UNIVERSITÀ DEGLI STUDI FIRENZE

DST DIPARTIMENTO DI SCIENZE DELLA TERRA

An advanced method to validate and compare susceptibility maps by investigating local-scale differences and highlighting the role of geomorphological features

EGU

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Background and research questions

- In landslide susceptibility mapping (LSM) studies, a widely used approach to compare different models is to calculate ROC curves and to compare the AUC (area under curve). The model providing the highest AUC value is considered the «best» one.

- However, AUC provides only an averaged and global evaluation, and the local scale information is lost and completely neglected.

- A new approach is proposed that:
  - shifts the comparison from an overall statistic (AUC value) to the pixel scale,
  - investigates the impact of each input variable in the differences encounterd.

Materials and methods

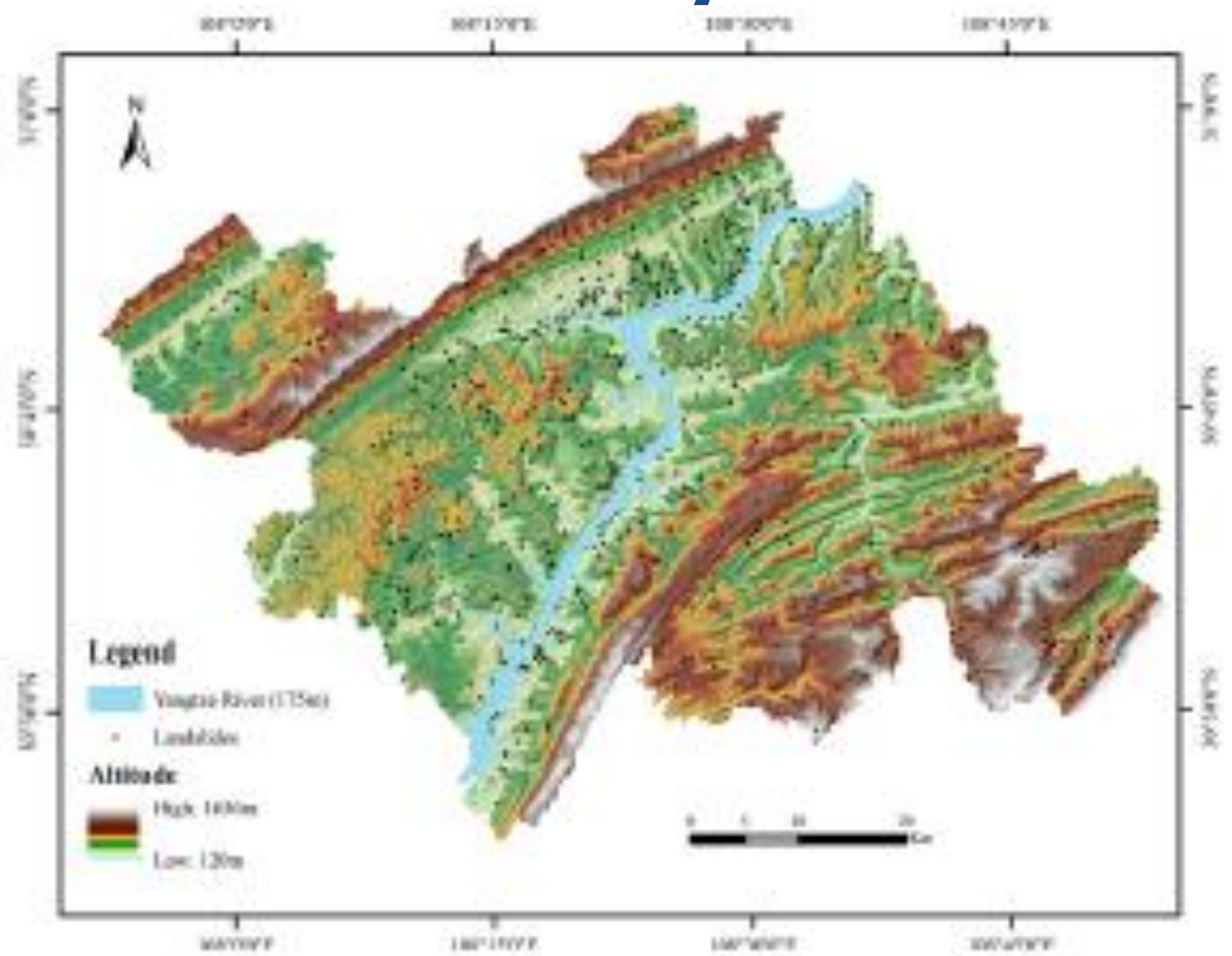
Compared susceptibility maps:

:

- Published in Xiao et al. (2019)
- based on random forest (RF), frequency ratio (FR), certainty factor (CF), and index of entropy (IOE) models.
- 13 causative factors (altitude, slope, aspect, plan curvature, profile curvature, SPI, TWI, bedding, lithology, land use, distance to faults, distance to rivers, distance to roads/railways.
- Subdivided into 80 classes

Xiao T, Yin K, Yao T, Liu S (2019) Spatial prediction of landslide susceptibility using GIS-based statistical and machine learning models in Wanzhou County, Three Gorges Reservoir, China. Acta Geochimica 38(5):654–669. 1-16. https://doi.org/10.1007/s11631-019-00341-1

Study area:



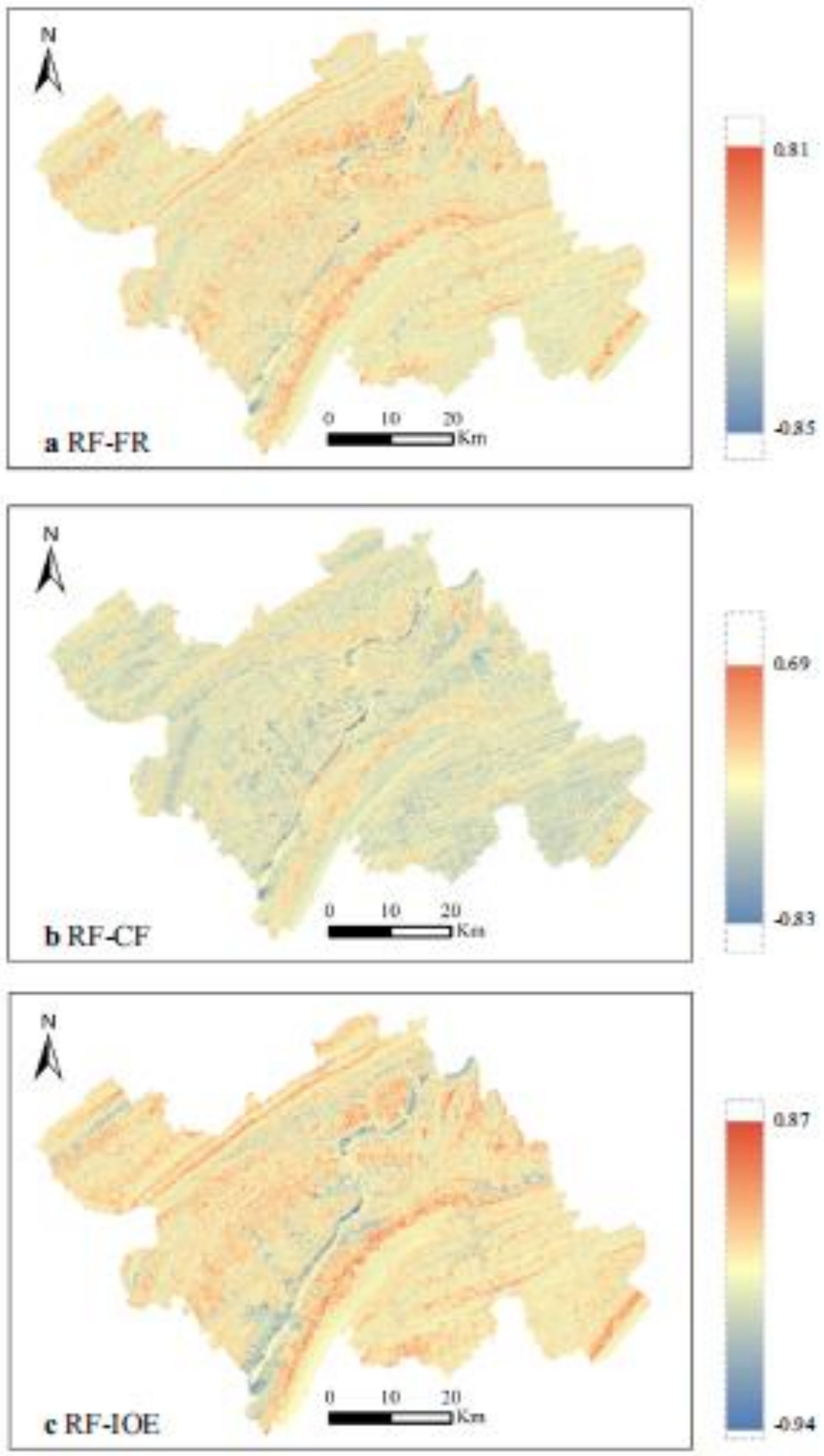
- Key section of Three Gorges Reservoir (TGR), China
- 3,457 km^2 - Landslide area: 102 km^2
- Lithology: sandstones, mudstones, shales, and limestones
- step-like morphology: multi-level fluvial terraces, (combination of tectonic uplift and Yangtze River erosion)

The new approach

1) The susceptibility maps obtained by different models are compared on a pixel-by-pixel basis to define pixels affected by **underestimation** (UE) and **overestimation** (OE) of susceptibility values.
2) Systematic spatial patterns of UE and OE are identified.

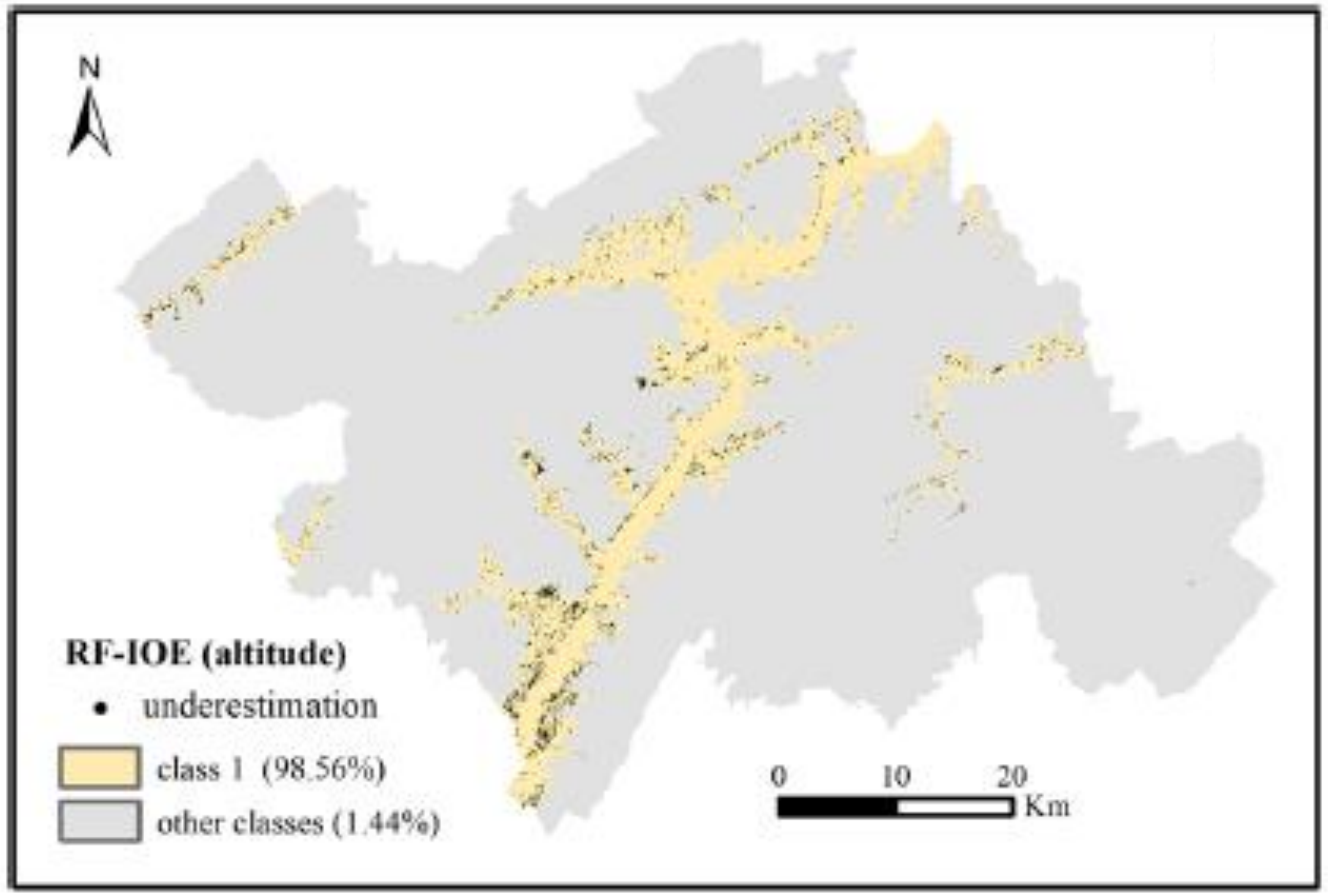
→ With GIS calculations, susceptibility values are subtracted
→ Resulting maps show the differences:
HOW RELEVANT,
WHERE ARE LOCATED

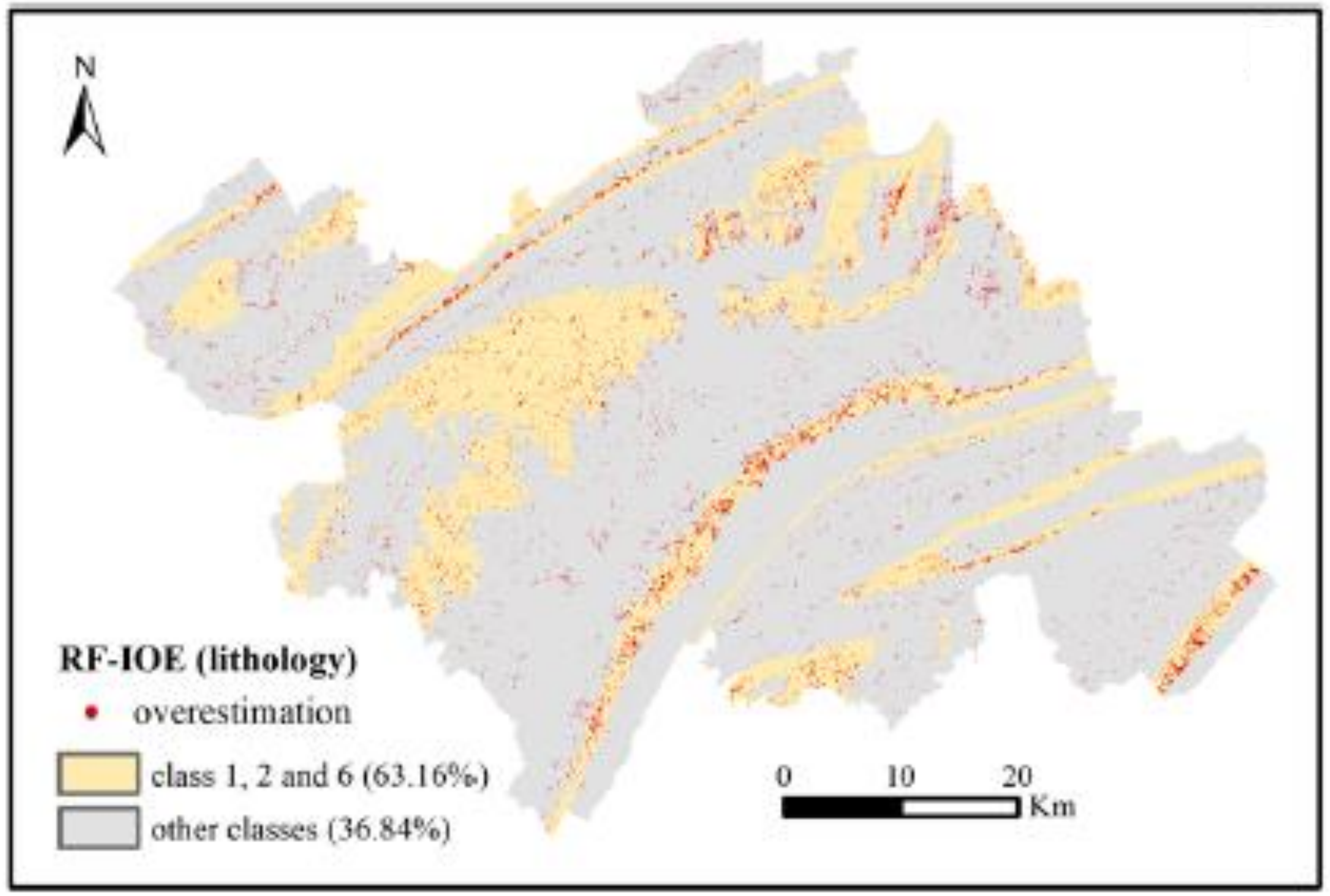
	Value	Classification		Percentage
RF-FR	− 0.85~0.81	Underestimation	− 0.85~− 0.50	0.18
		Approximation	− 0.50~0.50	98.43
		Overestimation	0.50~0.81	1.39
RF-CF	− 0.83~0.69	Underestimation	− 0.83~− 0.50	1.57
		Approximation	− 0.50~0.50	98.31
		Overestimation	0.50~0.69	0.12
RF-IOE	− 0.94~0.87	Underestimation	− 0.94~− 0.50	0.93
		Approximation	− 0.50~0.50	96.65
		Overestimation	0.50~0.87	2.42



The new approach

3) The patterns are cross-checked with all the explanatory variables used in the susceptibility assessments.

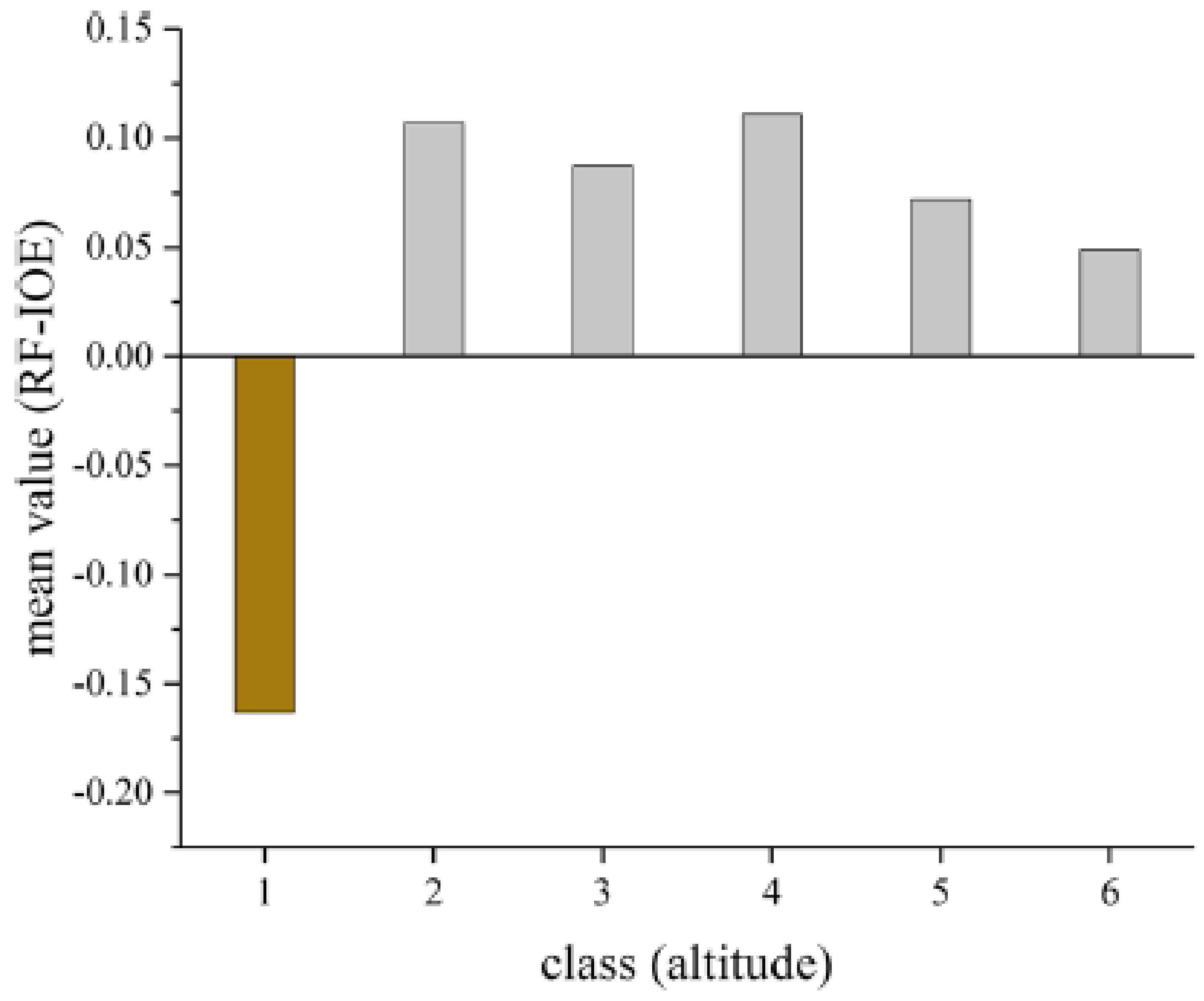




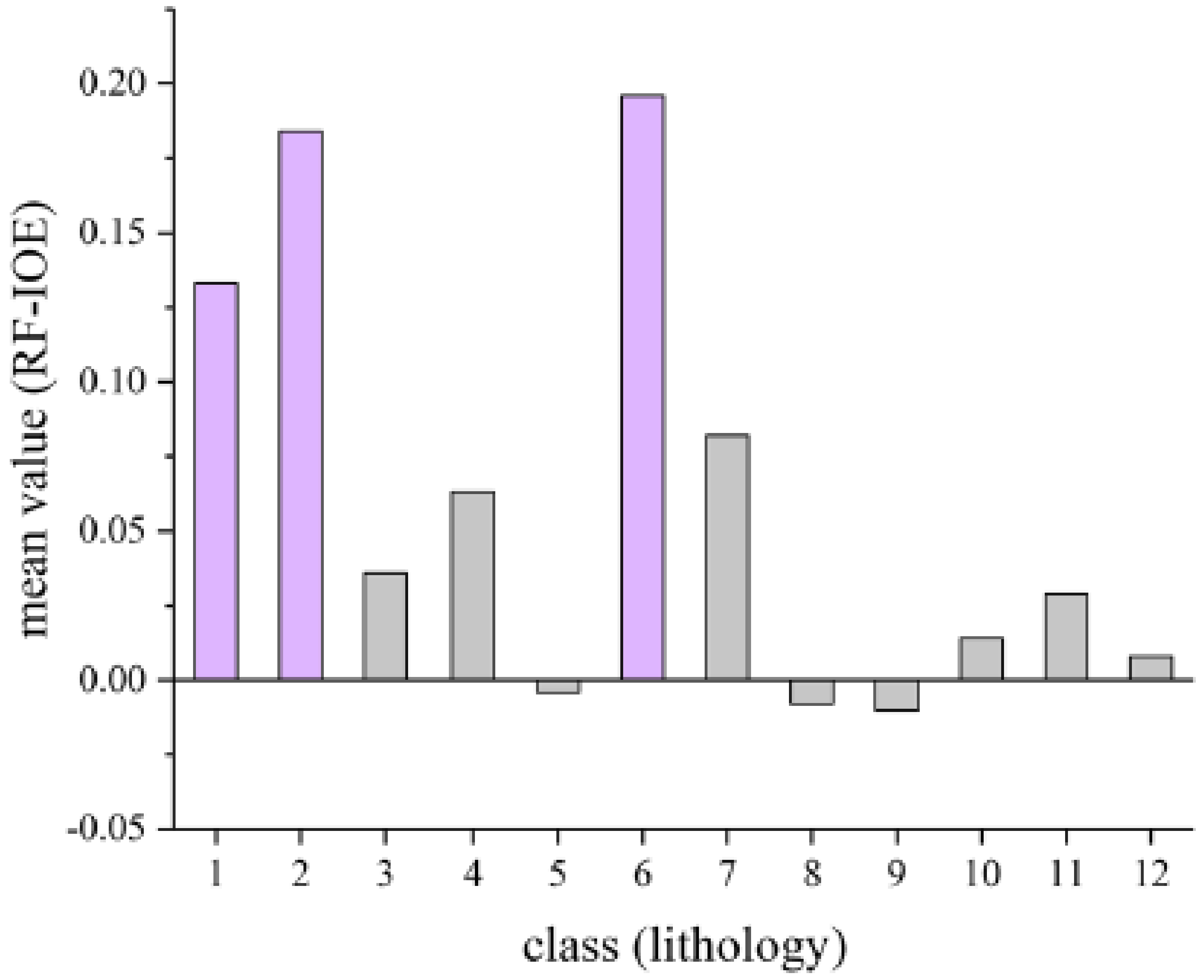
→ Despite UE and OE are limited in number, their spatial distribution seems systematically connected with some classes of the input variables

The new approach

4) The lithological and morphological features of the study area that are typically associated to underestimations and overestimations of susceptibility are identified and quantitatively characterized.



	Comparison maps	Imbalanced classes (descending order)
Underestimation	RF-FR	Altitude, class 1; land use, class 6; Slope, class 1; aspect, class 1
	RF-CF	Lithology, class 10; plan curvature, class 2; Slope, class 1; profile curvature, class 2; Altitude class 3; aspect, class 1
	RF-IOE	Altitude, class 1
Overestimation	RF-FR	Lithology, classes 1, 2, and 6
	RF-CF	Lithology, classes 1, 2, and 6
	RF-IOE	Lithology, classes 1, 2, and 6



The new approach

5) The quantitative information provided by the previous steps is used to provide a geomorphological interpretation of the differences in the susceptibility values provided by the models, thus adding a more robust element to judge which of them should be used in hazard management, and how.

Compared to Random Forest model, the other models (FR, IOE and CF):

overestimate susceptibility in certain lithological classes:
-Red purple quartz sandstone with interbedded mudstone
-Light gray lithic sandstone and silty shale
-Gray quartz sandstone with interbedded shale

underestimate susceptibility in correspondence to relict and inactive fluvial terraces
--> landslides could have been one of the geomorphological processes most involved in the disruption of relict and inactive terraces, which originally were developed in 5 orders.

Conclusions

Traditional comparison:

MODEL	AUC
RF	0.80
IOE	0.74
CF	0.73
FR	0.73

Better model

Proposed approach:

- Differences on a pixel-by-pixel basis ("where" and "how much");
- Identification of systematic errors;
- Errors explained with geomorphological features of the area;
- Additional knowledge is gained on the geomorphological processes of the area;
- Identification of hotspots for further geomorphological investigation.

Thank you for your attention

Based on

Xiao, T., Segoni, S., Chen, L., Yin, K., & Casagli, N. (2020). A step beyond landslide susceptibility maps: a simple method to investigate and explain the different outcomes obtained by different approaches. Landslides, 17(3), 627-640. DOI 10.1007/s10346-019-01299-0

https://link.springer.com/article/10.1007/s10346-019-01299-0