – flood hazard 5, 10, 20 yrs

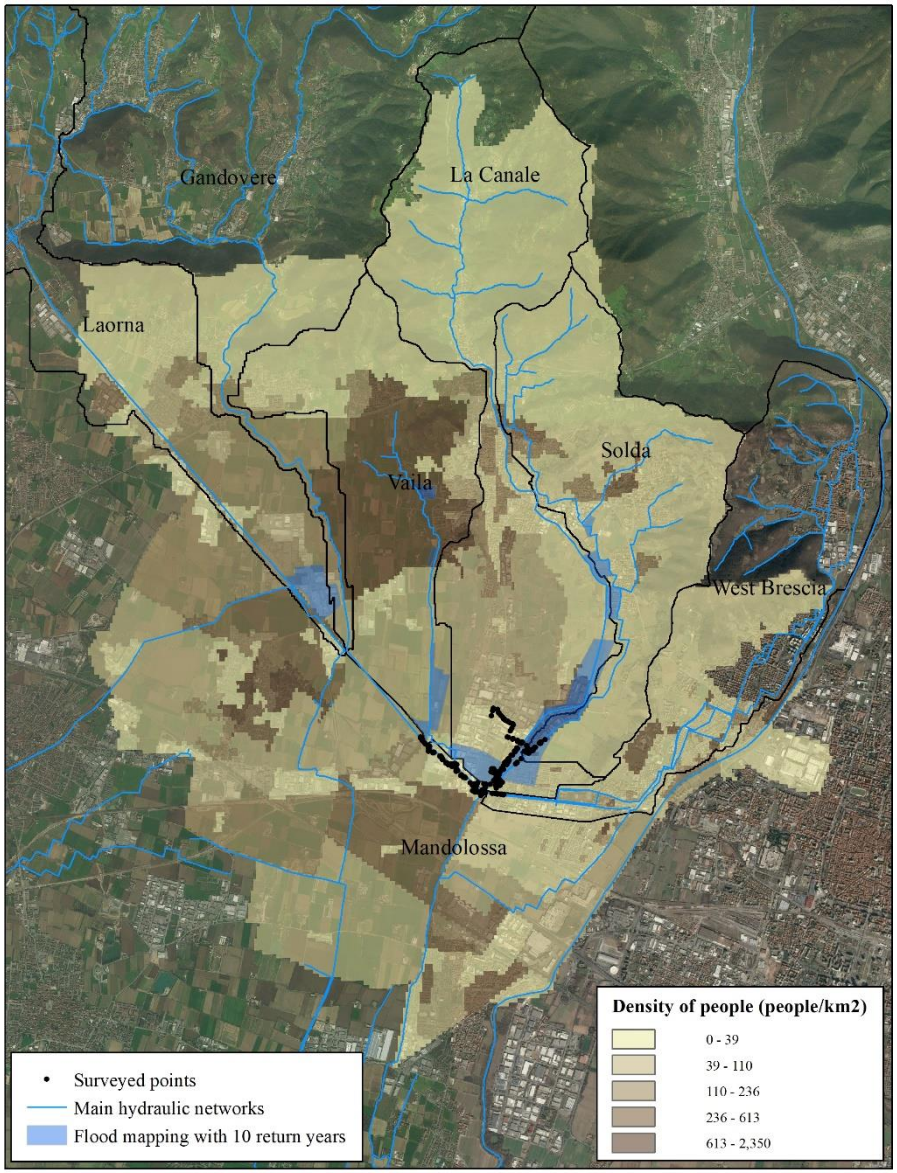




Density from mobile phone and flood hazard 5 years return year



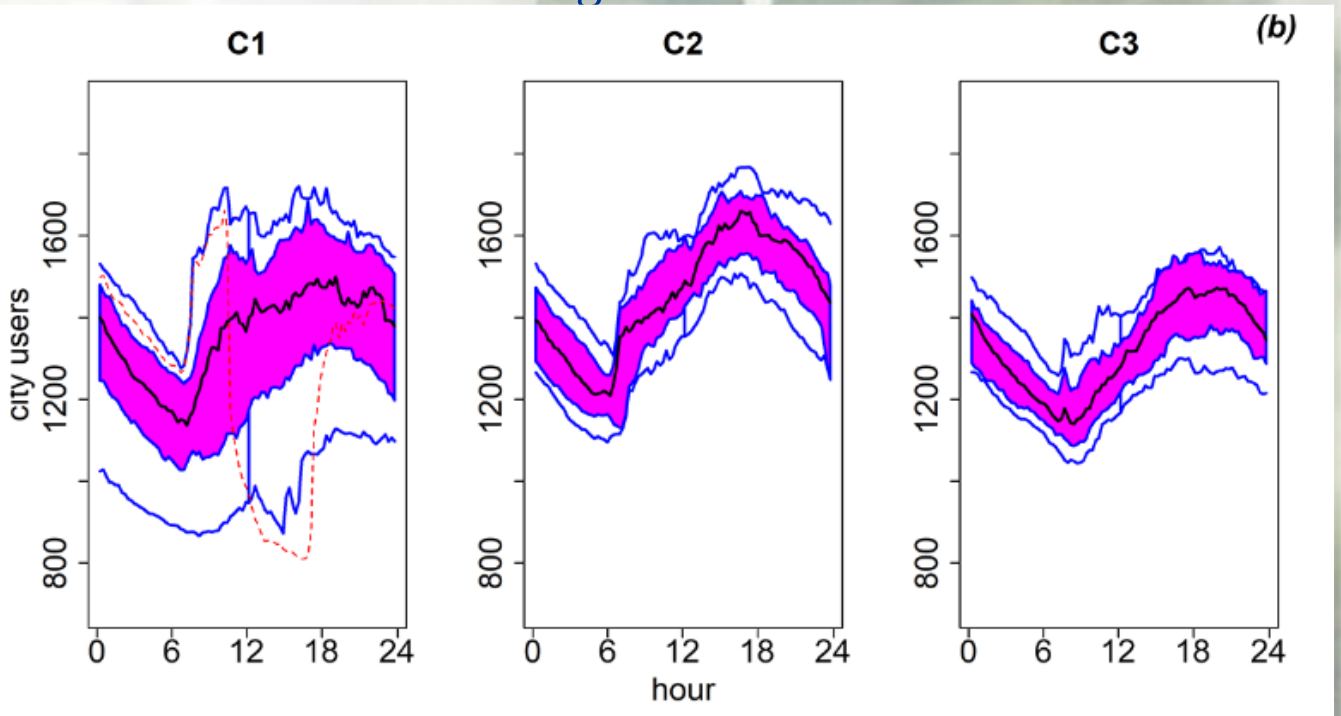
Density from mobile phone and flood hazard 10 years return year



Future development

- To include additional hydrometeorological data in ”real-time” (e.g. precipitation data) for flood risk management
- Consider the **in- and out-flows of people** transiting through the flooding areas in different time, to organize flood protection as **traffic management**.
- Produce off-line time-variant exposure (resulting from clustering) and risk maps to have realistic scenarios for flood management.

Cluster 1 (JAS, C1),
Cluster 2 (working-days October-June, C2),
Cluster 3 (week-ends from October to June, C3).



Acknowledgments

MOSORE (Infrastrutture e servizi per la Mobilità Sostenibile e Resiliente) - CallHub ID 1180965, bit.ly/2Xh2Nfr, Regione Lombardia

References

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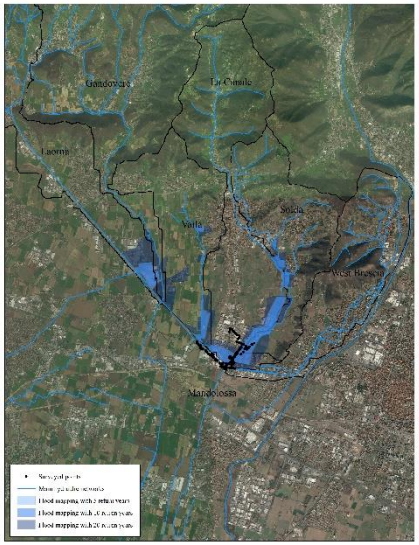
Material and methods

Flood propagation model

Why combination of local surveyed and DEM were used?

During the physical modeling of overland flows, the highly irregular microtopography is sometimes replaced by a smooth surface. This does not lead to significant differences in discharge hydrographs because the continuity requirements are met in both cases (Tayfur et al. 1993), unless the micro topography is represented at a very fine scale: in this case all the local irregularities in the soil surface manifest in terms of vastly different slopes for neighboring nodes and mobile phone network data better suits with the aim of developing dynamic exposure to flood risk maps (as done in Balistrocchi et al., 2020).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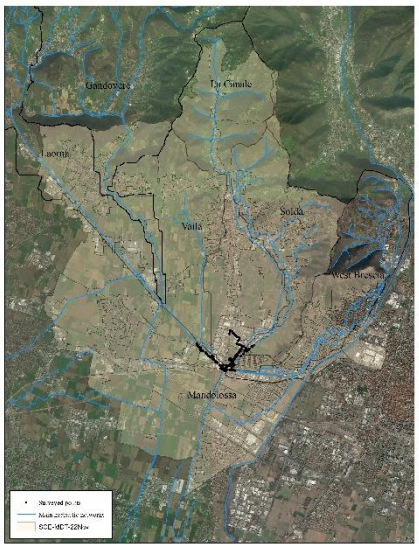
Le Cimule
Laorna
Solda
Valle
West Brescia
Mandolossa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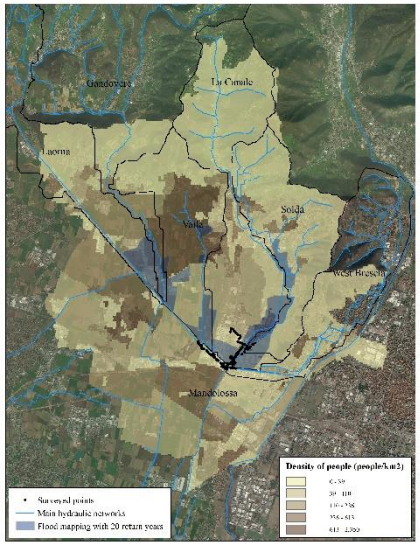
Gandovere
Le Cimule
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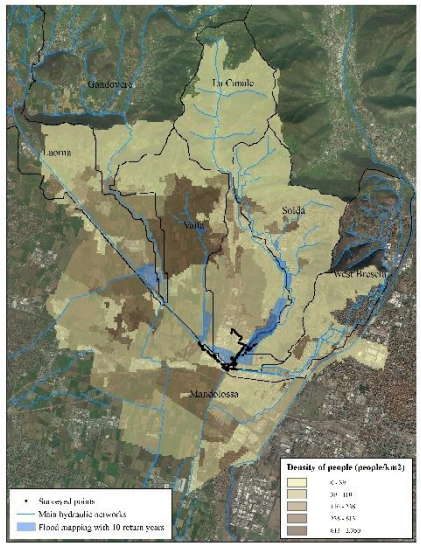
West Brescia
Mandolossa
Density of people (people/km2)
Surveyed points
Main hydraulic networks
Flood mapping with 20 return years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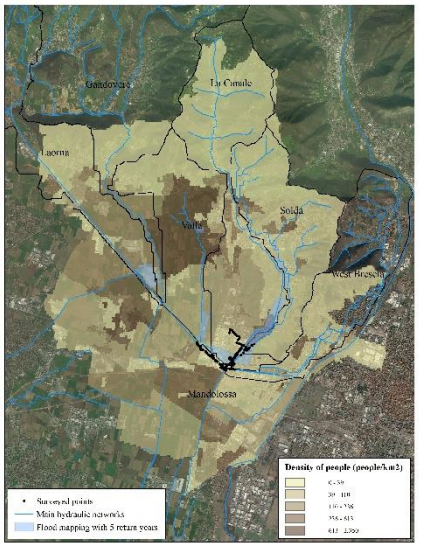
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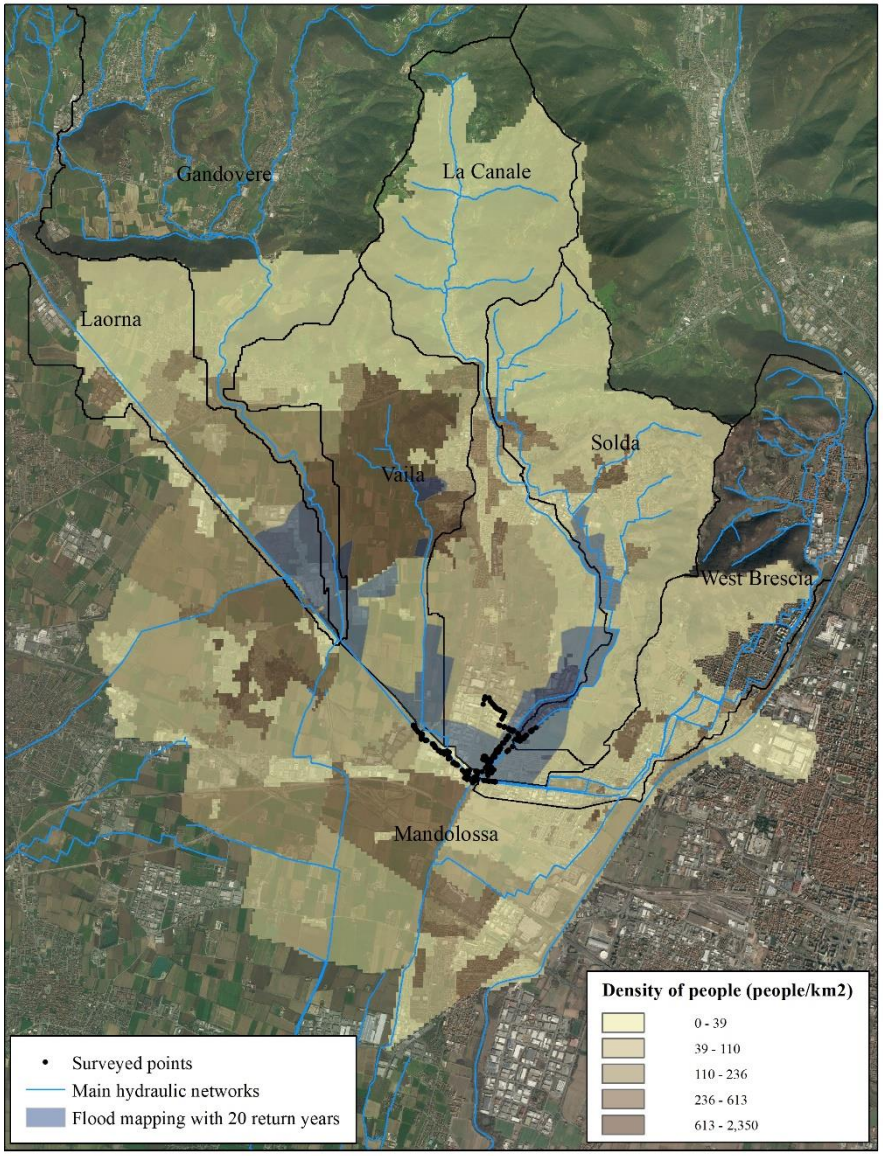
Mandolossa
Density of people (people/km2)
Surveyed points
Main hydraulic networks
Flood mapping with 5 return years


Gandovere
La Canale
Laorna
Solda
Vaila
West Brescia
Mandolossa
Density of people (people/km2)
0 - 39
39 - 110
110 - 236
236 - 613
613 - 2,350
Surveyed points
Main hydraulic networks
Flood mapping with 20 return years