UNIVERSITÀ DEGLI STUDI FIRENZE

DST DIPARTIMENTO DI SCIENZE DELLA TERRA

An attempt to increase the geological information in landslide susceptibility mapping and sensitivity to different geological parameters

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Background and research questions

- **Geology** is widely acknowledged as one of the **main predisposing factors** in landslide susceptibility mapping (LSM).

- Usually, LSM studies include **only lithology**, which is just **a part** of the information conveyed by geological maps.

- **Additional information** provided by geological maps may incude: age, paleaoenvironment of deposition, genesis, tectonic history.

- The **potentiality** of geological maps is largely **unexploited** in LSM studies.

Objective and study area

Main objectives

:

- Defining new and advanced parameters based on geology.

- Testing their effectiveness.

- Exploring the sensitivity of LSM to geological parameterization.

- Defining an optimal set of geological parameters and understanding how to handle complex geological information to improve future LSM studies.

Study area

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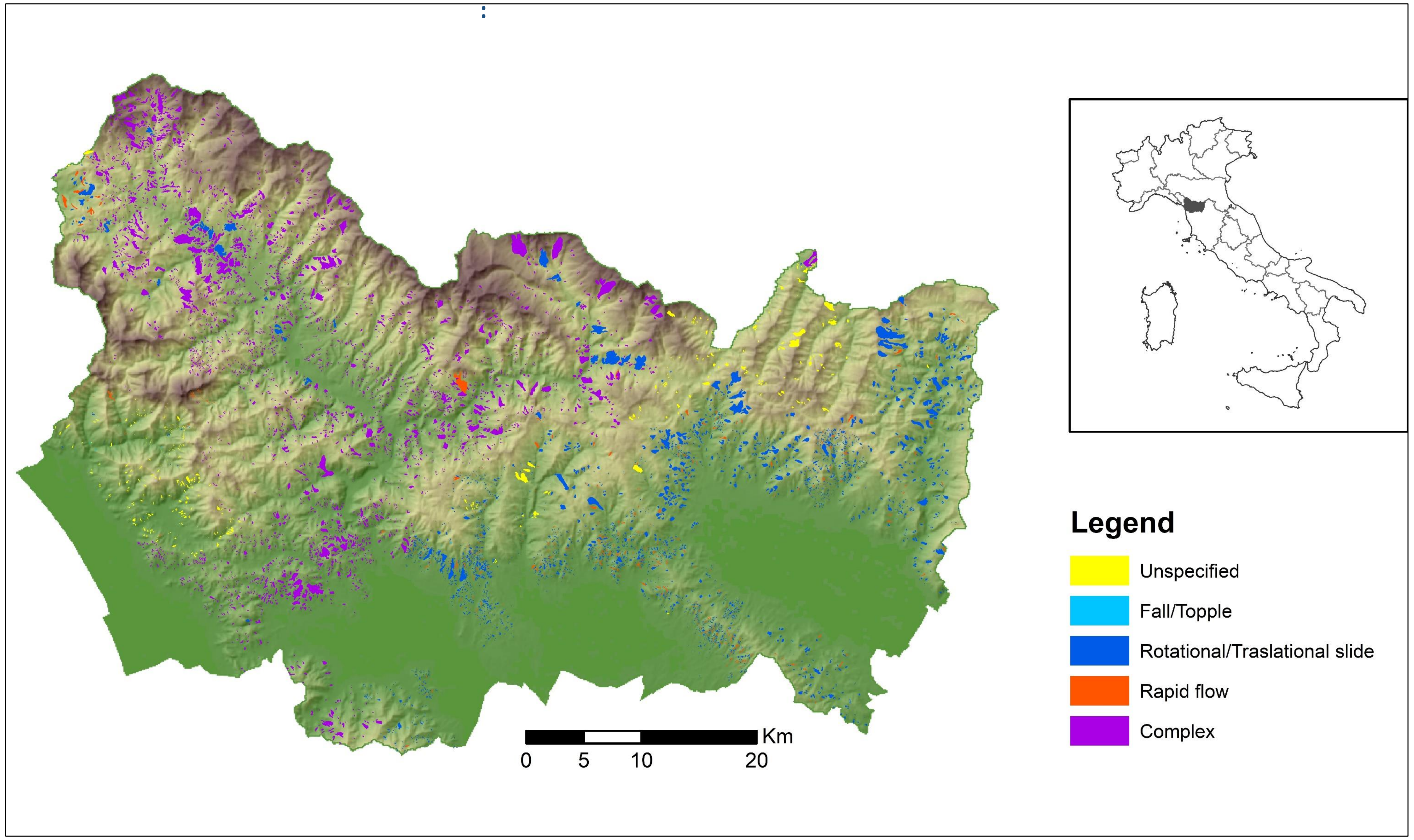


- Northern Tuscany, 3,100 km^2
- Complex geological setting (see next page)
- Italian National inventory of Landslides (IFFI)
- About 7000 landslide polygons with triggering mechanism initiated as a slide

Methodology - geology

Geological parameters derived from a 1:10,000 scale digital geological map including 194 lithostratigraphic units

The lithostratigraphic units were grouped in six different classes related to specific geological characteristic

Lithologic approach: 6 units classified according to their prevailing lithology. The criterion is widely used in landslide susceptibility studies

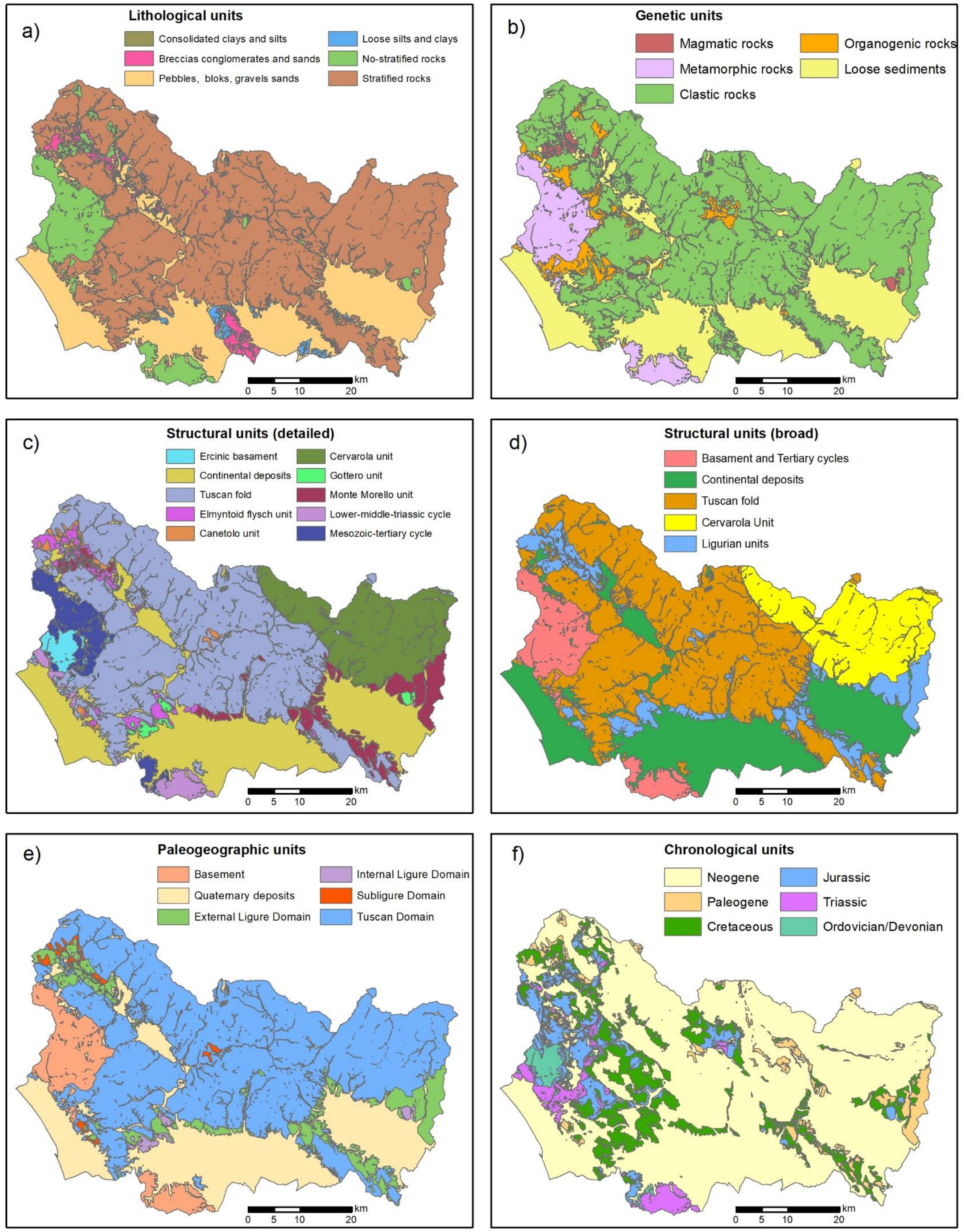
Genetic approach: 5 units grouped according to the genetic process: magmatic rocks, metamorphic rocks, clastic rocks, organogenic rocks, soils

Structural approach (detailed): 10 structural units subdivided according to their evolution and response to tectonic forcing. The units were subject to a particular tectonic stress-strain history (uplifting, folding, faulting, displacement, and thrusting).

Structural approach (broad): 5 structural units classified according to the above criterion.

Chronological approach: 6 units grouped according to the age of deposition (accounting for the degree of weathering and the exposition to tectonic stress).

Paleogeographic approach: 6 units to highlight differences on mineralogical or textural characteristics according to the environment of deposition



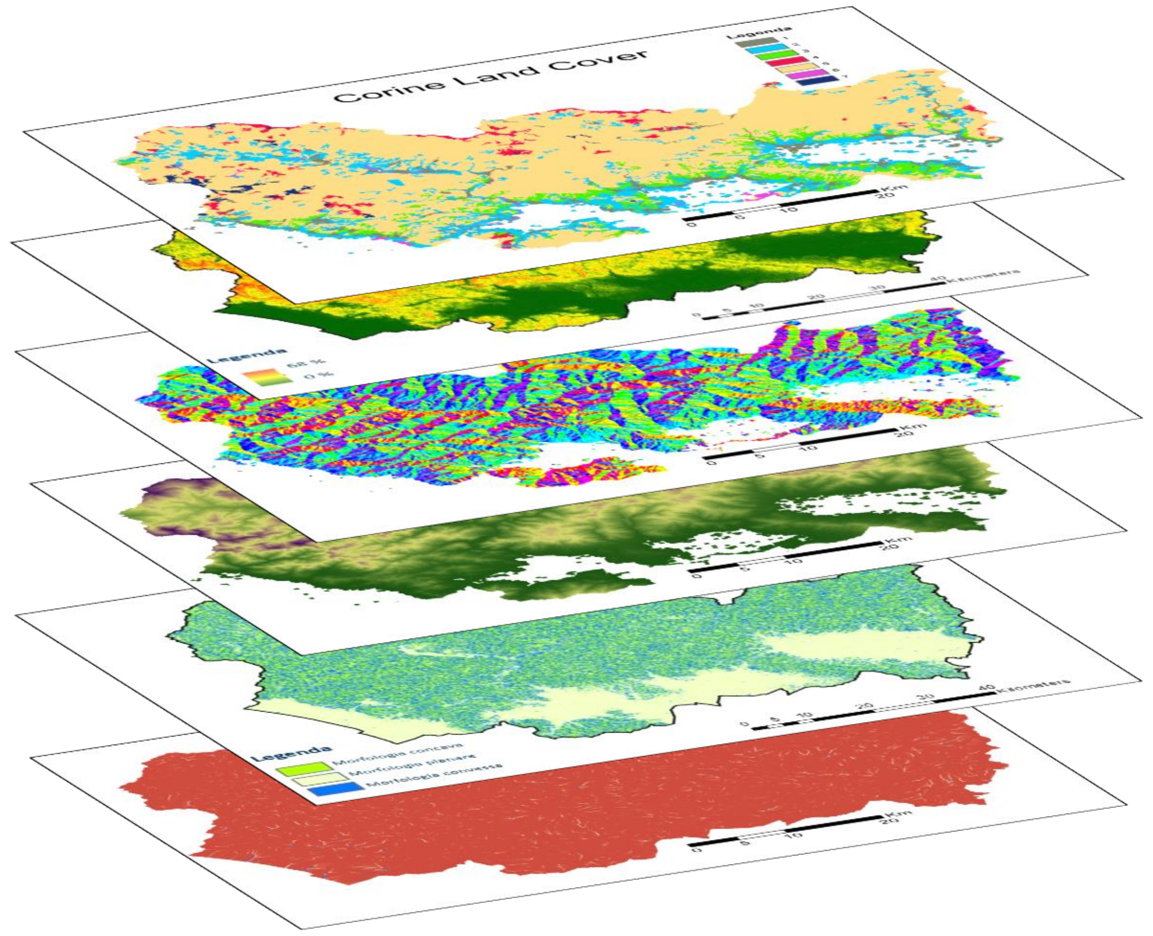
Six geological parameters

Methodology - modeling

- Random Forest algorithm
- Regression mode (200 trees, 20 runs)
- Rotational/translational/compound slides
- 15,500 sample points
  - 50%-50% landslides and no landslides
  - 70% training, 30% test
- Different tests varying the geological parameterization

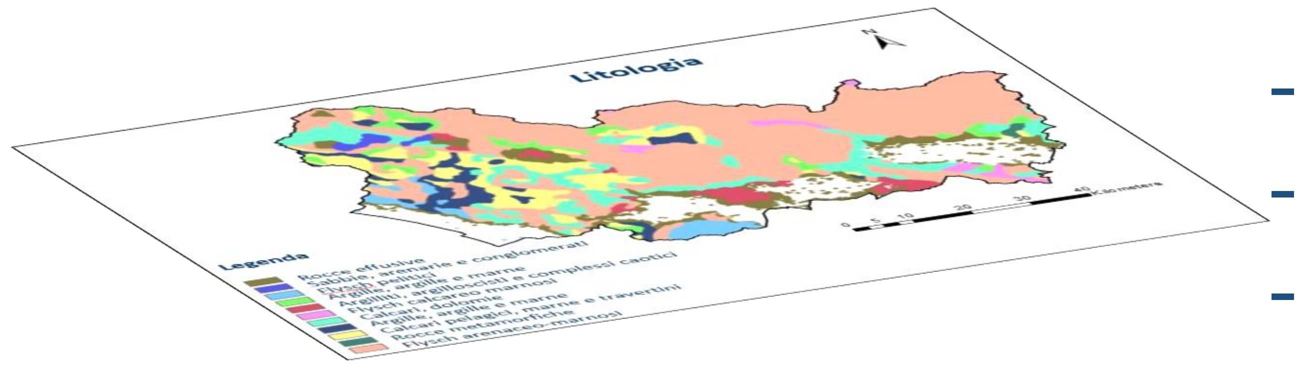
Independent variables

6 «base variabiles»



Land use / land cover
Elevation
Aspect
Slope gradient
Planar curvature
Flow accumulation

Geological variables



- Each variable alone
- None of them
- All of them together

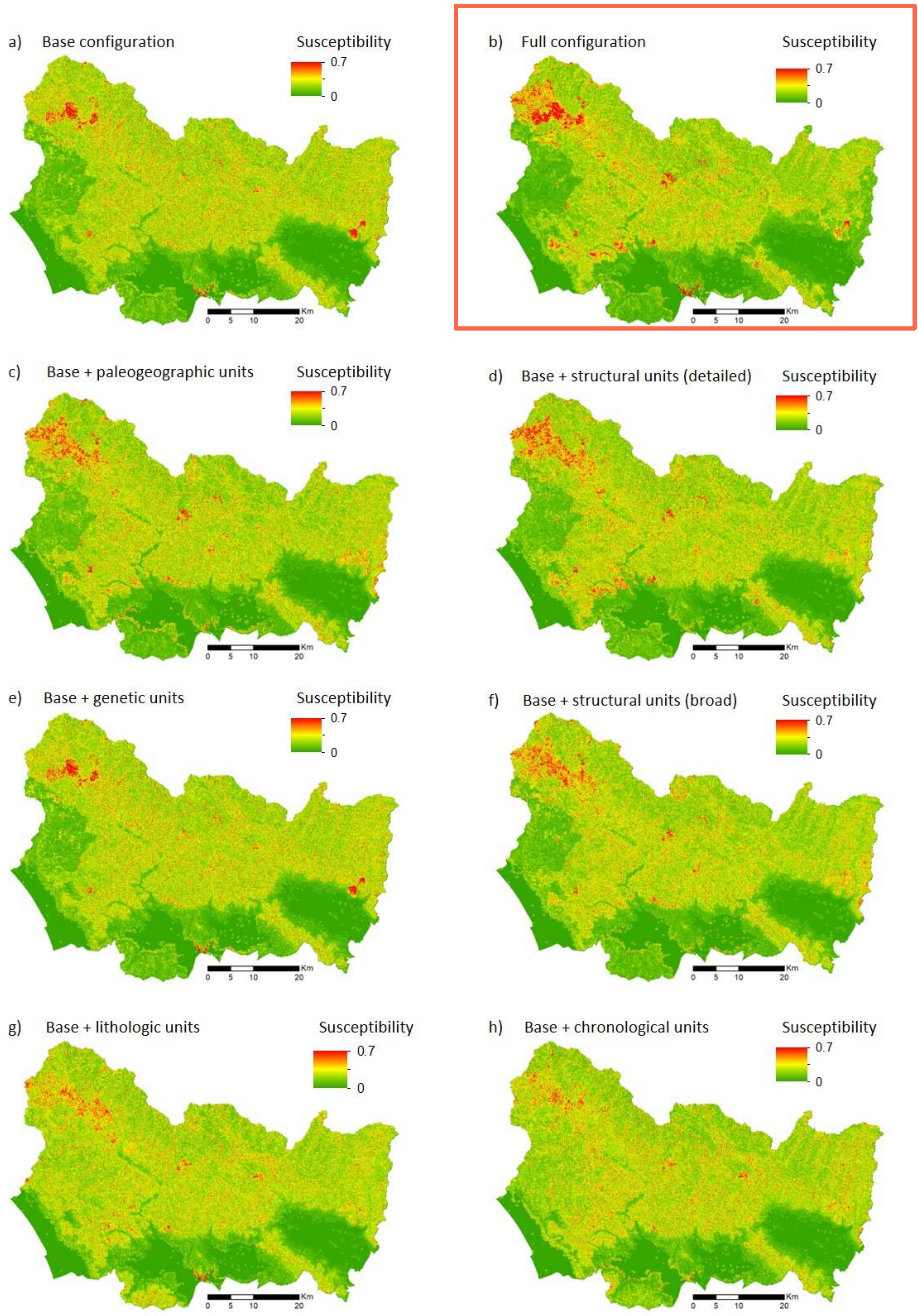
Results (AUC)

- Model run in different configurations
- Susceptibility maps
- Validation
- ROC curves, AUC values (overall accuracy of the model)
- Comparison and identification of the most effective parameterization

Test	Mean AUC	Max AUC
BASE configuration (no geology)	0.606	0.630
BASE + chronological units	0.635	0.656
BASE + structural (detailed)	0.640	0.652
BASE + paleogeographic units	0.648	0.665
BASE + structural units (broad)	0.657	0.676
BASE + lithologic units	0.661	0.682
BASE + genetic units	0.700	0.724
Full configuration (base + all criteria)	0.752	0.774

Overall accuracy

Ranking of the model configurations according to their effectiveness (assessed by the AUC values)



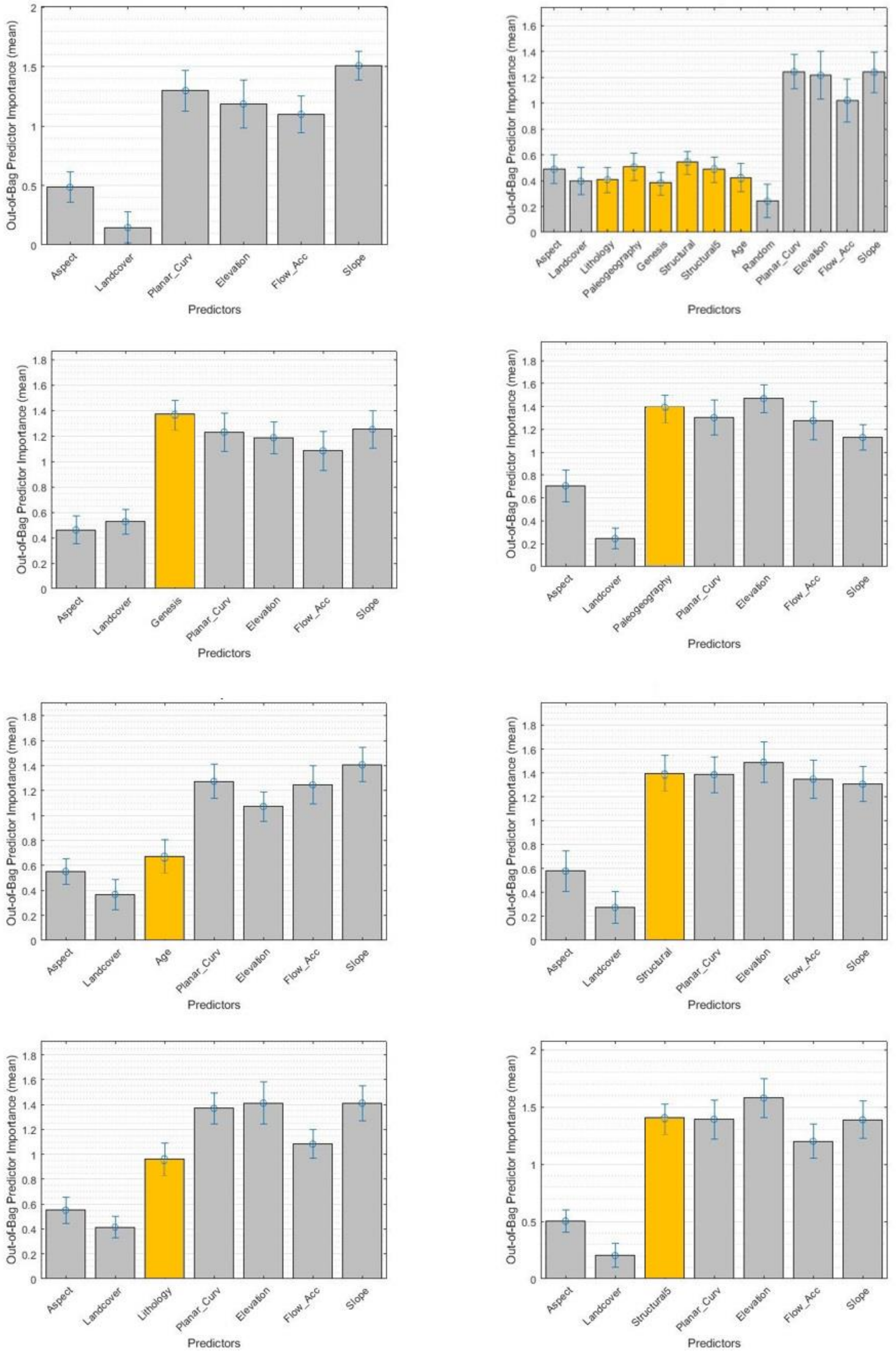
Susceptibility maps obtained with the different configurations tested

Results (OOBE)

- Out Of Bag Error (OOBE) estimates the relative importance of each variable used in a model configuration.

- It can be used to rank the variables according to their explanatory power.

- Where the relative importance of the geological variable is high, also the AUC is high.



Out of bag error (OOBE) of the variables

Predictors with geological significance

Conclusions

- Landslides susceptibility is very sensitive to geological parameterization.
- If a single geological parameter is used, lithology is not always the best option: in our case of study it was outperformed by age.
- The best prediction was obtained when all the geological parameters were used together.
- Different geology-based parameters can perform better than only a geological parameter:
  - the information is not redundant;
  - different geological characteristics influencing landslide predisposition may be accounted for.

Thank you for your attention

Based on

Segoni, S., Pappafico, G., Luti, T., Catani, F. Landslide susceptibility assessment in complex geological settings: sensitivity to geological information and insights on its parameterization. *Landslides* (2020).

https://doi.org/10.1007/s10346-019-01340-2