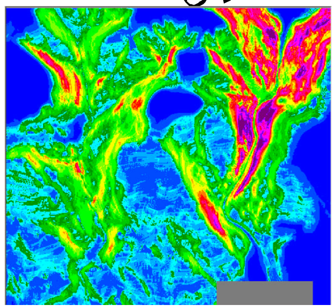
HOW GOOD IS MY HAZARD MAP?



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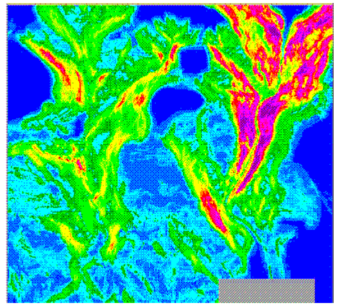
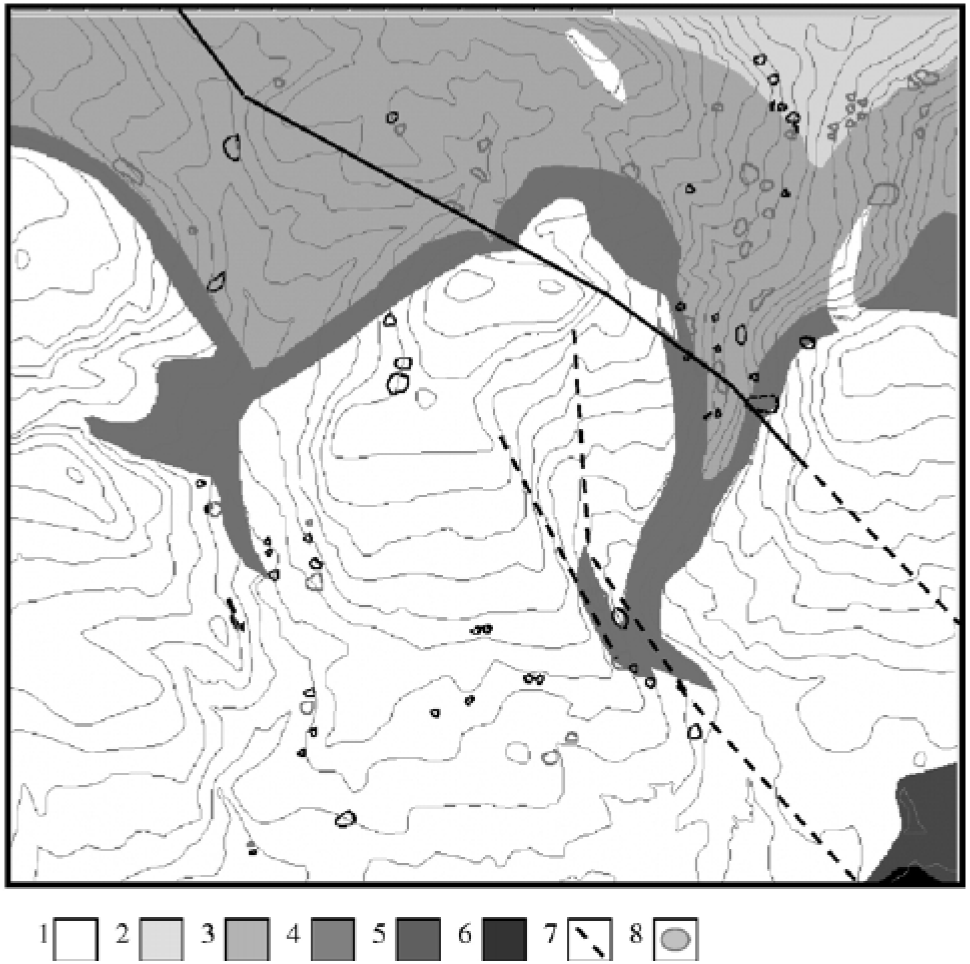


Motivation

- Spatial databases of categorical- and continuous-value maps can be used to represent **typical settings** of occurrence of specific type of slope failure and to generate hazard maps.
- How to interpret such maps?
  How good is my hazard map?
- Goodness relative to **quality** of spatial database? Relative to robustness, **effectiveness** and number of hazard classes?
- **Cross-validation** more important than the prediction models!

Case-study in Portugal part of **training material** in Spatial Prediction Modeling of natural hazard

Location and geologic units in the Fanhões-Trancão Study area, Portugal



1. Volcanics,
2. Sandstones,
3. Marls and marly limestones,
4. Limestones,
5. Lacustrine limestones,
6. Conglomerates and sandstones,
7. Fault (dashed where uncertain),
8. Shallow translational landslides (Gray boundary for 43 pre-1959 landslides and black boundary for 49 post-1980 landslides) (after Zêzere et al., 2004).

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Shallow translational slide triggered in November 993 in the East slope of the Trancão Valley

Source: Zêzere *et al.* (2005)

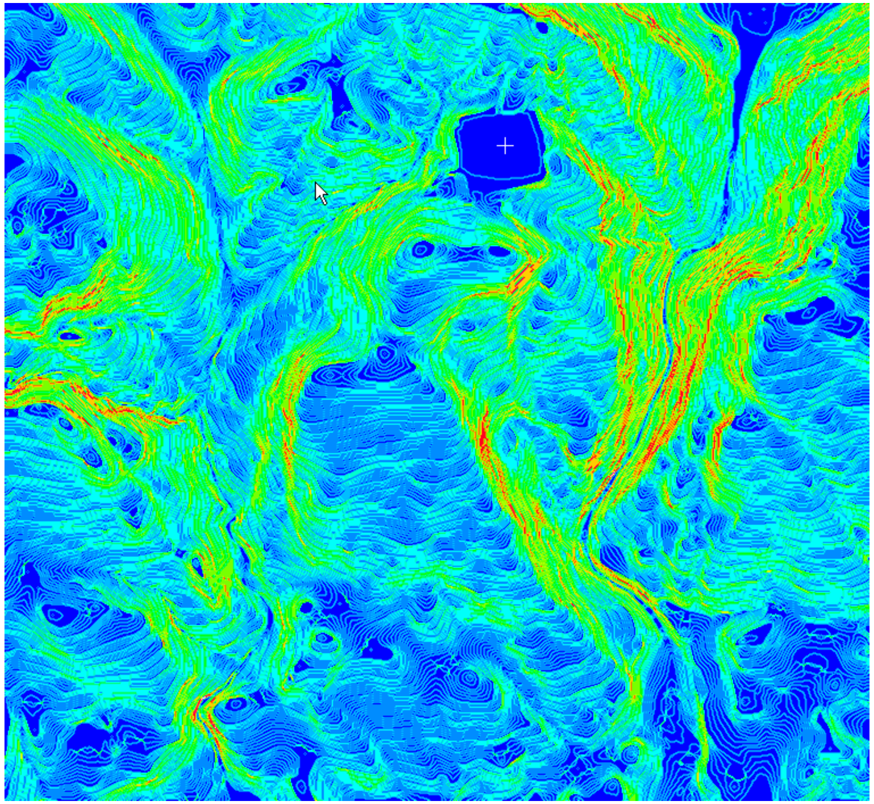
1. Study area 17.36 km^{2}:; within a 760x700 pixel of 5m resolution.
2. Causal map layers: elevation, slope, aspects, geology (6 units), surficial deposits (7), land use (5);
3. Database documented in 1998 (EC Project NEWTECH, Corominas et al., 1998) derived from a study region of University of Lisbon, (Zêzere, 1996a, 1996b, 1997). Start of GIS application at the Department of Geography;
4. Construction time 4-5 months using ILWIS GIS.

Two geomorphological input data layers for prediction models, Fanhões-Trancão area, Portugal

Caegorical Data Layer:
Surficial materials

Land-use maps, forest-coverage maps, bedrock geology maps, etc

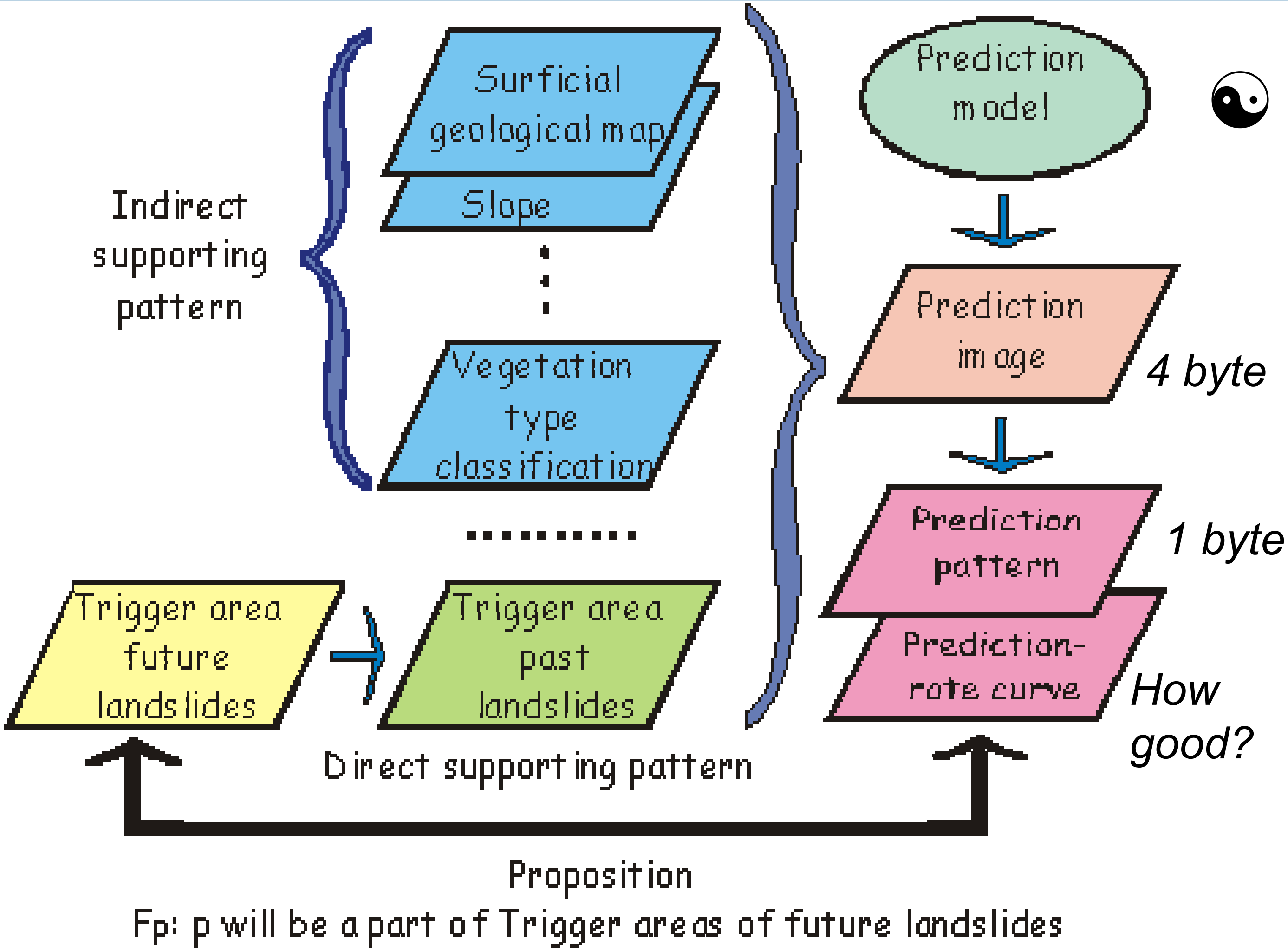
Continuous Data Layer:
Slope angles

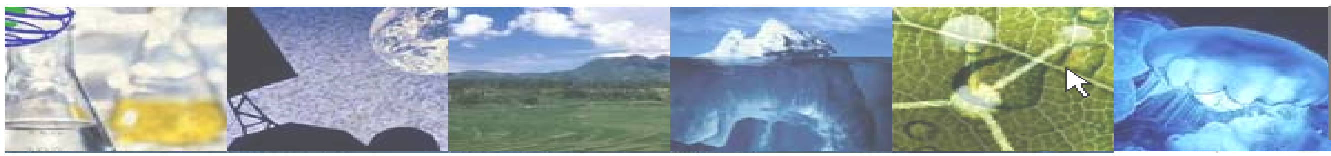


Aspect angles, elevations, concavity/convexity measures, etc

Construction of a prediction target map for future landslide hazard

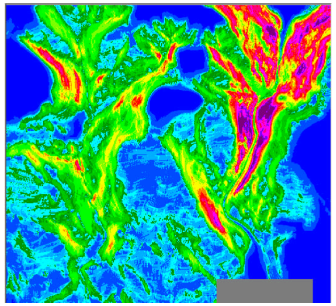
Example of a proposition **and related symbolic relationships among the** target or prediction pattern**,** direct supporting pattern**,** indirect supporting patterns**, and** prediction model**,** image **and** patterns**.**



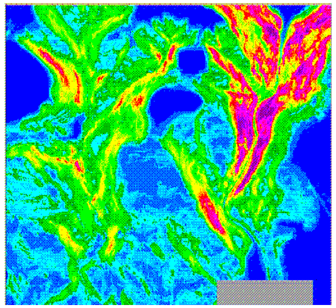


Purpose

- Fuzzy Set, **EFZ**, and Empirical Likelihood Ratio, **ELR**, application to a database with “strong” **supporting patterns**
- Interpretation of results of spatial prediction model by **blind tests**
- Establishment of **quality** of predictions



Are these prediction maps any good?



What is a blind test ? Pretend that part of the known events is unknown, use the rest to predict, and the unknown events to validate…the <u>prediction</u> NOT the *model!*

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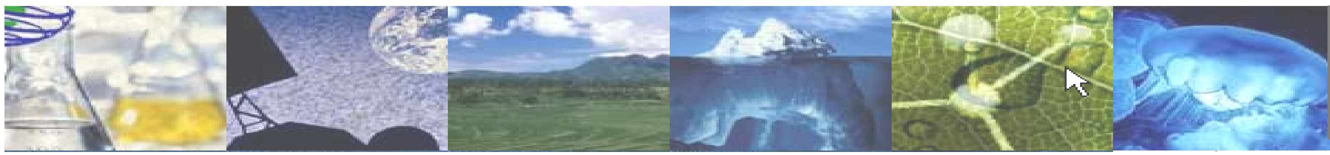

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E. Likelihood Ratio function as *g* (Y=1 or Z=1 | c_1, … , c_m)

Basic mathematical idea

$\mathbf{M_p}$: p ***comes from the area affected by landslides*, M**

$\overline{\mathbf{M}}_p$: p ***comes from the area not affected by landslides*,** $\overline{\mathrm{M}}$

$f\{c_1, \cdots, c_m \mid M_p\}$: distribution function of area affected by landslides

$f\{c_1, \cdots, c_m \mid \overline{\mathbf{M}}_p\}$: distribution function of area not affected by landslides

Likelihood ratio function:

It highlights the differences between two functions.

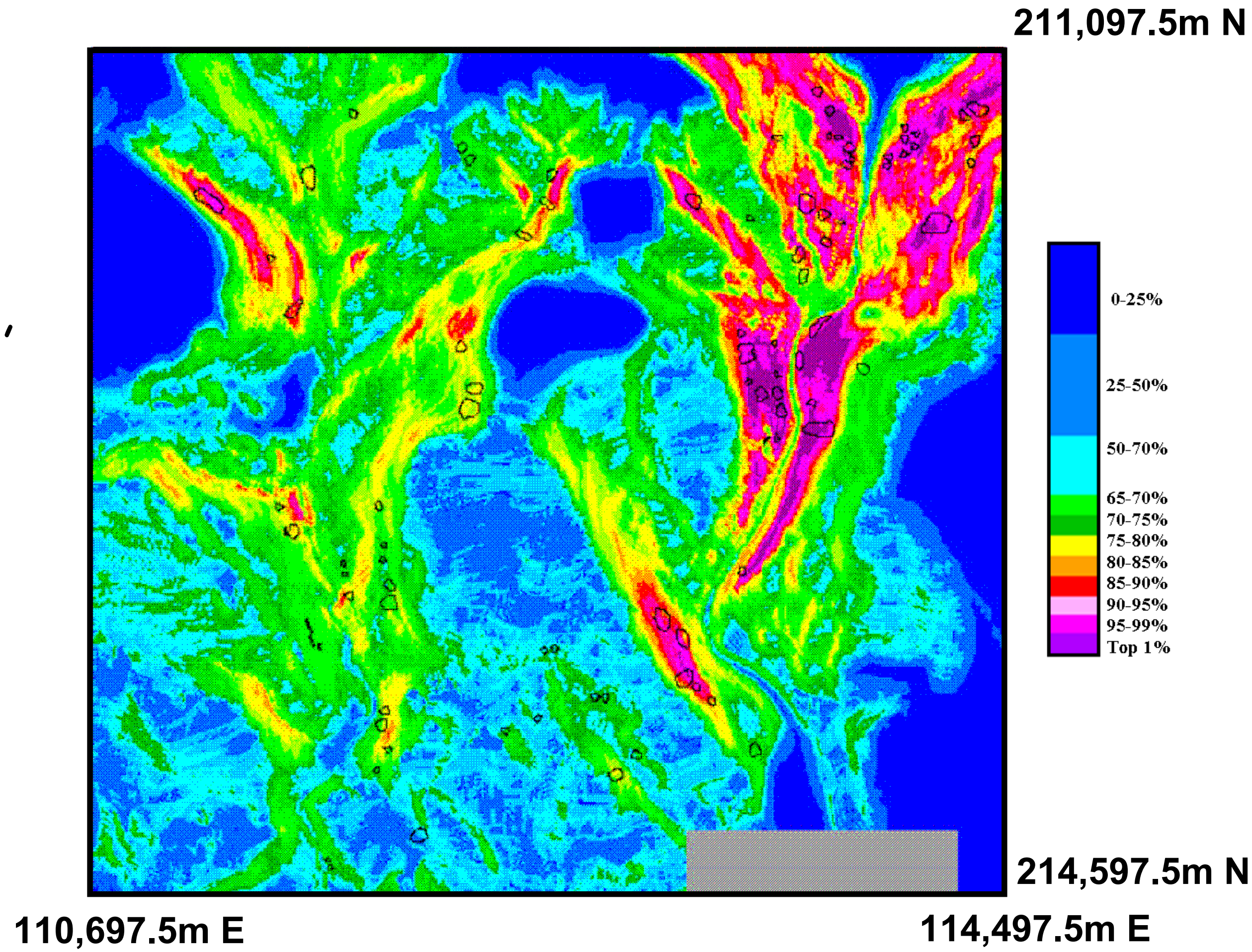
$$\lambda_p(c_1, \cdots, c_m) = \frac{f\{c_1, \cdots, c_m \mid M_p\}}{f\{c_1, \cdots, c_m \mid \overline{M}_p\}}.$$

Favourability function target mapping

g **(Y=1 or Z=1 : *given* m causal factors $X_k(p)$, k=1,…, m)**

Fuzzy Set EFZ prediction hazard map of the Fanhões-Trancão study area in Portugal

Using all 92 shallow translational landslides and six data layers, geology, land-use, surficial-materials, elevation, aspect and slope. Trigger zones shown as black contours.



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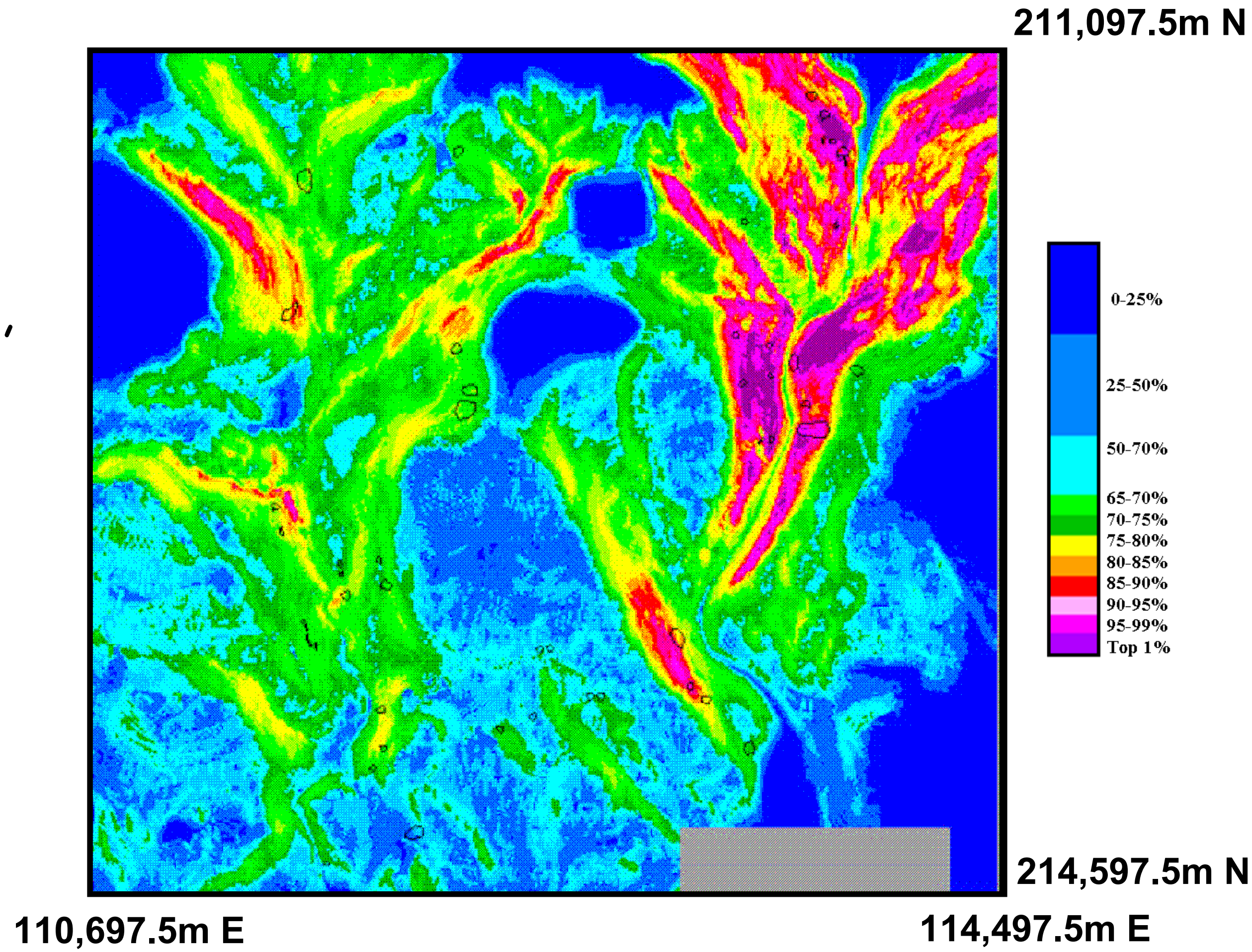
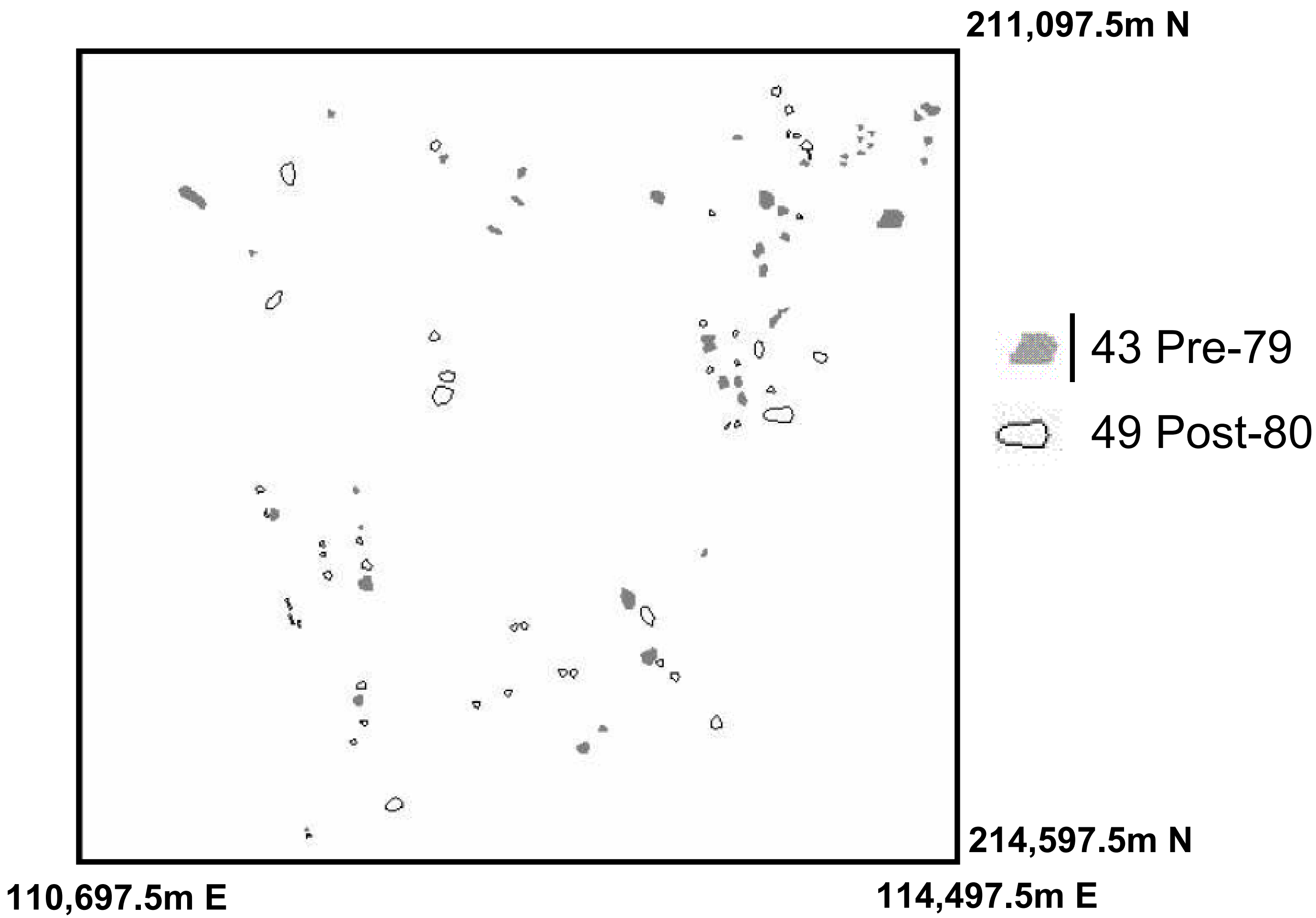
ELR prediction hazard map of the Fanhões-Trancão study area in Portugal

Using all 92 shallow translational landslides and six data layers, geology, land-use, surficial-materials, elevation, aspect and slope.
Trigger zones shown as black contours.



Two time periods of trigger zones of 92 shallow translational landslides in the Fanhões-Trancão study area in Portugal .



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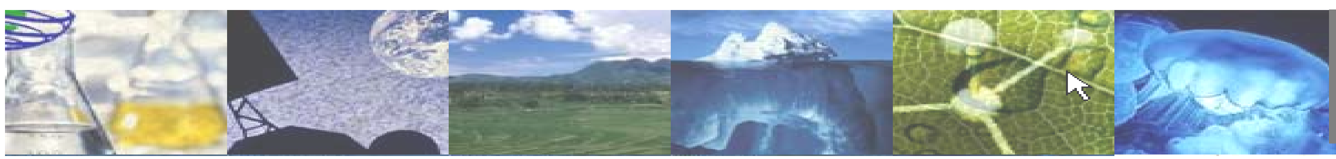

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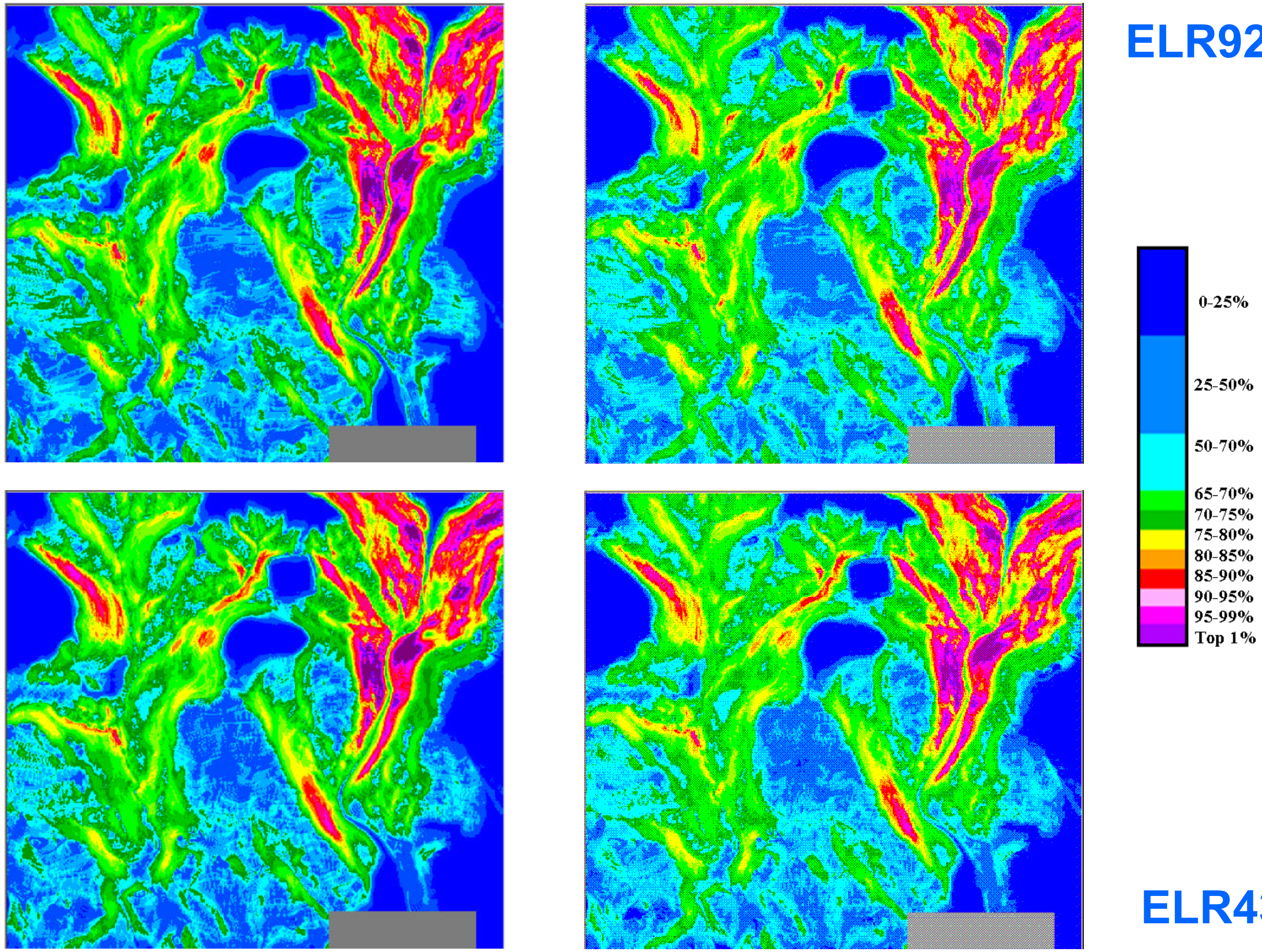
EFZ-ELR prediction patterns using 92 and 43 pre-79 lqandslides

EFZ92

ELR92

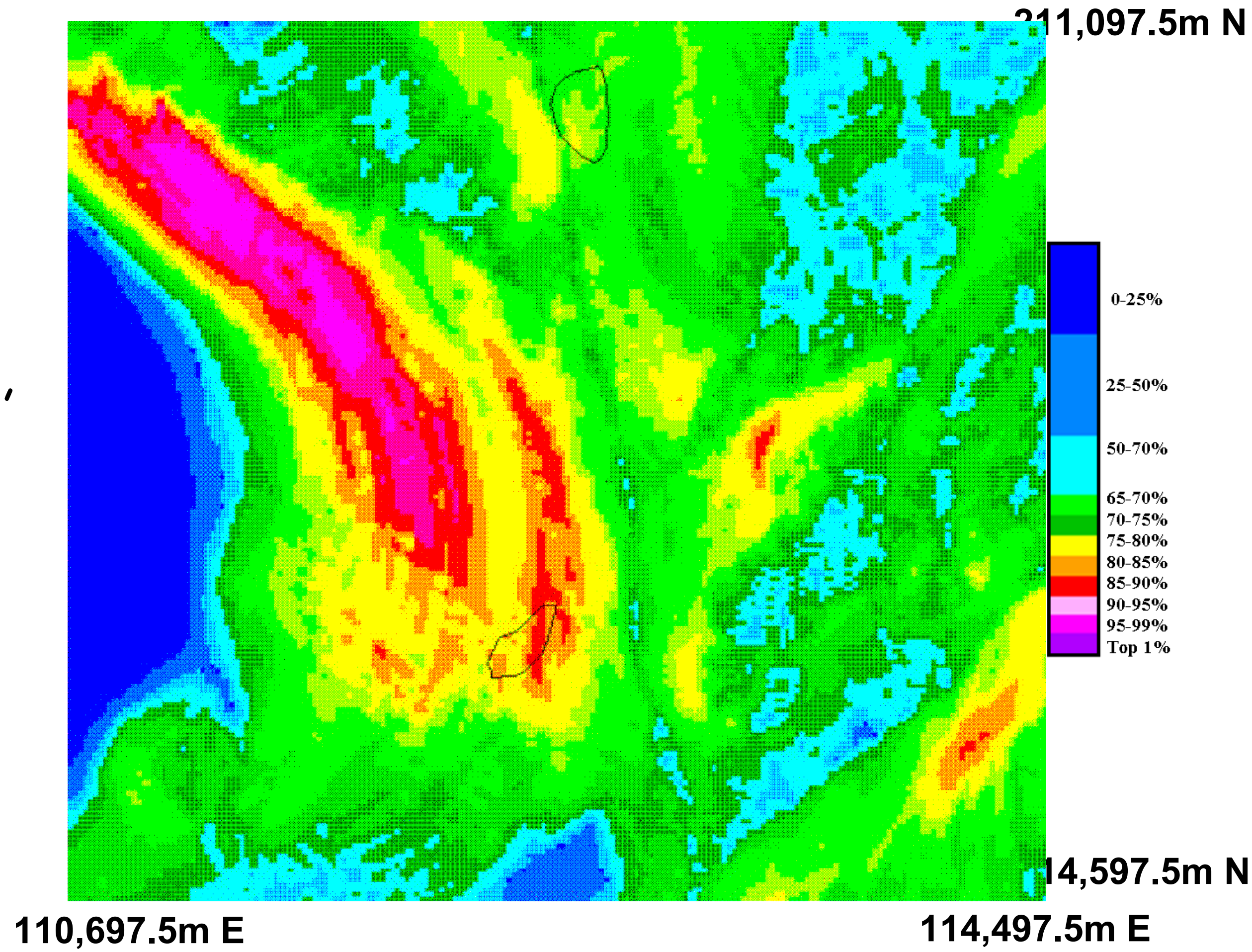


EFZ43

ELR43

Fuzzy Set **EFZ43** prediction hazard map of the Fanhões-Trancão study area in Portugal

Using only the 43 pre-79 shallow translational landslides and six data layers, geology, land-use, surficial-materials, elevation, aspect and slope. Trigger zones shown as black contours.



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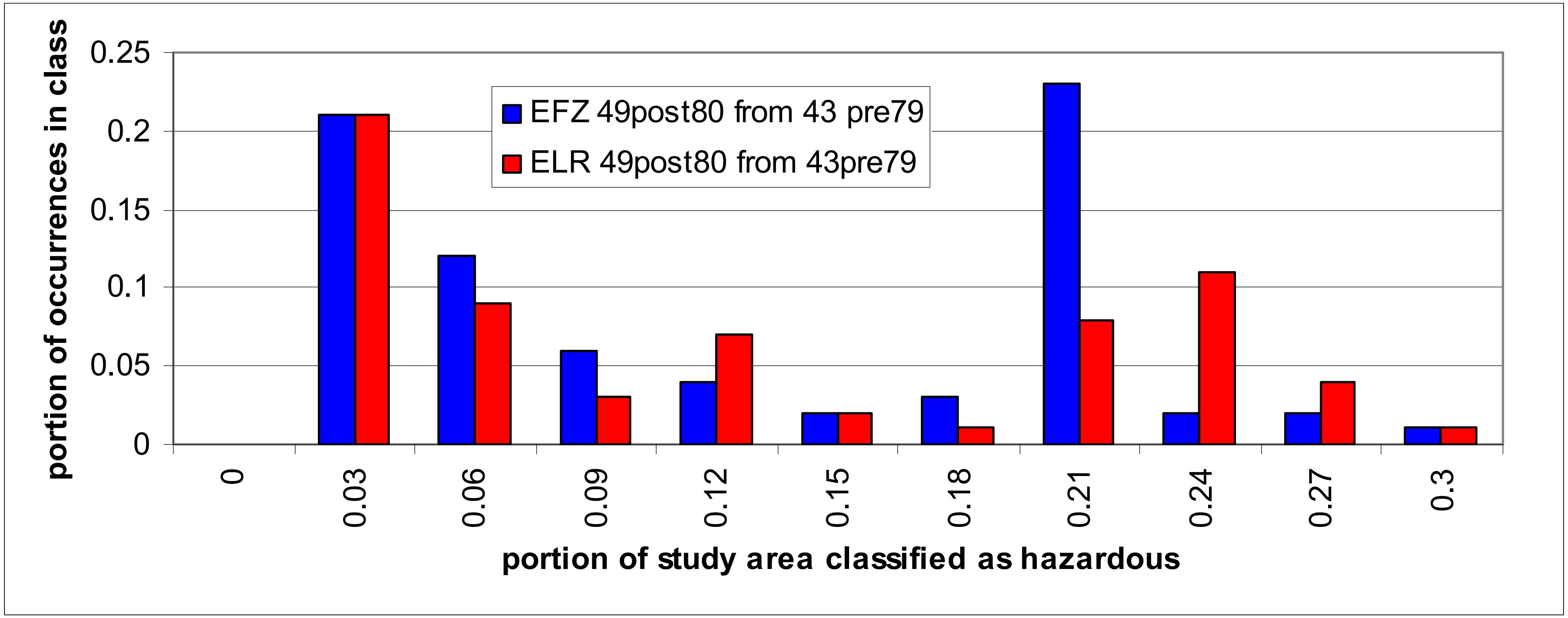
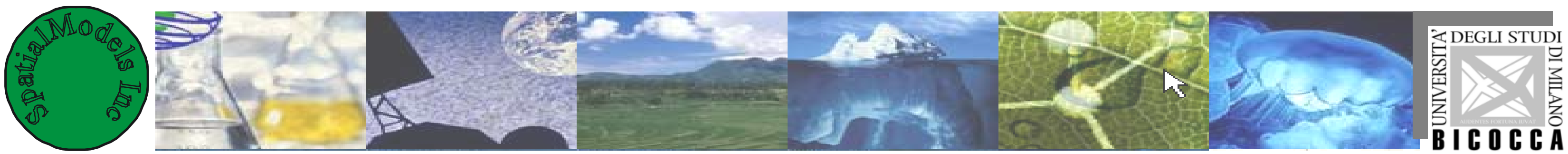
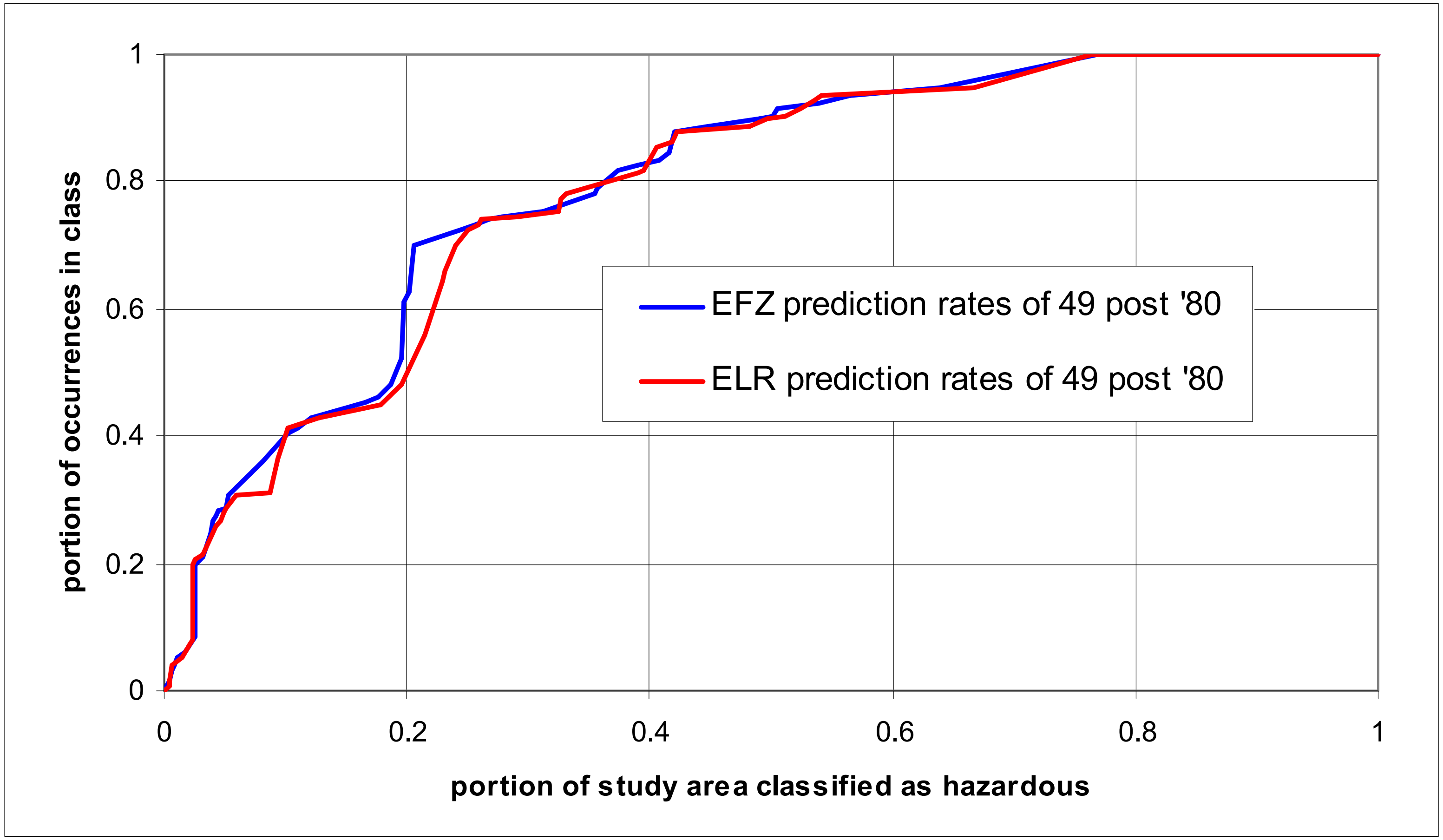
Prediction-rate histograms of highest 30% study area using 43-pre79 to predict 49-post80

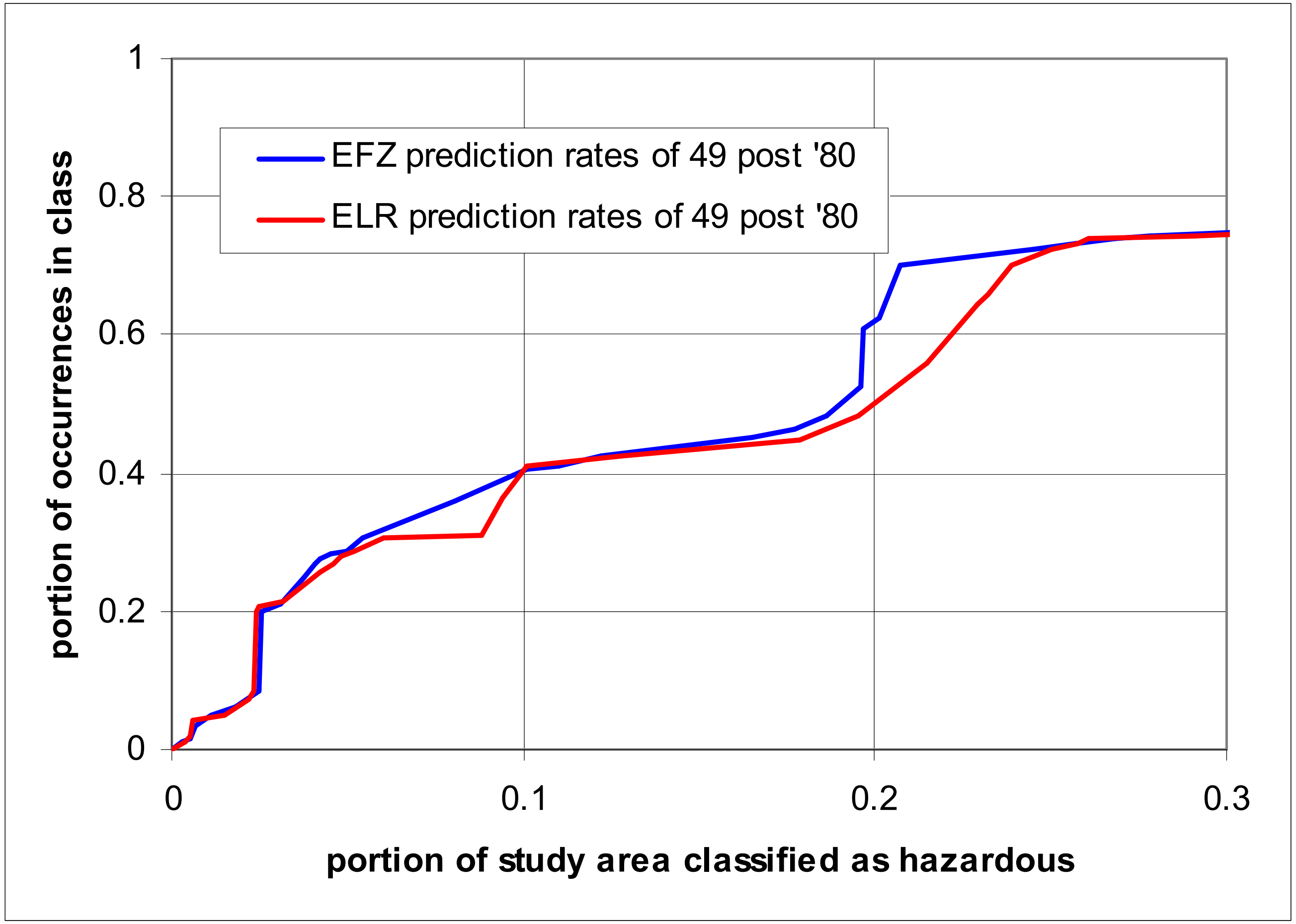




EFZ-ELR cumulative prediction-rate curves

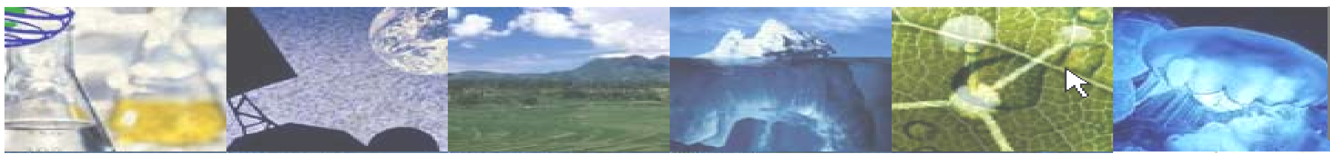


EFZ-ELR cumulative curves for highest 30% of study area

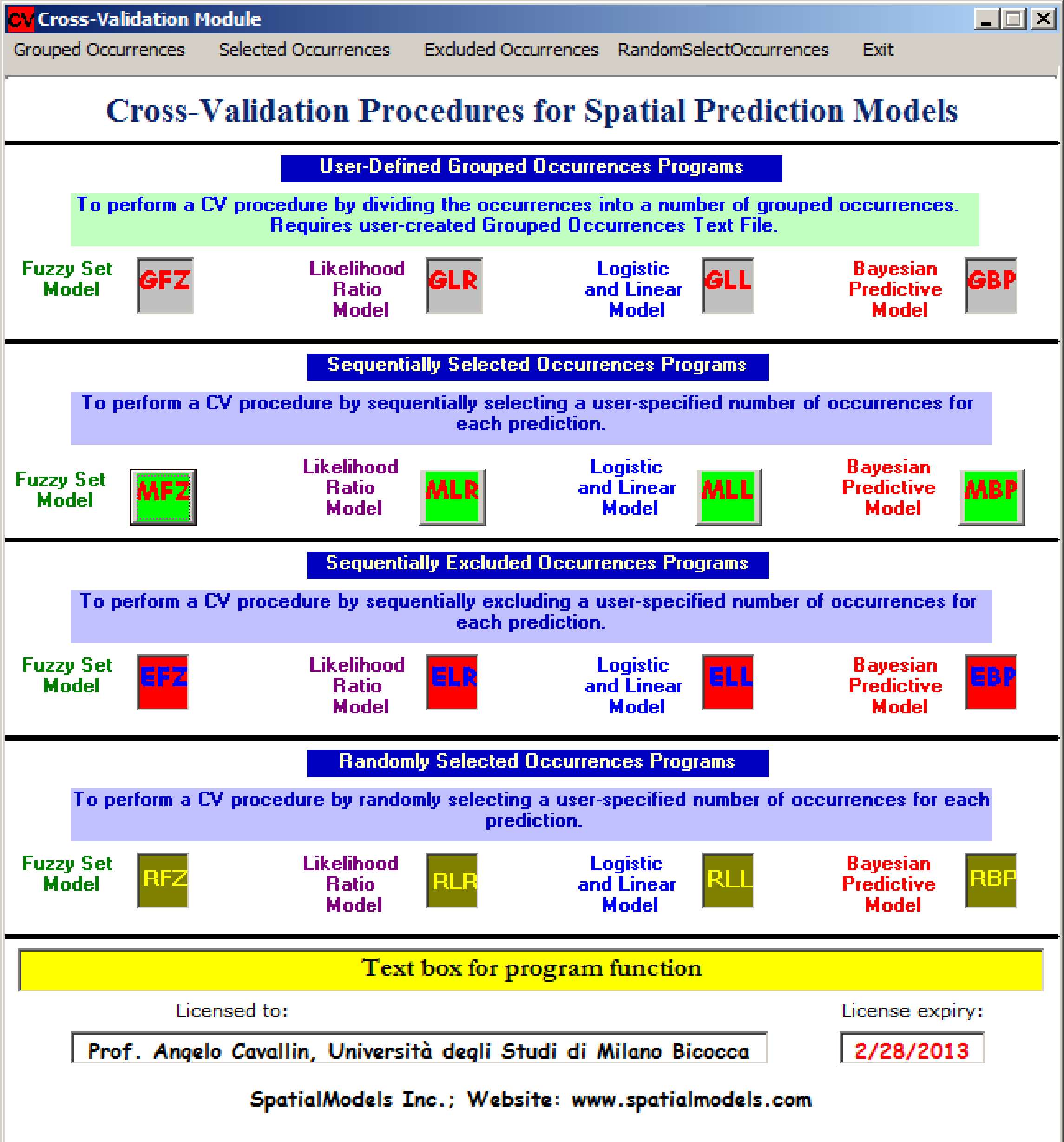


Assuming not to know the time of occurrence of the 49-post80 landslides

- We only expect 49 new landslides of the 92 to occur in a second time period.
- Select at random 43 landslides to predict the remaining 49.
- Repeat the random selection of 43 n times, say 16 or … 160.
- Generate 16 to … 160 prediction patterns and that many average prediction-rate curves.
- **How good are the new prediction-rate curves?**
  Better or worse than the previous ones?
  For EFZ43 and ELR43?



The Spatial Prediction Modeling system SPM



Random selection

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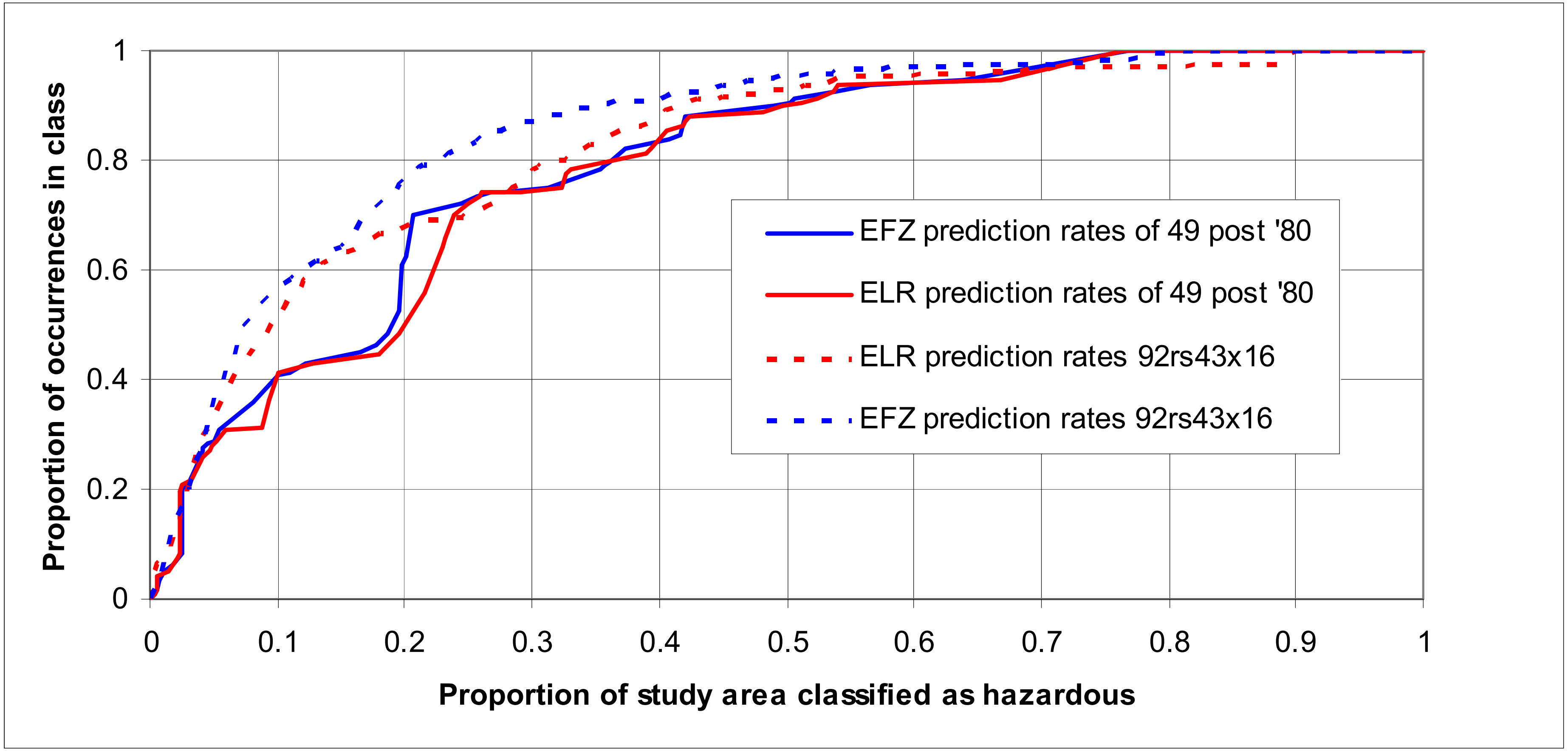
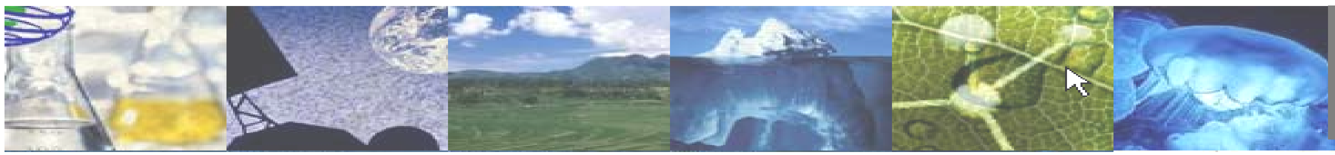
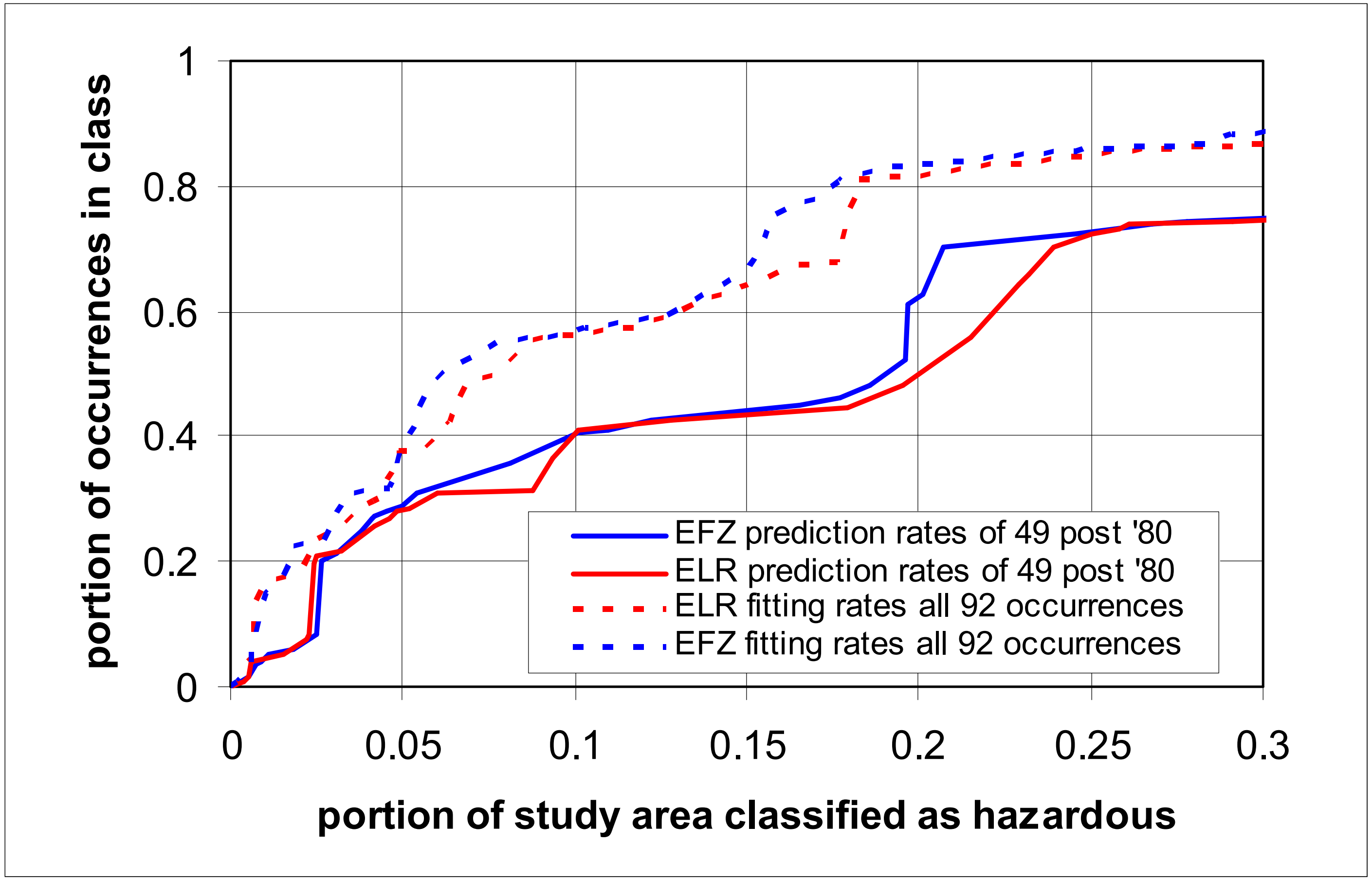
Prediction-rate curves for landslide hazard in the Fanhões-Trancão study area, Portugal.





Comparison of prediction-rate curves: EFZ-ELRrs43 overestimate!



Concluding remarks

- Interpreting the quality of prediction results?
- Either ignored or misunderstood!
- Relative “goodness” of hazard map? UNKNOWN!
- Model is less important than validation strategy…
- ∴ A hazard map is as good as its prediction-rate curve…
- *The implications of this are far reaching in hazard prediction and risk assessment.*