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Immobiliare Lab, Rome - Italy



# Geospatial Data Integration with Jupyter Notebook and Open Source Software

Luigi Selmi  
[lselmi@datiaperti.it](mailto:lselmi@datiaperti.it)

NIEDERBERG

HORCHHEIM

KLEIN-VERNICH

GROSS-VERNICH

Weilerswist

NEUHEIM

FRIESHEIM

Umweltzentrum  
Friesheimer  
Busch

Villewälder

61

61

METTERNICH

Verbra  
Maa  
Hellenr

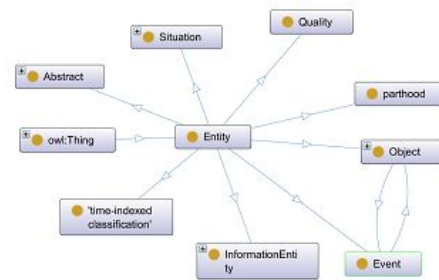
# Who am I



Working Experience: software engineer in enterprises and research institutions in Italy, Switzerland, Germany

Academic Background: Atmospheric Physics (Sapienza University of Rome)

Interests: satellite imagery, algorithms and machine learning applied to geospatial and climate data



# PyData

- Communities of open source software users and developers: 230 groups in 80 countries, 6 in Italy
- Supported by NumFOCUS (Jupyter, NumPy, Pandas, Matplotlib,..)
- PyData Rome started in Nov. 2022, 102 members, 4 meetups

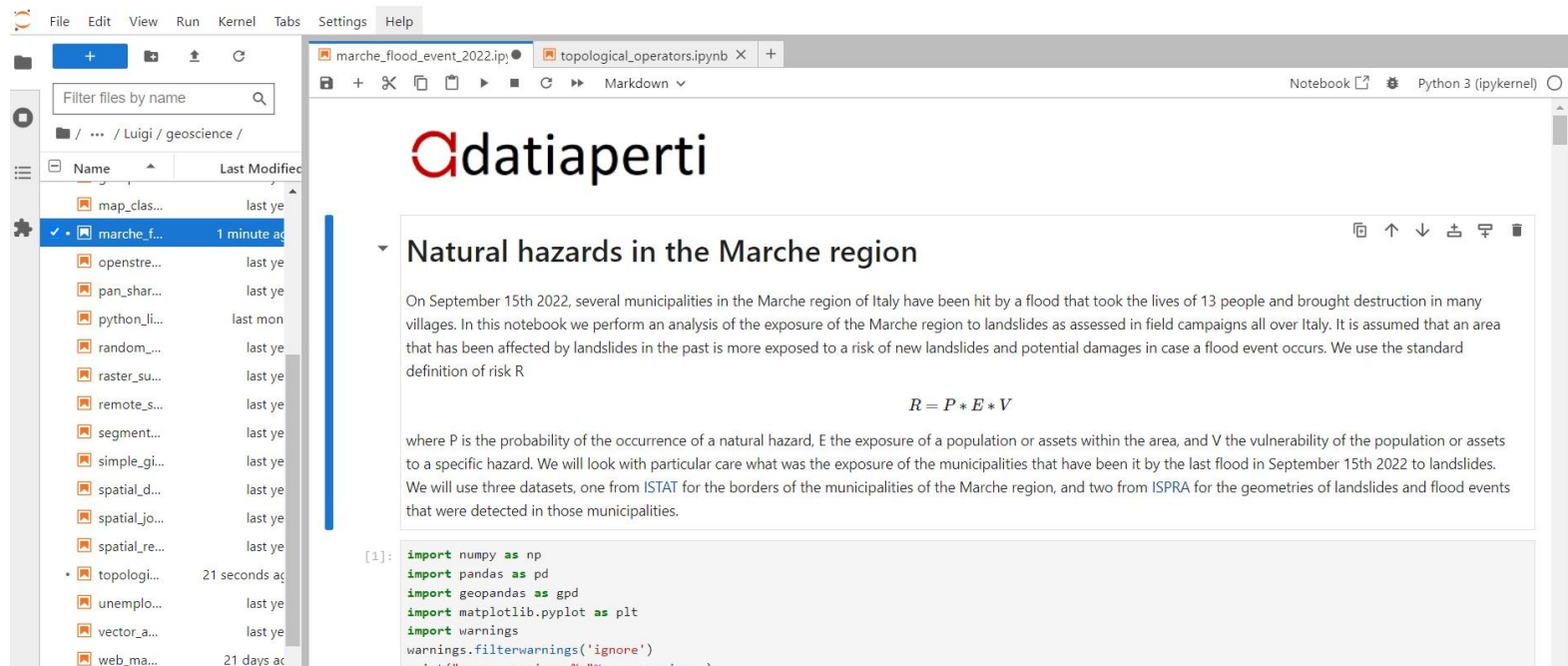


# Outline

- Jupyter Notebook as an IDE for prototyping
- Creating new data products from open datasets: raster, vector, statistics
- Topological operators for spatial reasoning
- Risk assessment: landslides and floods in the Marche region
- Conclusion

# Jupyter Notebook

Without further ado..



The screenshot displays the Jupyter Notebook interface. On the left is a file explorer sidebar showing a directory structure under 'Luigi / geoscience /'. The main notebook area has a menu bar (File, Edit, View, Run, Kernel, Tabs, Settings, Help) and a toolbar. The notebook title is 'marche\_flood\_event\_2022.ipynb'. The content of the notebook cell includes the 'datapierti' logo, a section header 'Natural hazards in the Marche region', a paragraph of text, a mathematical formula, another paragraph, and a code block.

**datapierti**

## Natural hazards in the Marche region

On September 15th 2022, several municipalities in the Marche region of Italy have been hit by a flood that took the lives of 13 people and brought destruction in many villages. In this notebook we perform an analysis of the exposure of the Marche region to landslides as assessed in field campaigns all over Italy. It is assumed that an area that has been affected by landslides in the past is more exposed to a risk of new landslides and potential damages in case a flood event occurs. We use the standard definition of risk  $R$

$$R = P * E * V$$

where  $P$  is the probability of the occurrence of a natural hazard,  $E$  the exposure of a population or assets within the area, and  $V$  the vulnerability of the population or assets to a specific hazard. We will look with particular care what was the exposure of the municipalities that have been hit by the last flood in September 15th 2022 to landslides. We will use three datasets, one from ISTAT for the borders of the municipalities of the Marche region, and two from ISPRA for the geometries of landslides and flood events that were detected in those municipalities.

```
[1]: import numpy as np
import pandas as pd
import geopandas as gpd
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')
```

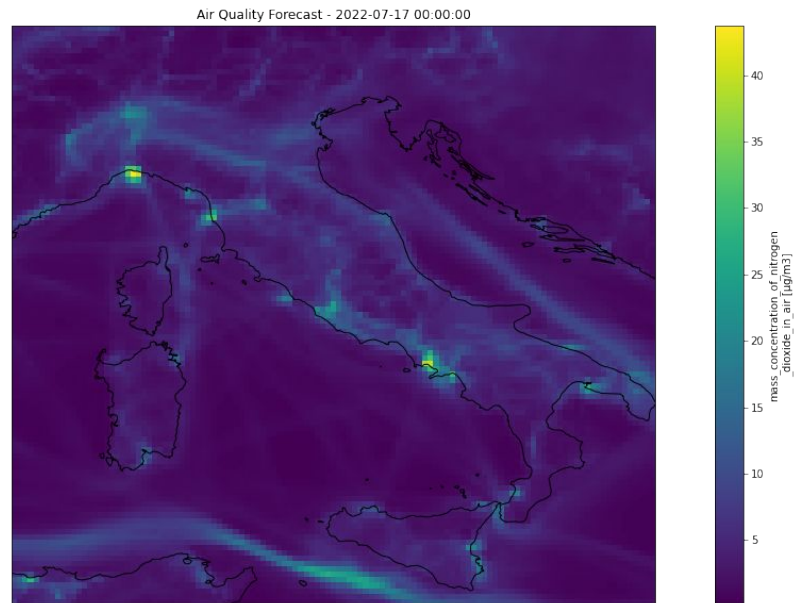
# Open Data

The EU Directive 2019/1024 on open data and the re-use of public sector information established the following as high-value datasets

- Geospatial
- Earth observation and environment
- Meteorological
- Statistics
- companies and company ownership
- mobility

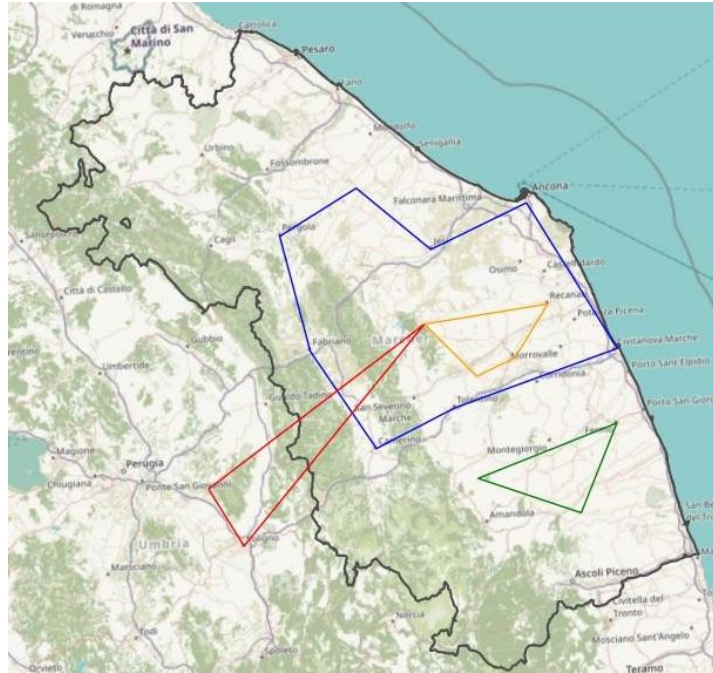


# Open Data - Examples



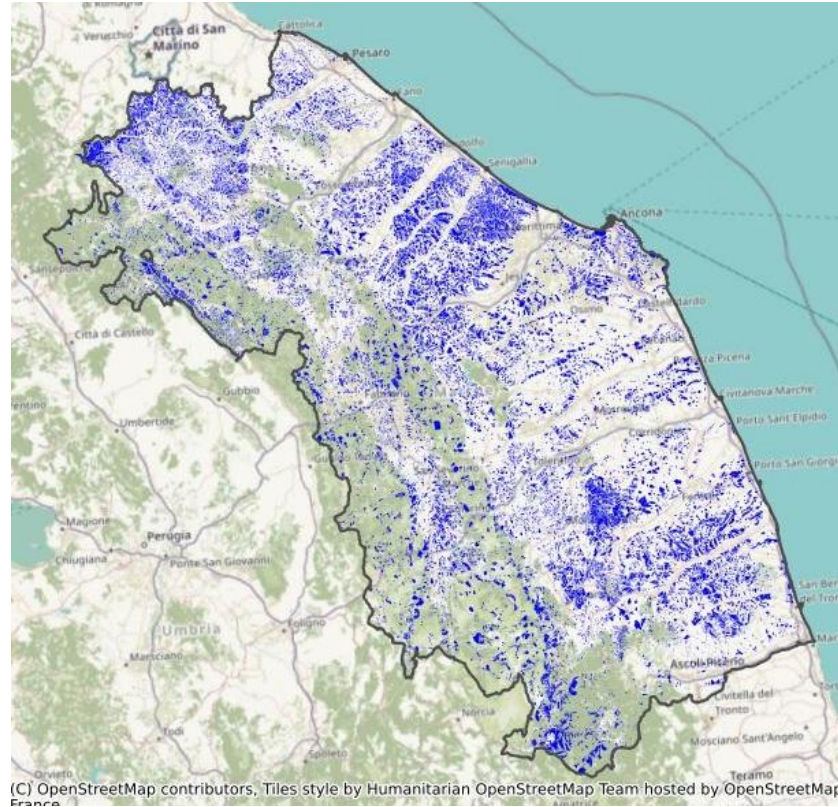
# Spatial Reasoning: Topological Operators

within, intersects, touches, covers, overlaps

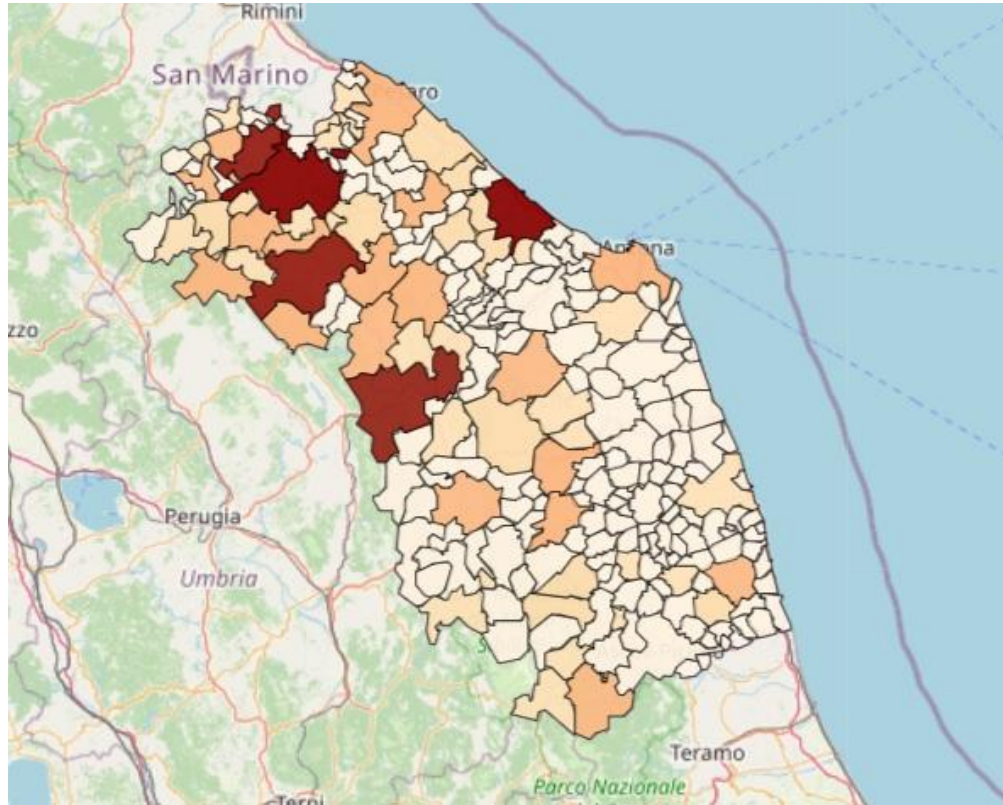




# Risk Assessment: landslides in the Marche region



# Number of landslides



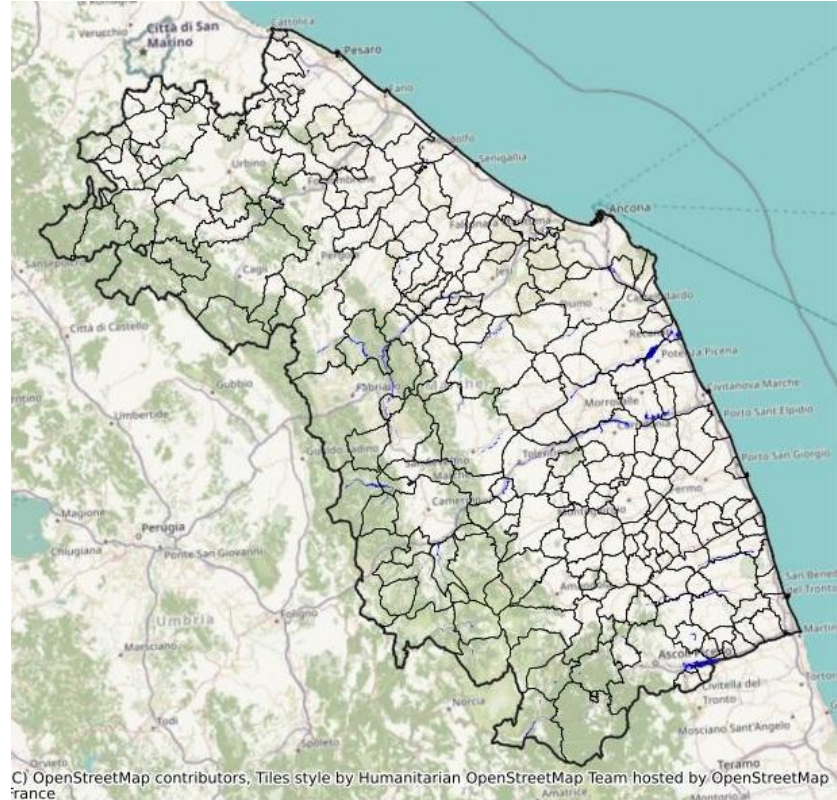
# Flood risk in the Marche region

There are 158 areas at risk of flood but the dataset does not provide the toponyms so we need to add them to it using the topological operators and the dataset of the region's municipalities

	scenario	geometry
0	Pericolosita' idraulica bassa - LowProbability...	POLYGON ((816476.192 4173280.111, 816449.779 4...
1	Pericolosita' idraulica bassa - LowProbability...	POLYGON ((807674.627 4200250.348, 807691.313 4...
2	Pericolosita' idraulica bassa - LowProbability...	POLYGON ((810203.964 4208515.556, 810266.895 4...
3	Pericolosita' idraulica bassa - LowProbability...	POLYGON ((812030.591 4214361.886, 812019.495 4...
4	Pericolosita' idraulica bassa - LowProbability...	POLYGON ((811810.404 4215280.789, 811849.523 4...

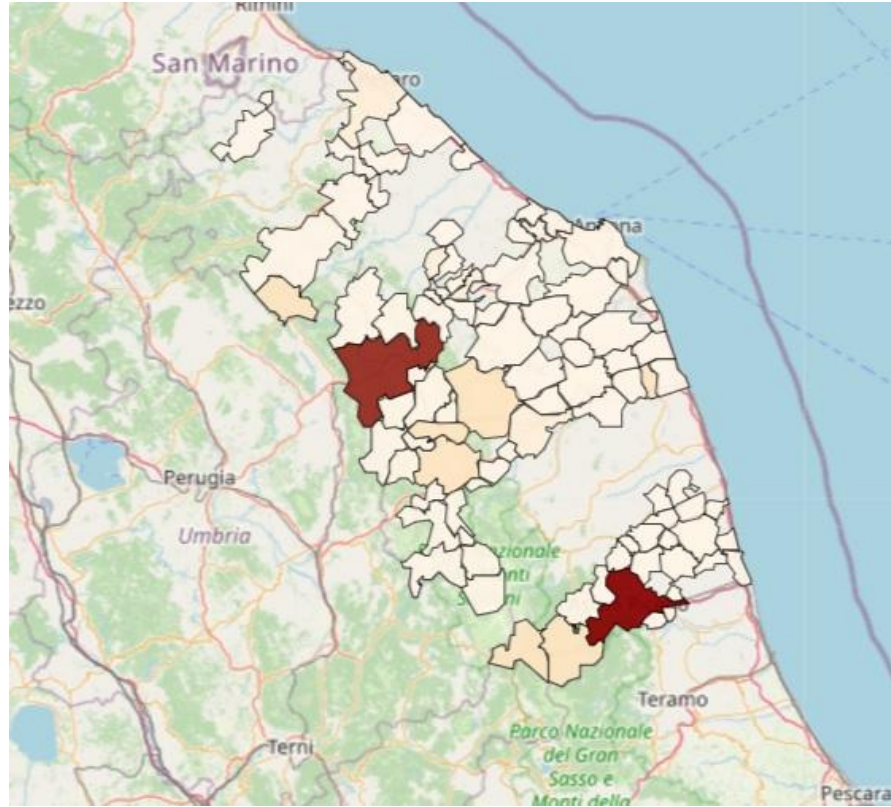
# Risk Assessment: floods in the Marche region

Using the ***within*** and the ***intersects*** operators between the areas at risk and the polygons of the Marche region and of its municipalities we can map them and have some useful statistics, e.g.: 90 municipalities out of 225 are at risk of flood





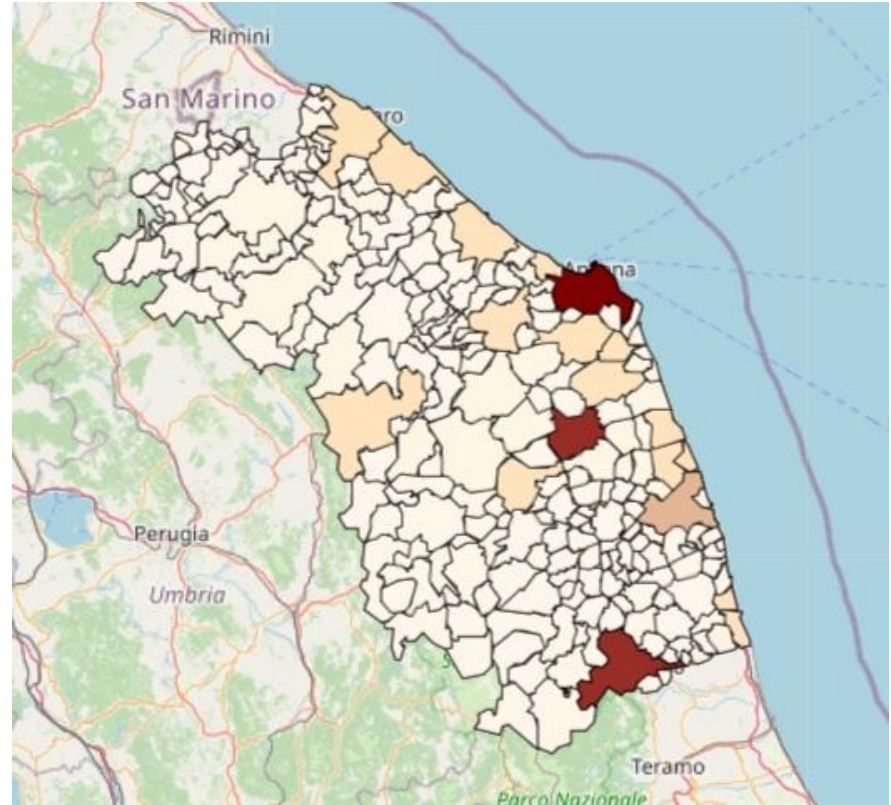
# Risk Assessment: floods in the Marche region





# Population

Risk is associated to events that have a negative impact on the population or on their assets that are exposed to them, depending on their vulnerability, i.e. their capacity to avoid or reduce those impacts.



## Risk: a definition

$$R = \sum_i P_i * E_i * V_i$$

Probability = [0, 1], probability of floods or landslides (aka extreme events)

Exposure = [0, 1], population or assets

Vulnerability = [0, 1], infrastructures or safety systems (or lack of them)

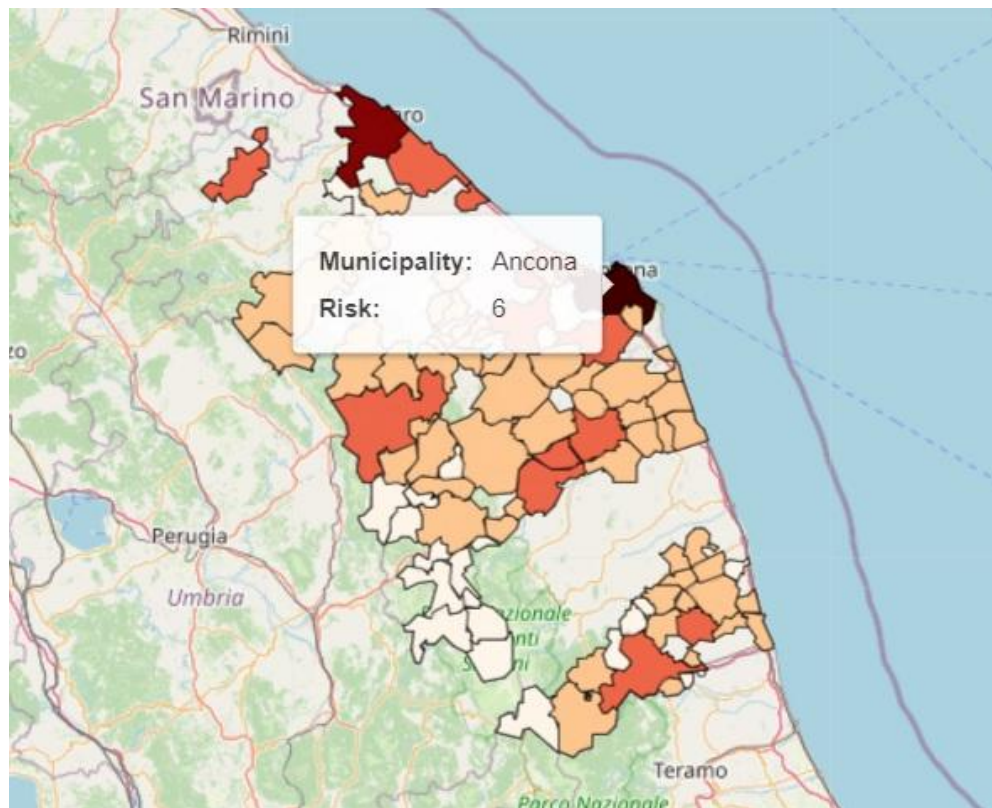
# Ranking the municipalities by risk

We can order the municipalities by their exposure to floods and landslides using a formula such as

$$Risk = \log\left(\frac{Floods + Landslides}{Area} * Population\right)$$

This is of course a very rough estimation, its only purpose is to show how to compute a ranking.

# Risk map



# Conclusion

We have shown how to make up a very rough idea of risks using a Jupyter Notebook, some open datasets, and some topological operators to merge those datasets. More precise and useful estimations of risks can be computed with more detailed datasets and procedures.



# Code and more details

## **Topological operators:**

[https://github.com/luigiselmi/geoscience/blob/main/topological\\_operators.ipynb](https://github.com/luigiselmi/geoscience/blob/main/topological_operators.ipynb)

## **Landslides and floods in the Marche region**

[https://github.com/luigiselmi/geoscience/blob/main/marche\\_flood\\_event\\_2022.ipynb](https://github.com/luigiselmi/geoscience/blob/main/marche_flood_event_2022.ipynb)

# Some references

- Pasini - L'equazione dei disastri
- FEMA - National Risk Index
- Bousquet - Extreme Value Theory with Applications to Natural Hazards



# Thank you for your attention!

Email: [lselmi@datiaperti.it](mailto:lselmi@datiaperti.it)

Personal website:

<https://www.luigiselmi.eu/>

Company website:

<https://www.datiaperti.it/>



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## Connecting data that matters

Data is not a scarce resource  
In order for it to be useful and become information  
and knowledge we need to unearth the gems  
buried under gigabytes of waste

Data is not a scarce resource. In order for it to be useful and become information and knowledge we need to unearth the gems buried under gigabytes of waste and connect them in a mosaic, something that we can use and share. We have decided to focus on data that matters. Nowadays many datasets are released by scientific institutions, governmental organizations and communities under an open data license. Those datasets can help to address the challenges we have in front of us, improve our work and products, and help us to plan our future the way we want.

### Areas of Expertise

We work on projects in the areas described in the following sections

