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Estimation of flood risk exposure with cross fertilization between multi-platform remote sensing and census information.

EGU 2020 Sharing Science Online

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Work Outline

Why and How….

Why?

- ✓ The evaluation of the built and the population exposed to floods needs information that should be updated often, especially in countries with strong economic and urban development
- ✓ International land use – urban footprints maps are updated with frequencies often inconsistent with the rate of land use development (e.g. CLC every 6 years)
- ✓ Monitoring of flood risk exposure at higher frequencies might be required at national/provincial/municipality scale (e.g. indicators of SFDRR)

How

- ✓ Satellite-based nightlights have been used by various authors in the literature, as a proxy for urban and population density
- ✓ Information from this kind of sensors can be updated at very high frequency (e.g. year or month)
- ✓ The idea is to **calibrate** nightlight vs. urban density/population relations where contemporary estimations of both variables are available.
- ✓ Then **estimate population exposed** to flood risk using official flood hazard maps.
- ✓ Finally **validate** results using independent estimates of the population exposed to the flood risk in the same area, based on the same hazard map.

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Data

Databases used

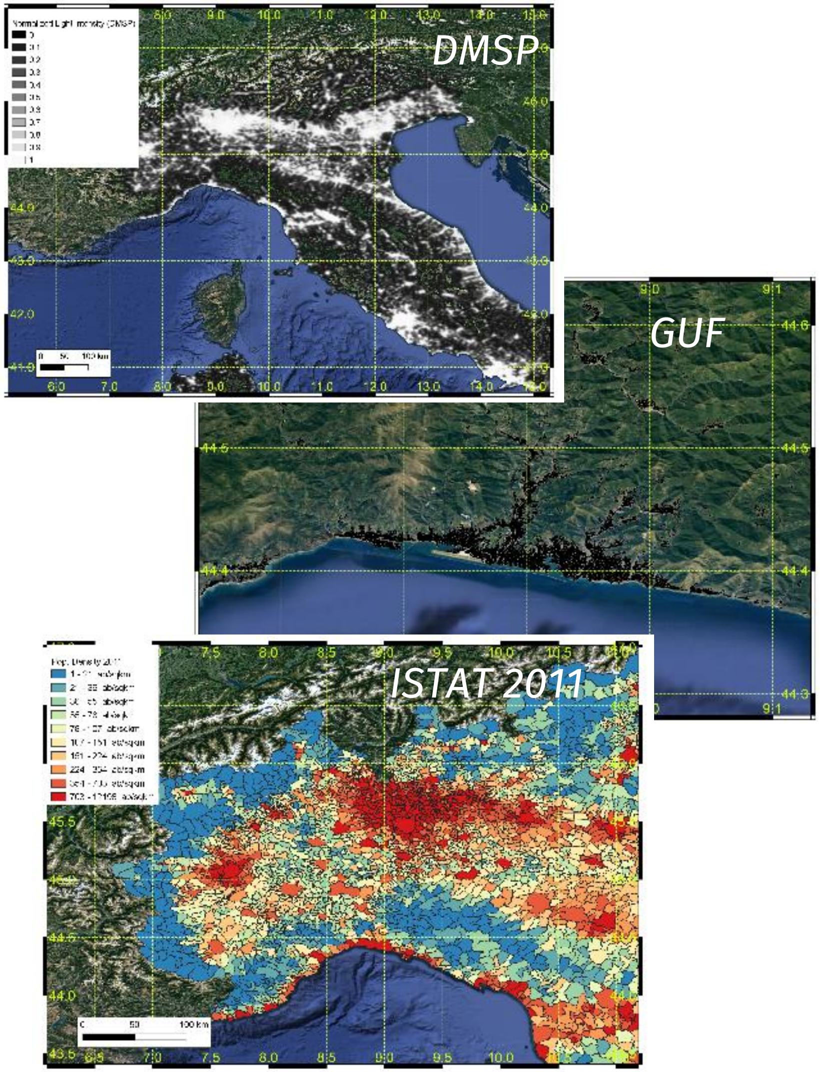
DMSP night-time light series (30 arc seconds, 2011)

Global urban footprint (GUF) maps by DLR (12 m, 2011-12)

CLC 2012 (100 m)

Census data from the Italian institute of statistics (ISTAT 2011, vector layer).

Independent data for the **population exposed to flood hazard** by the Italian Environmental Protection Agency (ISPRA 2011, vector layer).



All databases have been regridded on the DMSP 30 arc seconds grid

Method

Methodology in brief

1. All data have been regridded on the DMSP 30 arc seconds grid and normalized (0-1)
2. Urban density is obtained from aggregated GUF
3. The curves have been calibrated in different parts of Italy (Tuscany, Sicily and Lombardy) representing different levels of urban development and masking industrial areas using CLC 2012
4. The curves are used to derive urban density for Italy
5. Derived urban density is used to redistribute population in municipalities provided by ISTAT2011
6. Distributed population is crossed with flood hazard zones provided by ISPRA and population exposed is derived
7. Results are validated against population exposed per hazard zone provided by ISPRA

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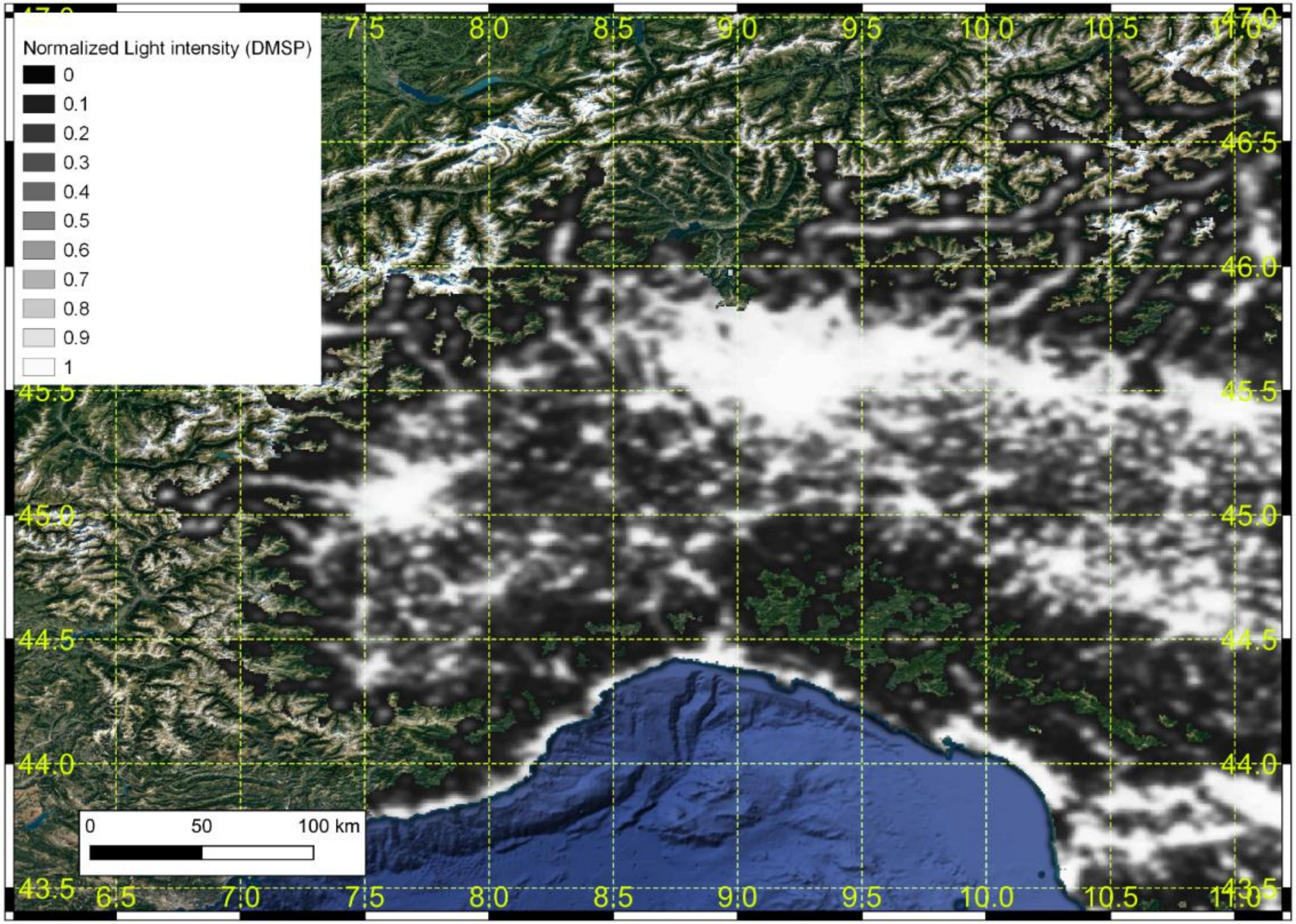
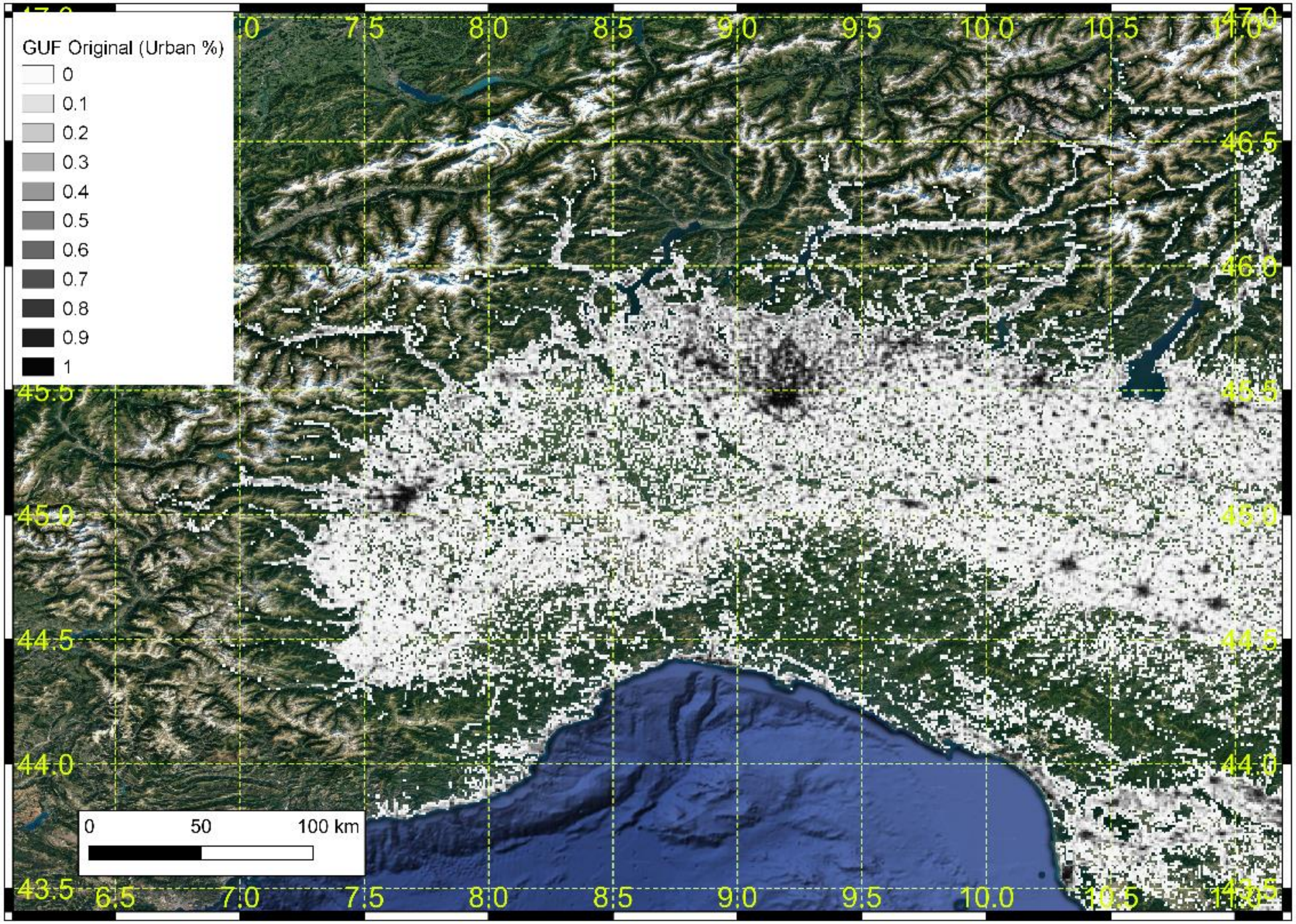
Results

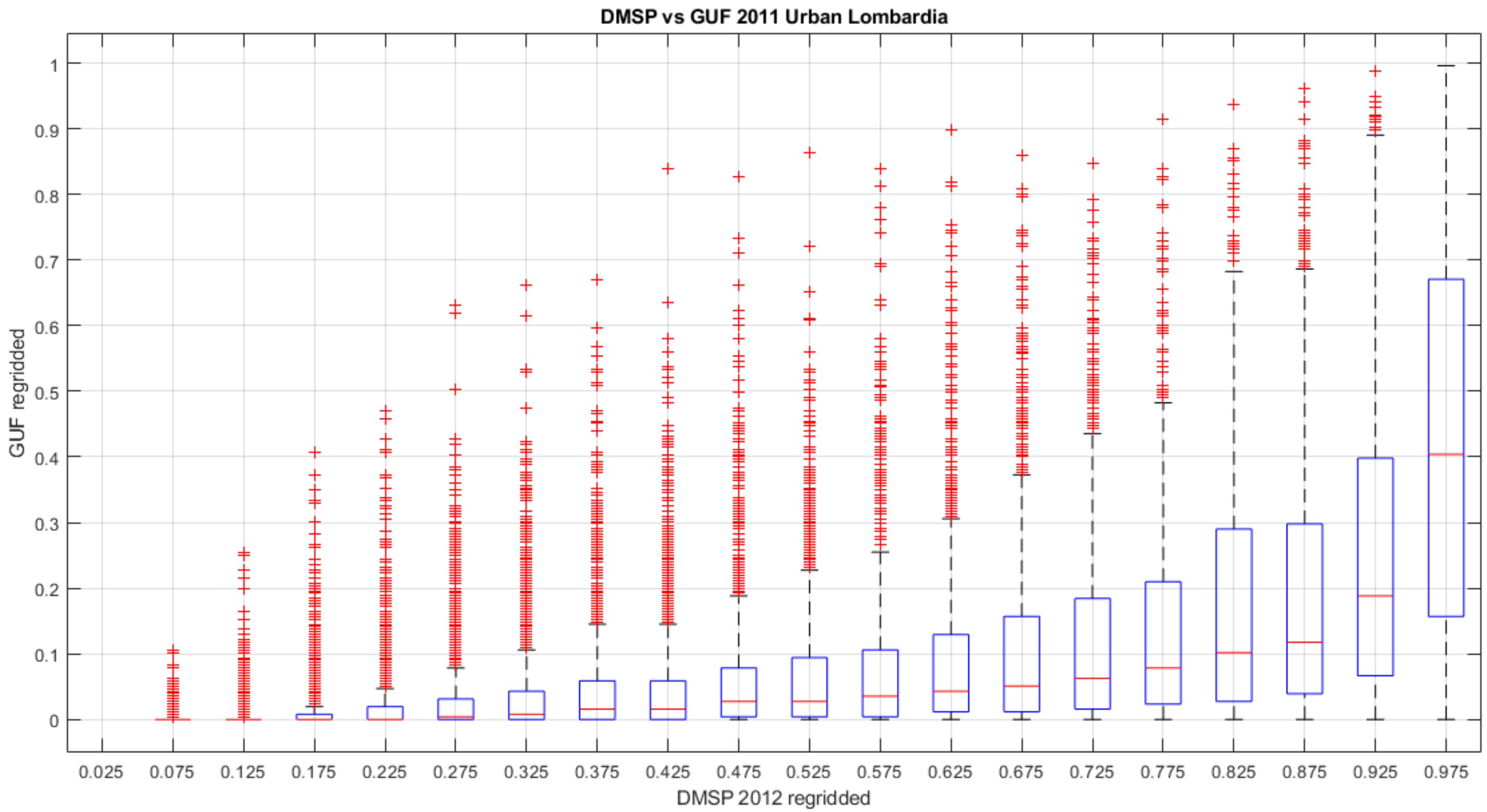
1) Normalized DMSP2011



2) 30" Urbanization density from GUF



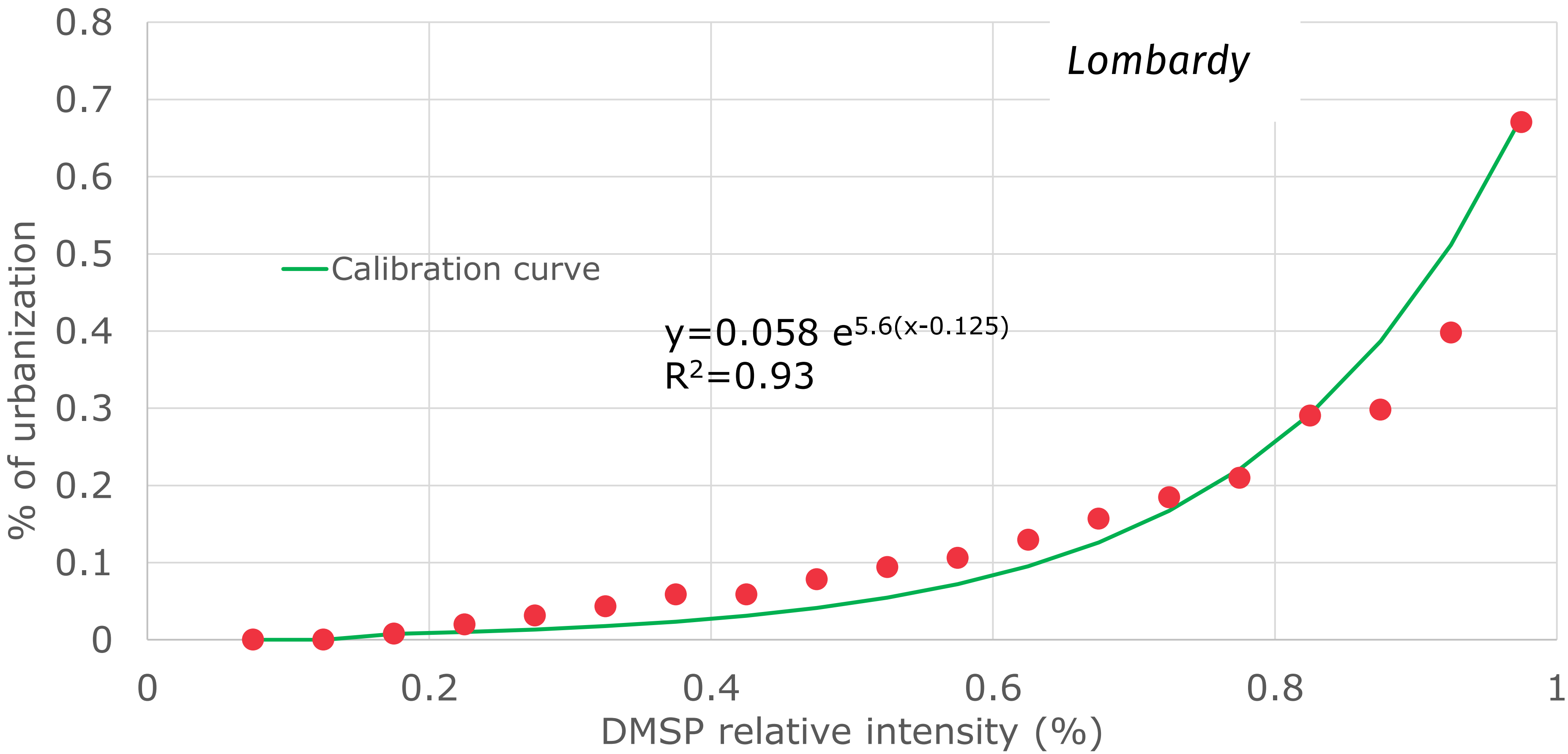
3) Light Intensity/Urban Density



Lombardy case (example): The light diffusion spreads the distribution of Urban density values per light intensity (boxes represents 25%-75% quantile limits)

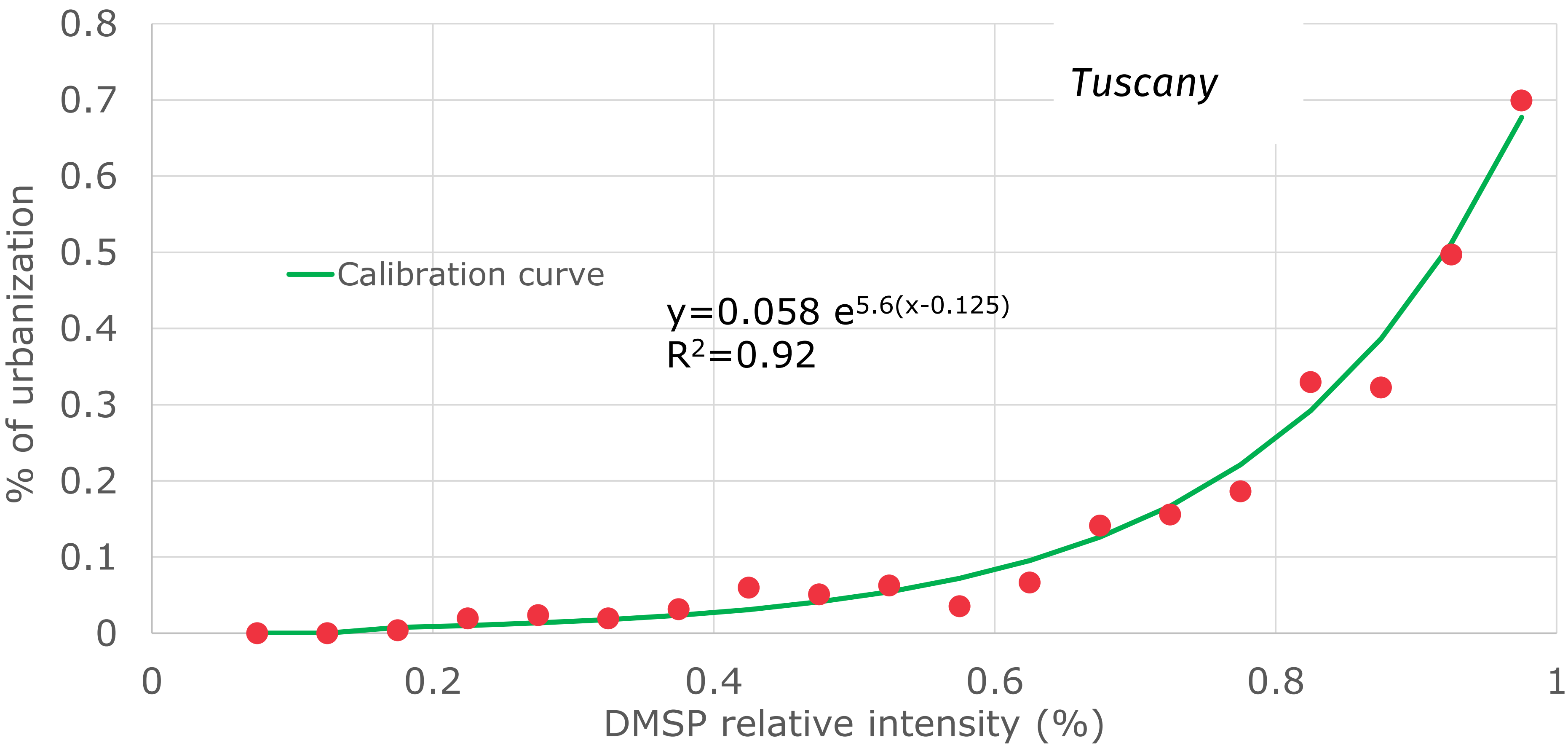
To avoid underestimation of GUF derived urban densities, curves are calibrated on the 75% quantile values instead of the average

3) Calibrated curves



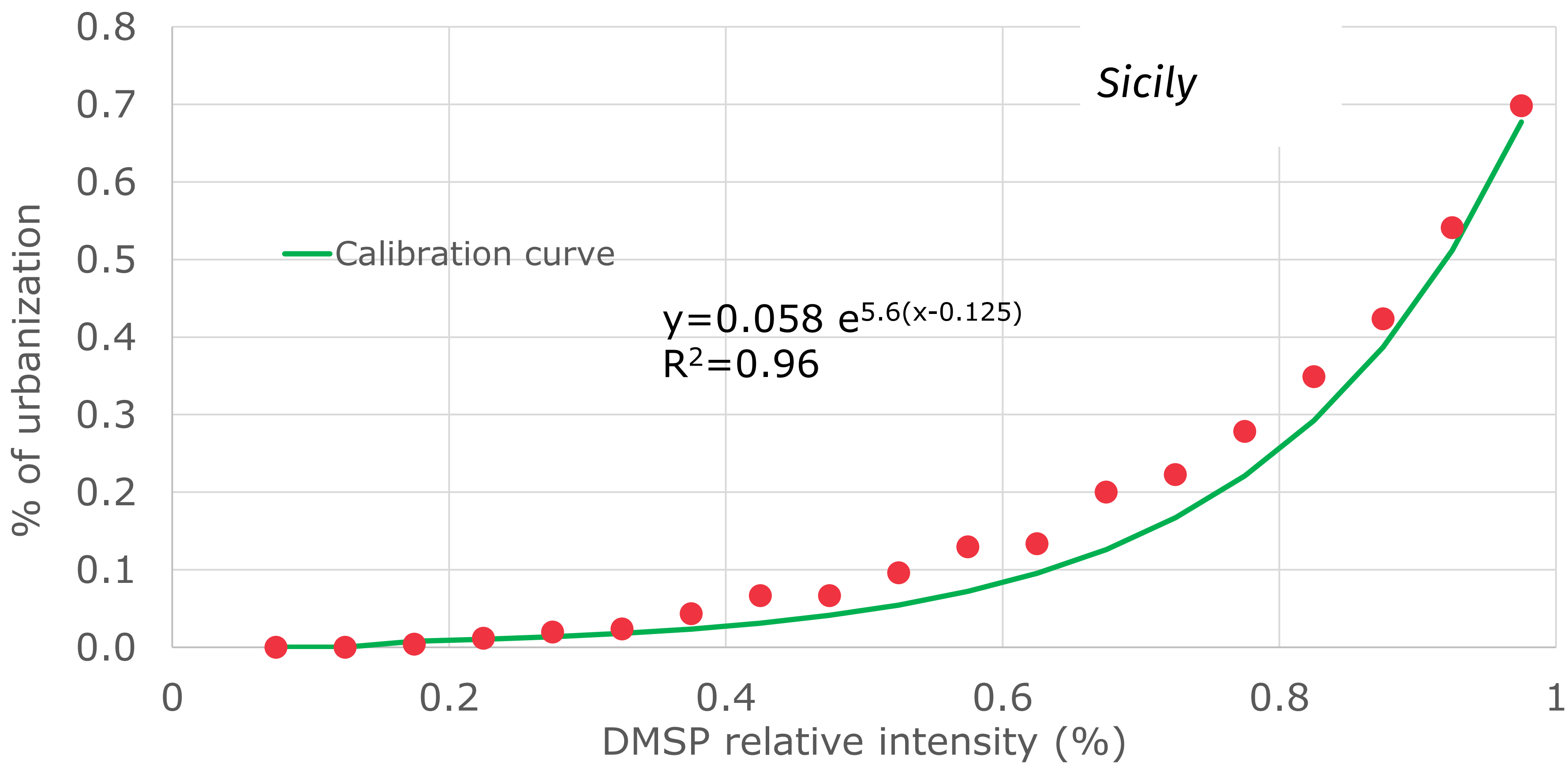
In the following slides the visual comparison between 75% quantiles and the fitting curve is shown, R^2 for the fitting is also displayed

3) Calibrated curves



Tuscany case. The calibration curve is constant among cases.

3) Calibrated curves



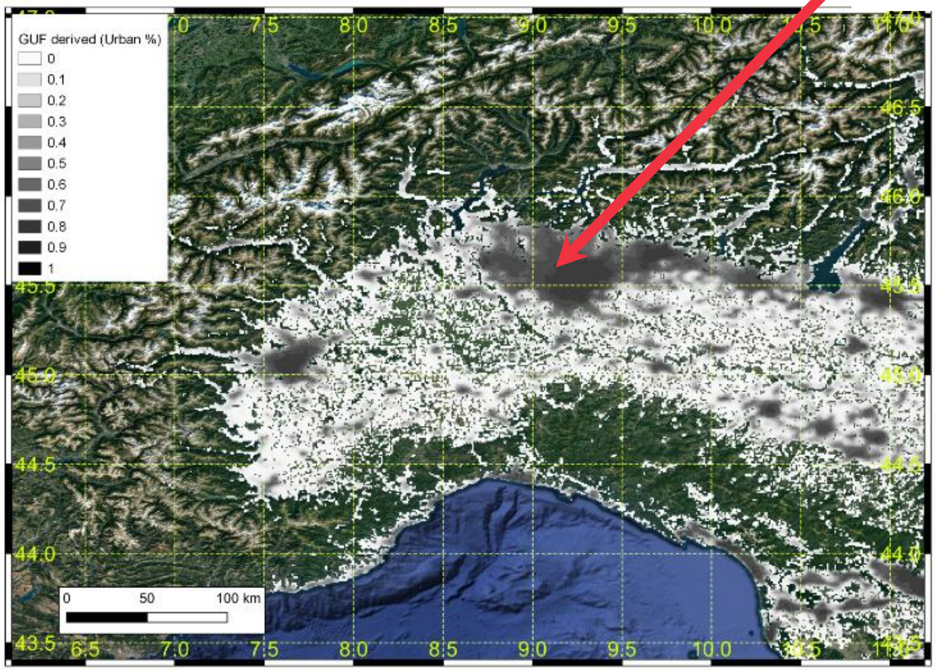
Sicily case. The calibration curve is constant among cases.

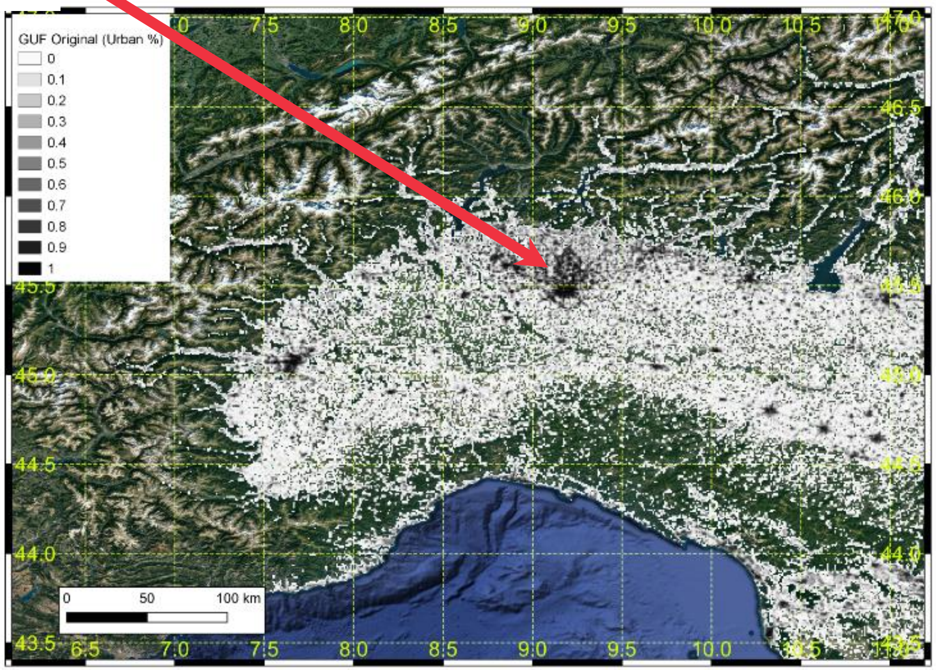
4) Derived vs GUF original urban density

Derived

Milan

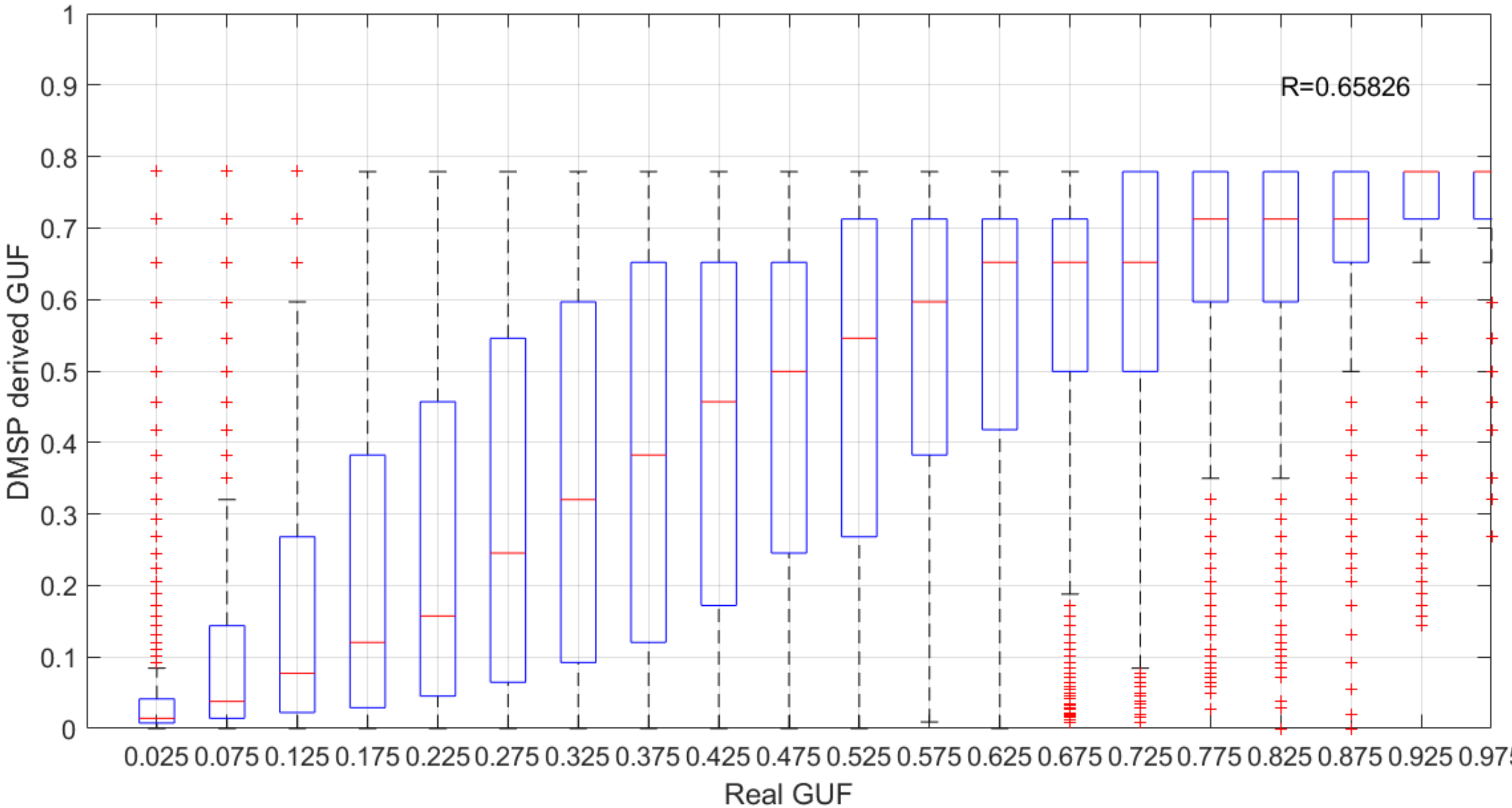
Original (GUF2011)





Urban densities shows very consistent patterns, effects of light diffusion are stronger in big urban areas (Milan in the figure). <u>Higher resolution satellite light intensity data may reduce the effect</u>

4) Derived vs GUF original urban density

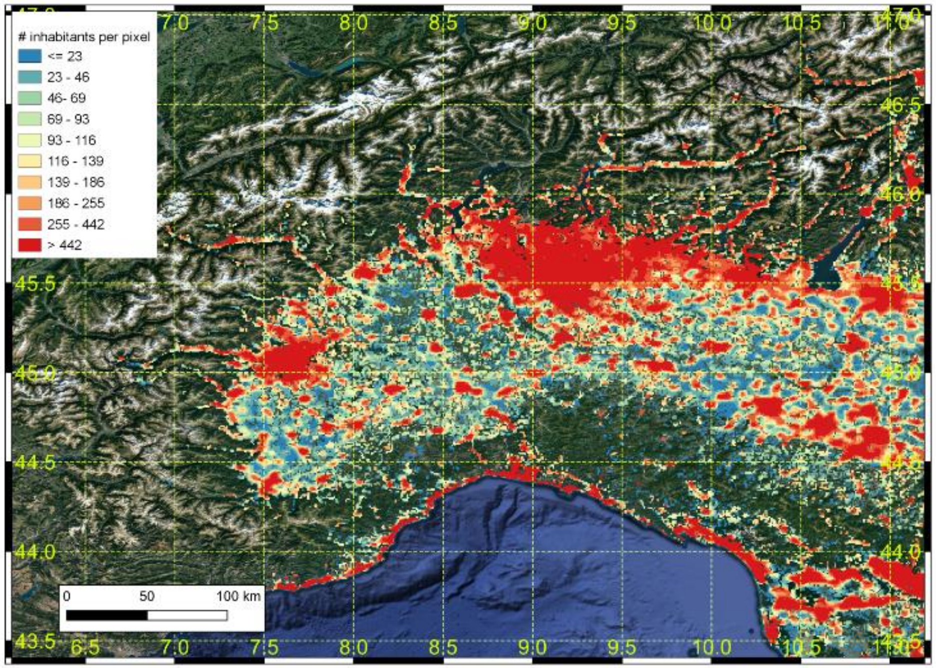


<u>The box plot shows good correlation (R=0.66) between derived and real urban density</u>. The cut to 80% in derived urban density is produced by the calibration curve and the choice of 75% quantile for fitting

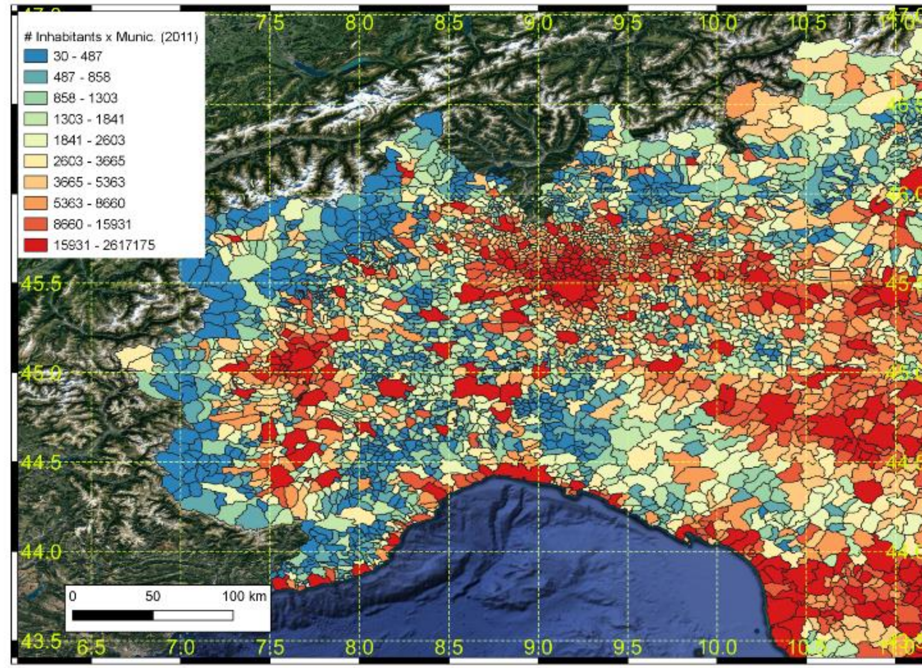
Boxes include the interval between 25% and 75% quantilesof the conditional distribuiton of derived urban density given a specific real value

5) ISTAT2011 population redistributed

Population redistrubuted



Istat 2011 (municipality based)

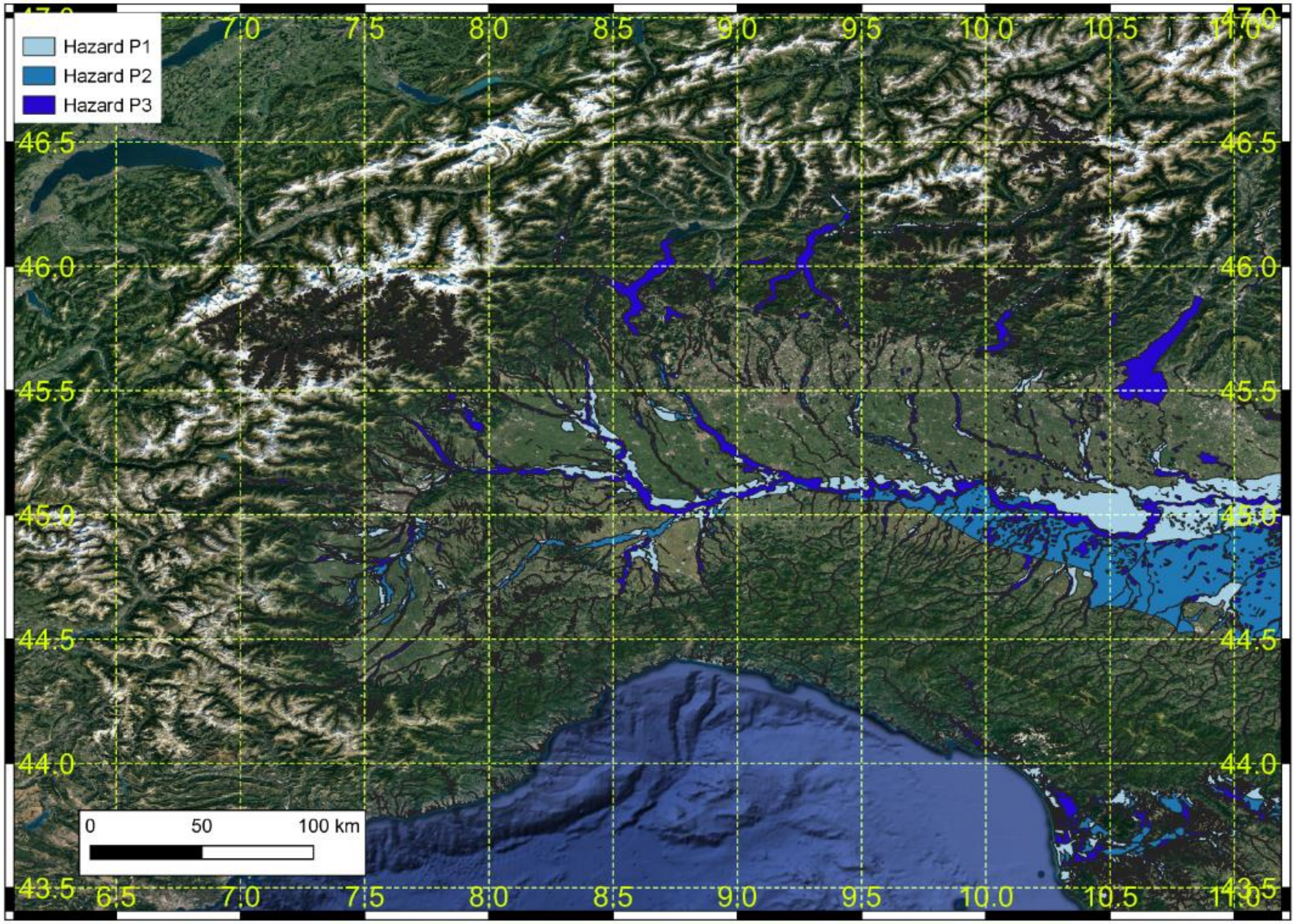


$$PopRed_{pixel\_i} = \frac{PopTot_{mun\_j}}{\sum UrbDens_{mun\_j}} UrbDens_{pixel\_i}$$

The population provided by ISTAT2011 at municipality scale (right) is redistribiuted using the urban density derived from DMSP

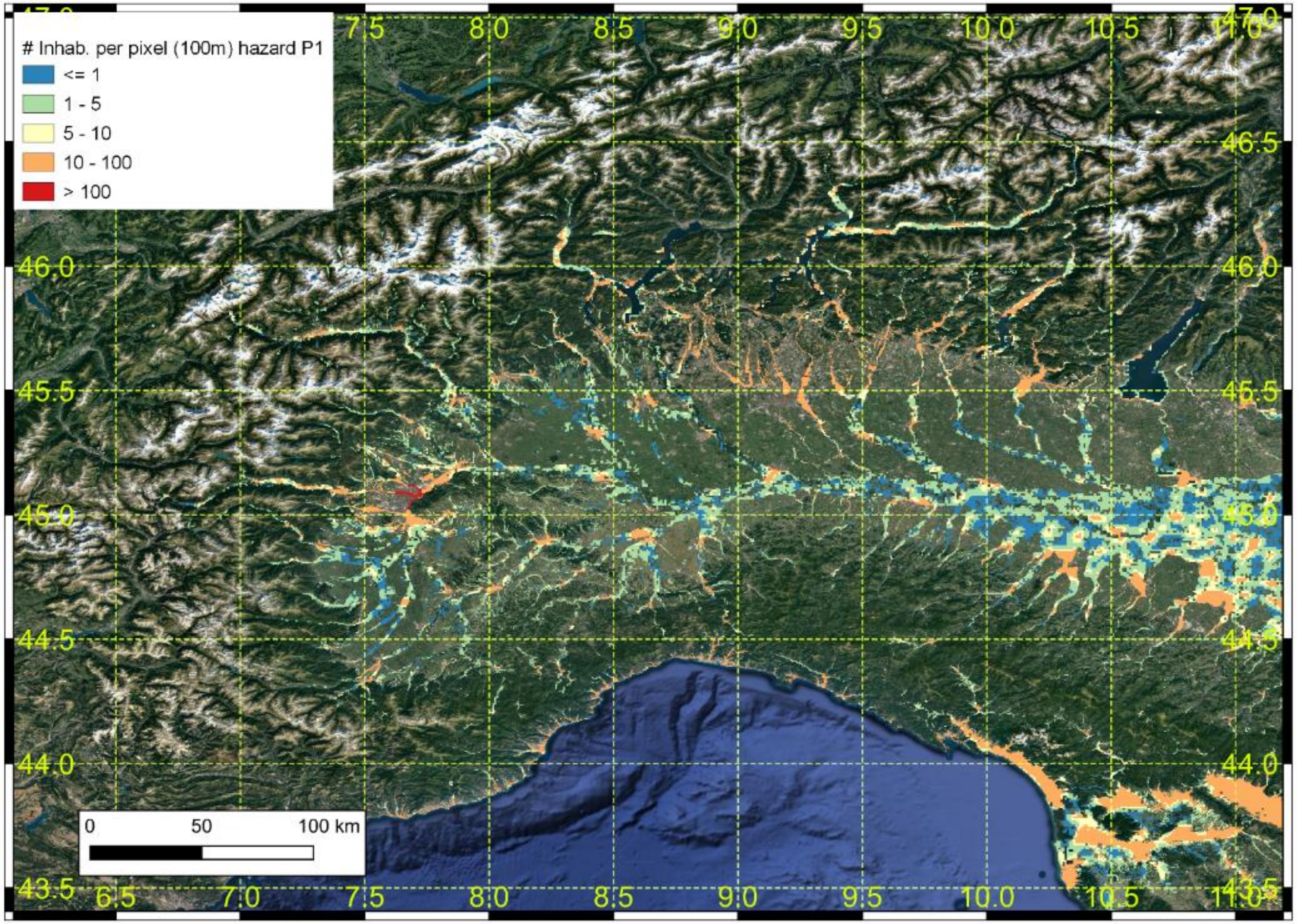
The added value of using DMSP data is the ridistribution in smaller areas inside ythe municipalities, actually urbanised

6) Crossing with Hazard Zones



ISPRA Hazard zones P1 (lower), P2 and P3 (higher). Zoom on the Po river valley

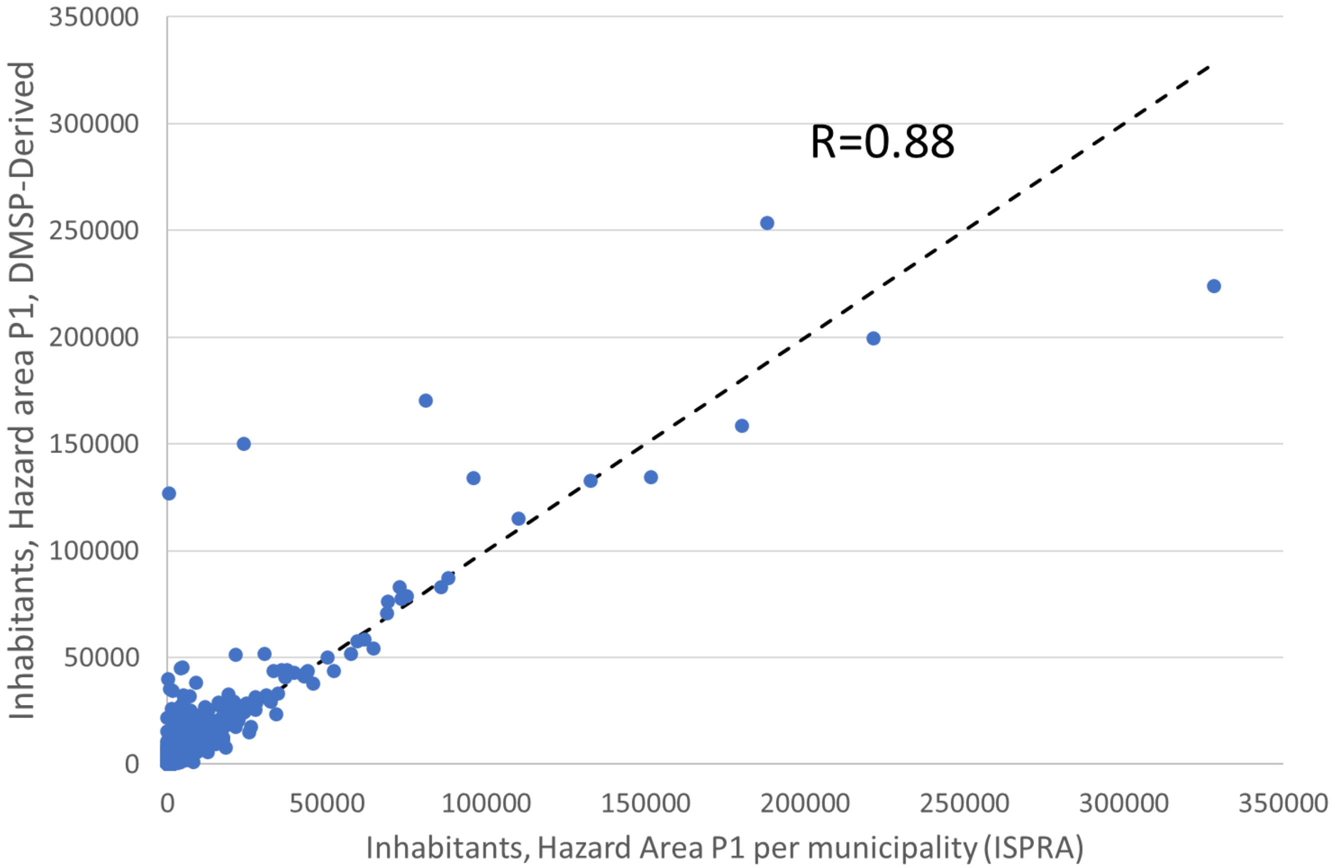
6) Crossing with Hazard Zones



Number of inhabitants per pixel in hazard zone P1. The inhabitant per pixels have been resampled from DMSP resolution (1 km) up to 100 m for better overlap with hazard zones detail

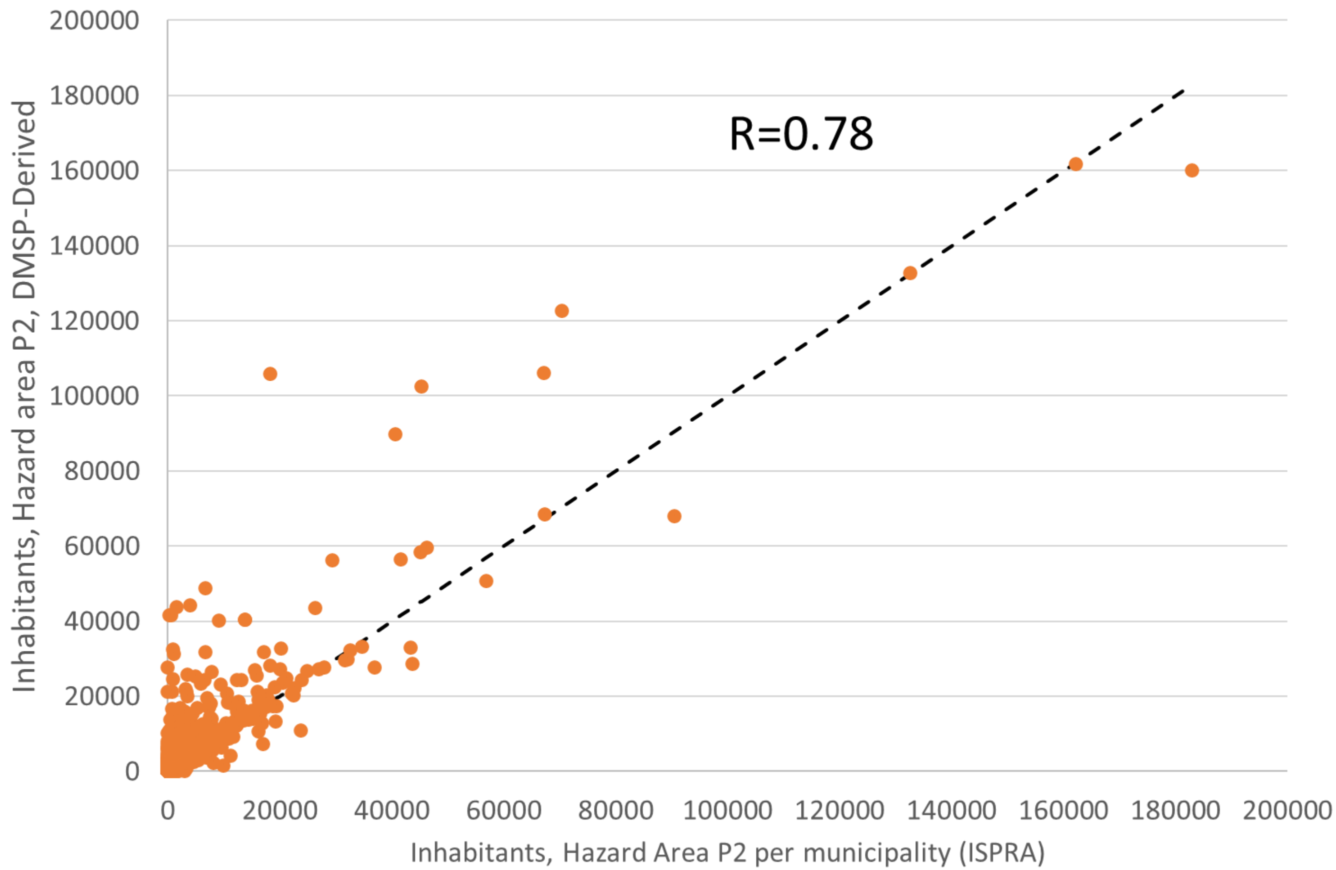
The same has been done for hazard zones P2 and P33 (nort shown)

7) Validation with ISPRA DB



This scatterplot shows the correlation between retrieved and actual (ISPRA2011) ***inhabitants in P1 hazard zone***

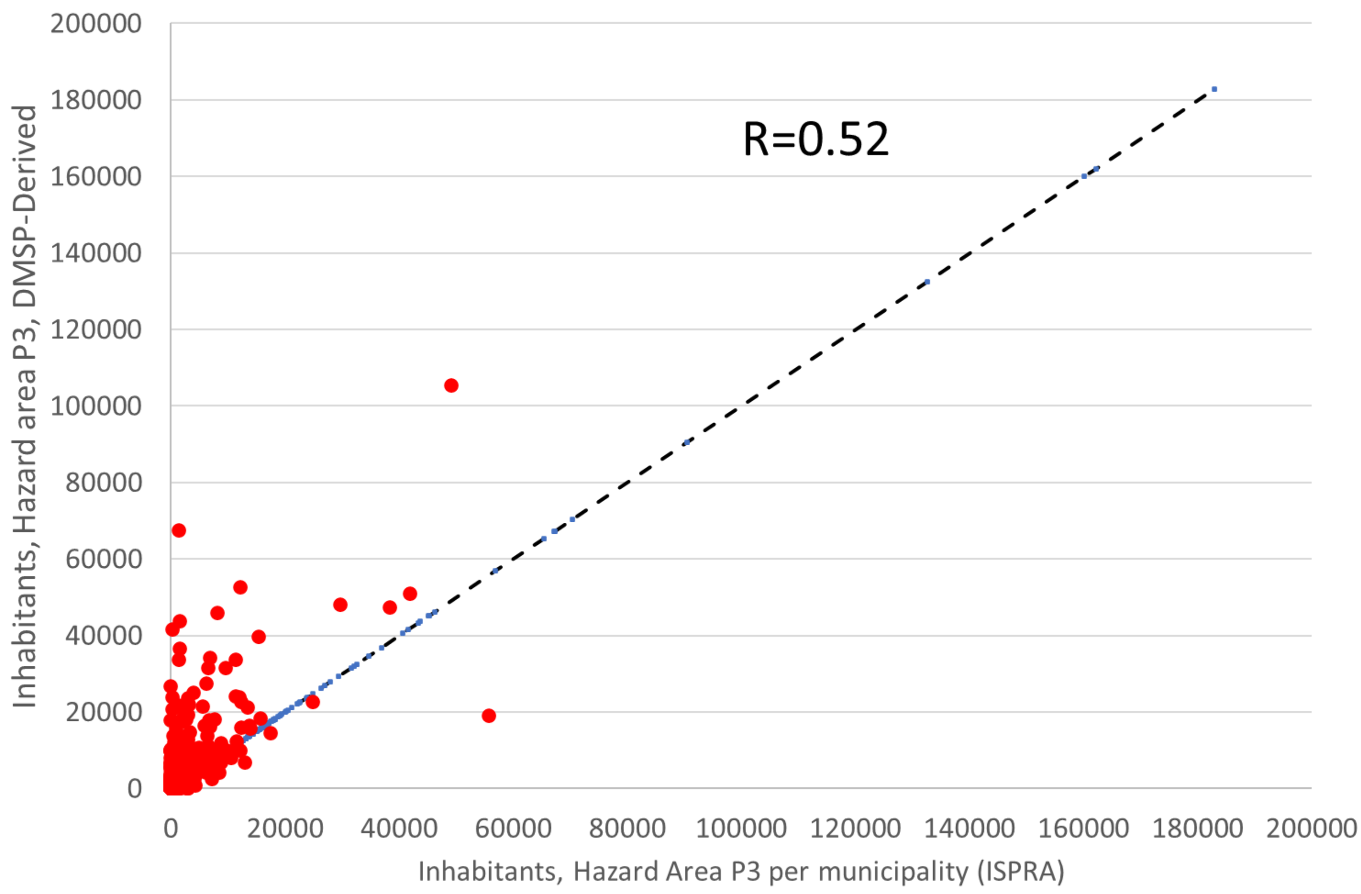
7) Validation with ISPRA DB



This scatterplot shows the correlation between retrieved and actual (ISPRA2011) ***inhabitants in P2 hazard zone.***

Correlation decreases due to the increasing inconsistencies between Satellite data resolution and detail of hazard zones (higher hazard -> smaller and more scattered areas)

7) Validation with ISPRA DB

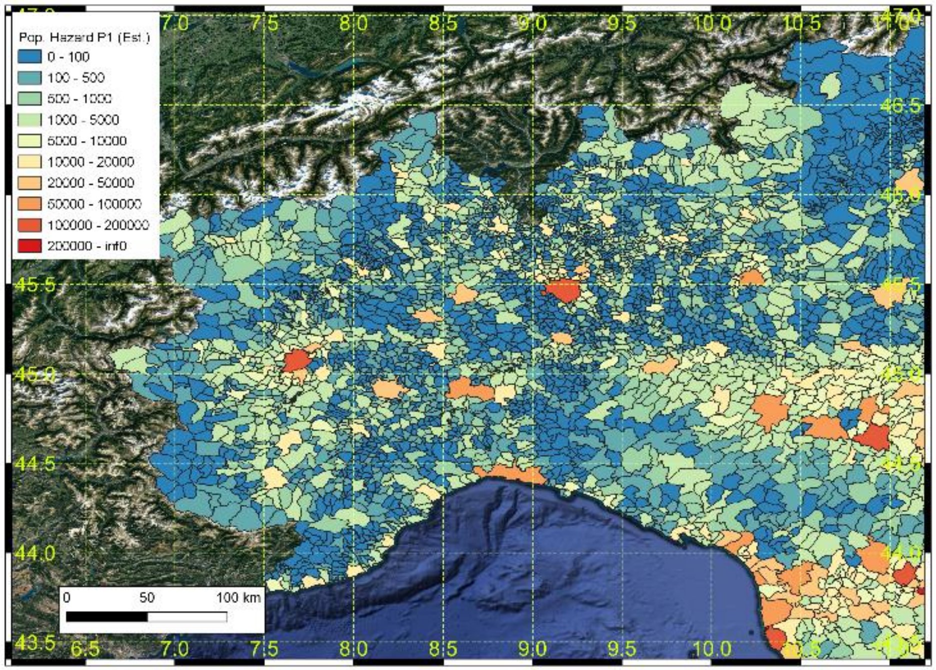


This scatterplot shows the correlation between retrieved and actual (ISPRA2011) ***inhabitants in P3 hazard zone.***

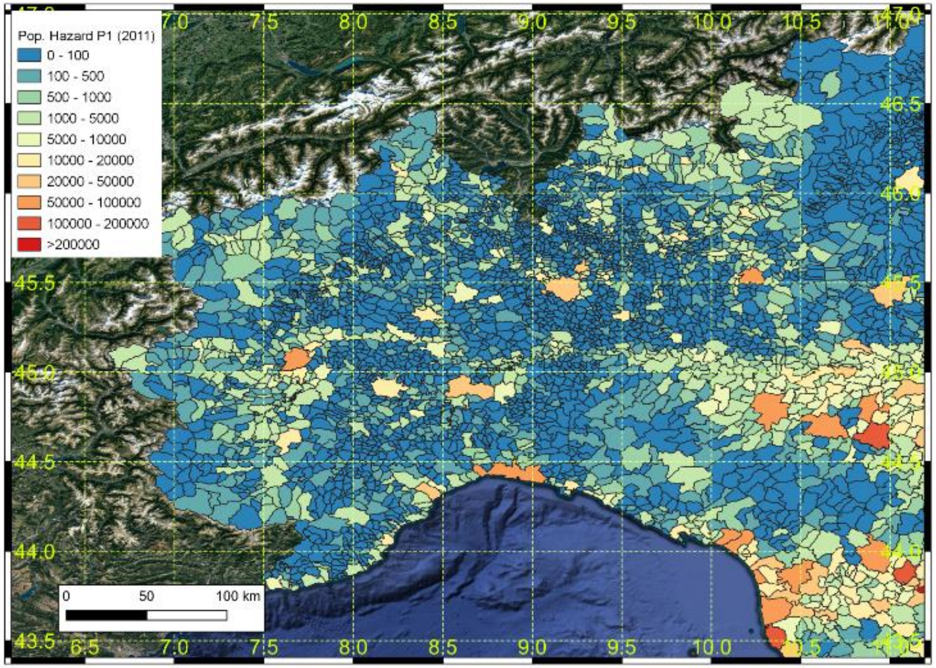
Correlation further decreases since P3 znes are very thin around a number of small rivers and redistributed population at 1km resolution (DMSP resolution) introduces higher approximations

7) Validation with ISPRA DB – visual comparison

Estimate



Istat 2011



Visual comparison between true (ISPRA2011 - right) population exposed to hazard P1 and estimated one (left) highlight the reliability of the method proposed

Final comments

Concluding remarks

1. The methodology proposed allows to produce, using readily available satellite-based information on small portions of a country (calibration region), and national/continental/global flood hazard maps, **maps of population exposed to flood hazard at country scale**
2. **The derived information can be updated quickly** each time a new night light intensity map is available
3. The method can be used reliably to redistribute at smaller scales the population provided by common census data aggregated at municipal, province or country scale outside the calibration region, for a whole country
4. **The validation with independent data shows good agreement** between estimated and true population exposed to flood hazard
5. **The methodology is impacted by the resolution of the night light intensity data**. Products with better resolution than DMSP may improve the performance
6. The methodology provides better results on large flood hazard areas, consistently with the light intensity map resolution

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