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Interactive Comment

Interactive comment on "Assessing the spatial variability of weights of landslide causal factors in different regions from Romania using logistic regression" *by* M. C. Mărgărint et al.

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We thank the reviewer for his valuable comments, an answer to all comments are given bellow. Questions and remarks are in italic whereas the answers are in bold.

We also uploaded the pdf version as supplementary material.

The data was newly modeled using a train and test dataset. Unfortunately, in the validation step the AUC values were only calculated for the train dataset. Only in table 3 true positives and true negatives are mentioned for both the train and test datasets. The AUC values should also be calculated for the test dataset, since otherwise the high

AUC values for the train dataset might indicate just an overfit of the model.

In the new form of the paper, ROC curves and AUC values were computed also for the test samples and commented.

The results section is relatively short and statements in the discussion section are not always supported by the results (e.g. "landslide susceptibility in all sectors is generally explained by the slope angle, land use and slope height above the channel network", this is not true for Helegiu sector where slope height is not significant at all!).The discussion seems to be a bit too simple and should be more detailed and of course supported by the results.

The results and discussion sections were improved, according to this comment. For the Helegiu sector, the discussion regarding the coefficient of slope height was corrected.

The paper would benefit of a table showing the landslide densities for each land use and lithology class for each of the four sectors. These results could then also be more clearly discussed.

The table has been inserted and commented. The landslide densities have been computed for categorical predictors, namely lithology, slope aspect and land use (see Table 1).

. . ., nothing is said about the correlation between the predictor variables. There might be correlations e.g. between lithology and slope or land use and slope. This might explain some of your results, e.g. why slope angle is less important in Helegiu sector.

The study uses the stepwise (forward) procedure in order to avoid the muticolinearity problem. The procedure is mentioned and explained in the text. If necessary, the correlation matrices can be inserted in the article. However, they would occupy quite some space as there would be 4 such tables. However, for all 4 sectors, we have commented in text the highest values between predictors.

In the study area section it is mentioned that different landslide types are dominant

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in specific sectors. They conclude that "it can be stated that the weights assigned to causal factors by means of logistic regression are capable to reveal some important regional characteristics for landslide manifestations". This statement does not get fully clear reading the paper. For me it seems that this might be also linked to the different landslide types. But this issue is not addressed in the discussion section at all. It still gets not clear for all regions which landslide types do occur. Pleas provide a table on no. of landslides with regard to the landslide types and state of activity for each sector.

A supplementary description of landslide types was included in the new form of the paper, also with photos and sketch for old landslides like “glimee” and “hârtoape” (figures 1-5). In the study area section we analyzed the relationships between this old landslides and shallow landslides, which led to the modeling of susceptibility. A table on no. of landslides with regard to the landslide types and state of activity for each sector will be inserted in the paper.

For Căpuşu de Câmpie sector we added: Landslides are the dominant slope modelling processes, affecting important areas. Generally, they are shallow landslides, the slide depth being 2 to 5 m, and the surface of the landslide between 0,1 ha and 110 ha. Deep seated landslides are also present (21 cases), characteristic to all Transylvanian Depression, locally named glimee (Morariu & Gârbacea, 1968; Surdeanu et al., 2011). These are large rotational landslides, with deluvium thickness normally more than 30 m and showing usually steps-like and hummock morphology (Figures 1 and 2). Deep seated landslide repartition show a certain pattern of lithology and geologic structure: monoclinal, dome and anticlinal folds; alternance of permeable with impermeable strata; gross permeable strata (usually sand and gravels). Schematically, the mechanism of this landslide type development could be explained by a gradual development of the scarp towards the ridge. Old levels of the landslide are eroded by slope processes (splash erosion, rill erosion, landsliding), while the frontal lobes, by erosion or by agricultural practice, are smoothed (Figure 2). These landslides are considered to be of late Pleistocene – early Holocene ages (Preboreal and Boreal), but the pluvial

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period of 1970 to 1975 have shown that on smaller scales this type of landslides can develop (Figure 1). Old “glimee” sites can evolve in today climatic condition by the formation of new landslides, erosional shaping of the old hummocks and the retreat of the principal scarp (Surdeanu et al., 2011).

For Şipote and Lungani sectors we mentioned: Often landslides contribute to the formation of semicircular sliding depressions, known as hârtoape (Figure 4). Resembling an amphitheater, located on the slopes or at the origin of torrents valleys, these are typical for slope morphology in the Moldavian Plateau, previously being defensive natural sites, favorable for many human settlements. Hârtoape modeling was done in a long time, by the participation of complex geomorphological processes, especially landslide and erosion processes. Currently, important areas are associated with old, dormant landslides, which have thicknesses of 10-20 m, but are in turn affected by recent processes, such as shallow landslides (Figure 5), landslip, erosion.

For Helegiu sector we pointed: All these are conditions that favor mass movement processes-landslip, collapse and especially landslides, which often put their mark on the landscape, with ages, shapes and different intensities of expression. Very often old slope deposits, with average thickness of 3-5 m in relative equilibrium to the substrate, when favorable conditions are met, it can be reactivated or can support active sliding. The percentages of actives landslides for each sector will be also specified in the mentioned table.

Regarding the glimee in the first manuscript it was stated that these are generally stabilized at present (which would mean, that modelling landslide susceptibility with present day data is very critical). In the current manuscript this part was removed and it does not get clear why?

The inventory considered for modeling landslide susceptibility has considered only areas with obvious manifestation of sliding processes. These areas may be grafted to large, old, relict landslides sites (glimee and hârtoape), which were not included in the landslide inventory and, consequently, in the regression equation.

Regarding the hârtoape it is stated that these are slide amphitheatres, which are semicircular depressions, shaped through susccessive landslide and/or erosion processes.... It does not get clear if such features can also be formed just by erosion processes how the authors decide whether it is a landslide or not.

These aspects were clarified above, where Şipote and Lungani sectors were described.

For both processes a sketch and photo would be very helpful to understand these special landslide types.

Photos and a sketch for both processes were added (see figures 1-5).

Compared to the first version a whole paragraph on landslide susceptibility assessments in Romania in the past was deleted. From my perspective this was a very interesting paragraph and should be integrated again. If possible the authors should also discuss their approach and its benefits compared to the other approaches applied in Romania, at least the ones which were also carried out in their study area like Balteanu et al. 2010. The paper could really benefit from this.

We reintroduced the paragraph and also some considerations regarding the limitation of the actual Romanian methodology in landslide susceptibility assessment (from our point of view), like: applying the same weight to the predictors for all administrative units (with neglecting the major geomorphological units), data acquisition at different scales (unrelated with 1:5000 scale, at which it should be realize the final maps), absence of the geomorphometric variables, like slope angle, slope aspect, topographical curvatures, distance to drainage network etc. The map carried out by Bălteanu et al, 2010, was realized with another methodology, at 1:200,000 scale, with a less number of parameters. So, for small administrative units, at large scale, our approach could improve the accuracy of susceptibility maps. We added another 2 references regarding Romanian methodology (ChiÅču, 2010; Manea & Surdeanu, 2012).

Throughout the paper there is some sort of mixture of the terms weights and coefïňĄcients and causal factors and predictors, respectively. When referring more strictly to the statistical approach the authors use coefïňĄcients and predictors, in other cases weights and causal factors. I would prefer coefïňĄcients and predictors. Especially causal factors is misleading since most predictors have no direct cause-effect relationship towards landsliding.

We thank for this nuanced comment. It is real, for a statistical approach, like Logistic Regression it is better to use statistical terminology. So, we turn to "coefficients" and "predictors" terms. This includes the modification of papers' title as follows: "Assessing the spatial variability of coefficients of landslide predictors in different regions from Romania using logistic regression".

The abstract should be updated after all comments are addressed and the paper improved.

The abstract of the paper will be updated.

Introduction: You should add a short deïňĄnition of landslides.

We have inserted a short definition of landslides (Cruden, 1991) in the first part of introduction section.

p.1751 l.11: ...deïňĄned as spatial occurrence probability....

Done

p.1752 l.29: what is the meaning of "roughly the same predictors"?

Thanks, we removed the term "roughly".

p.1753 l.12-13: Please check the sentence. Furthermore, you should refer in the discussion sections also to your previous study and give some statements if the results are similar or different and if different, why?

The paragraph was modified as follows: "The sectors Căpuşu de Câmpie and Lungani have been already the subject of a previous study and the results were close, despite some small methodological differences, like predictors used and landslide inventory (Mărgărint et al. 2011)". In this previous study we used a different number of predictors and a landslide inventory based on topographical maps at 1:25,000 scale. Also, a sentence regarding the results of this paper was introduced in the discussion section.

p.1753 l.21-22: please explain shortly what relatively high relief fragmentation means, and what does low relief fragmentation mean.

We introduced the effective values of relief fragmentation for all 4 analyzed sectors.

p.1754 l.20ff: nothing is mentioned about the elevation in this sector. Do you have some numbers on the amount of deforestation? Was everything transformed into pastures?

This aspect was added in the new form of paper. In this sector the altitude varies between 194 and 979 m a.s.l. We inserted the paragraph: "In the last two centuries the forest surface decreased to a half, sometimes even more, especially around villages, being replaced by secondary meadows, vineyards, orchards, or by the extension of settlements (Ungureanu, 1993)".

p.1755 l.18: Have you transformed the aspect layer into northness and eastness? Otherwise there is always a problem with aspect since values close to 0 and close to 360 are indicating North!

The slope aspect values were grouped into 4 classes (North, East, South, West). The landslide densities for these classes were further used in logistic regression analysis.

p.1757 l.18ff: It does not clear how the landslide points in the depletion areas were sampled. Have you used just one point per landslide or more? Furthermore, you write that the same random sample size were generated outside the landslide depletion areas. Does this mean that non-landslide points can also be located in the landslide accumulation areas? This should not be the case! Furthermore, you should clearly state that the model was trained with the train dataset of 80% of the landslide and non-landslide points.

The depletion areas were identified semi-automatically by using a geomorphometrical parameter called mass balance index. This parameter was derived in SAGA-GIS using the DEM and vertical distance to channel network as input layers. It was found that values greater than 0.1 of mass balance index correspond largely to landslide depletion areas. Grid points were generated then in the areas with mass balance index values greater than 0.1 and inside landslide polygons. Finally, the resulting point sample was visually inspected and corrected when necessary. These samples contain about 800 – 1000 points. Small landslides often received a single point in the depletion zone, while larger landslides received several points. After the depletion areas were sampled, we generated random samples of similar sizes outside the depletion areas and outside landslide polygons. The article states: “In order to test the predictive potential of the models, 20% of the samples, randomly selected, were used for validation as independent datasets”. The following sentence was inserted into text: “Consequently the training samples represent 80% of the landslide and non-landslide points”.

p.1757 l.26ff: Please check sentence

The phrase was modified as: “The continuous susceptibility values (from 0 to 1) were further classified using the natural breaks method (Jenks) algorithm. This identifies the class breaks that the best group similar values and maximizes the differences between classes”.

p.1758 l.3ff: Most of these belongs to the introduction section. Here you should only describe the method you applied. Please describe the ROC Curve and AUC parameter more detailed as well as the way you prepared table 3.

The paragraph was moved to the introduction section. ROC curves and AUC values were computed for the test samples and commented. An additional figure was inserted.

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p. 1758 l.16-17: This is partly a repetition.

We corrected.

p. 1759 l. 1-3: This belongs to the methods section.

The paragraph was moved to the methodology section.

p.1759 l.20: slope aspect might was removed because it was not transformed (see-above).

The models didn't use the initial (0 to 360 degrees) values of slope aspect, but the landslide densities for the four aspect classes (N, E, S, W) (please see a previous comment).

p.1759 l.22: mean curvature probably was not selected since in 3 sectors plan and profile curvature was selected.

Indeed. As the mean curvature is well correlated with plan and profile curvatures, the model eliminates this parameter due to redundancy.

p. 1760 l.5ff: Why is it obvious that many landslides occurred prior to land use change? Nothing is stated on landslide age, maybe you should add something in the study area section. What are the consequences for your results and the applicability of your map if the landslides are older than the information on land use in your dataset?

It was a mistranslation. Two situations occur: first, changes in the land use (such as deforestation, grazing expansion) encouraged the landslides; second, there are lands affected by landslides which have been afforested (now being found as stabilized landslides). The phrase was modified as follows: "Since our database has not multitemporal nature, we cannot make judgments on the temporal relationships between landslides and land use change. However, given that the highest densities of landslides associated with land covered with pasture and forest, we can define the following two circumstances: first, the slides were favored by deforestation (currently being occupied mainly with grassland), the second, in which landslides surfaces were forested later.

p.1760 l. 20: What is the meaning of unproductive land class?

Degraded and unproductive lands include the excessive degraded areas that are virtually devoid of vegetation (gullies, ravines, streams, boulders, rocks, etc.) regarded as not having economic value.

Fig 1: Figure Caption: please add "(in red)" after distribution

Done.

Fig. 3: The two red classes are difficult to be differentiated. You might add a yellow colour before the orange one and delete one red colour.

Done.

Fig. 4: Please add the ROC Curves and AUC values also for the test datasets

We added a new figure.

References:

Bălteanu, D., Chendeş, V., Sima, M., and Enciu, P.: A country-wide spatial assessment of landslide susceptibility in Romania, Geomorphology, 124 (3-4), 102–112, 2010. ChiÅču, Z.: PredicÅčia spaÅčio-temporală a hazardului la alunecări de teren utilizând tehnici S.I.G. Studiu de caz arealul subcarpatic dintre Valea Prahovei şi Valea IalomiÅčei (in romanian), PhD. Thesis, Bucarest, 2010. Cruden, D. M.: A simple definition of a landslide, Bull. Internat. Assoc. Of Eng. Geol, 43, 27–29 1991. Manea, S. and Surdeanu, V.: Landslides Hazard Assessment in the Upper and Middle Sectors of the Strei Valley, Revista de Geomorfologie, 14, 49–55, 2012. Mărgărint, M. C., Grozavu, A., Patriche, C. V., Tomaşciuc, A.-M. I., Urdea, R., and Ungurianu, I.: Évaluation des risques de glissements de terrain par la méthode de la régression logistique: application à deux zones basses de Roumanie, Dynamiques environnementales, 28, 41–50, 2011. Morariu, T. and Gârbacea, V.: Déplacements massifs de terrain de type glimee en Roumanie, Révue Roumaine de Géologie, Géographie, Géophisique, Série de Géographie, 12(1-2), Academiei Press, Bucharest, 1968. Surdeanu, V., Moldovan, M., Anghel, T., Buimagă-Iarinca, Şt., and Pop, O.: Spatial distribution of deep-seated landslides (glimee) in the Transylvania Basin, Studia UBB Geographia, 2, 3–8, 2011. Ungureanu, A.: Quelques aspects de l'impact de la pression humaine sur la végétation forestière dans le plateau et les Sous-Carpates Moldaves, Révue Roumaine de Géographie, 37, 41–54, 1993.

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/1/C894/2013/nhessd-1-C894-2013-supplement.pdf

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Fig. 1. Figure 1. Deep-seated landslide in Transylvanian Plateau, locally named glimee (Căpuşu de Câmpie sector).

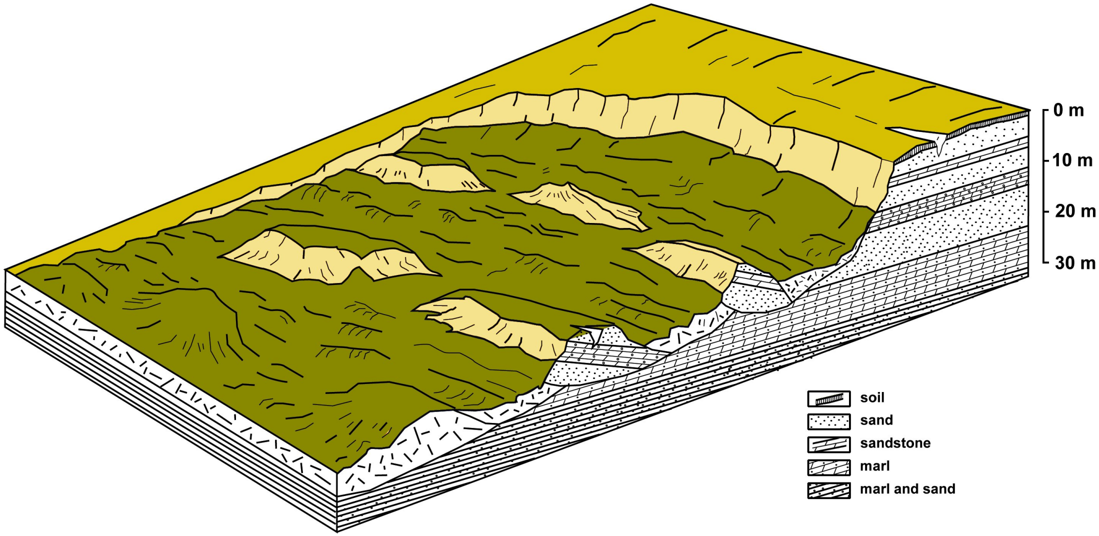

Fig. 2. Figure 2. Block diagram representing the deep seated landslide from Figure 1.

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Fig. 3. Figure 3. Deep seated landslide in Moldavian Plateau (Şipote sector).

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Fig. 4. Figure 4. Semicircular depression shaped by complex geomorphological processes (hârtop in Molvavian Plateau, Şipote sector).

Fig. 5. Figure 5. Shallow landslide in Şipote sector, detail from Figure 4.

Table 1a. Landslide density for lithology, slope aspect and land use classes.

Lithology		Slope Aspect		Land use	
Capuşu de Câmpie Sector					
Alluvial and colluvial deposits – *Quaternary*	0.196	North	0.710	Built area	0.001
Clays and marls, sand, sandstones, volcanic tuffs – *Sarmatian*	2.526	East	0.696	Arable land	0.200
Clays, sands, volcanic tuffs – *Pannonian*	1.058	South	1.226	Pastures	3.709
		West	1.574	Forest and pastures	4.100
				Forest	0.889
				Waters and wetlands	0.000
Şipote Sector					
Gravels, sands –*Quaternary*	0.472	North	1.638	Built area	0.084
Marls, clays, sandstones and sand complexes – *Sarmatian*	1.123	East	0.781	Arable land	0.268
		South	0.494	Pastures	2.744
		West	1.275	Forest	2.604
				Waters and wetlands	0.005
				Degraded land	5.053

Fig. 6. Table 1a. Landslide density for lithology, slope aspect and land use classes.

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Table 1b. Landslide density for lithology, slope aspect and land use classes.

Lithology		Slope Aspect		Land use	
Lungani sector					
Gravels, sands (fluvial terraces) – *Quaternary (pleistocene)*	0.065	North	1.138	Built area	0.321
Sands, clays – *Quaternary (holocene)*	0.328	East	0.861	Arable land	0.498
Marls, clays, sandstones and sand complexes – *Sarmatian*	1.200	South	0.466	Pastures	1.911
		West	1.618	Forest	1.950
				Waters and wetlands	0.003
Helegiu sector					
Gravels, sands –*Quaternary*	0.279	North	1.138	Built area	0.021
Sandstones, volcanic tuffs – *Tortonian*	1.048	East	0.736	Arable land	0.065
Sandstones, marls, gypsum – *Helvetian*	1.161	South	0.852	Arable land and pastures	1.462
Sandstones, clays – *Volhinian*	1.189	West	1.316	Pastures	1.998
Marls, clays, salt – *Badenian*	0.902			Forest	0.221
Sandstones, menilite, dysodilic shales – *Latorfian-chattian*	1.196			Waters and wetlands	0.000
Argilaceous shales, clays, sandstones – *Priabonian*	0.814			Degraded land	3.268
Calcareous sandstones, marls, conglomerates – *Lutetian*	1.888				

Fig. 7. Table 1b. Landslide density for lithology, slope aspect and land use classes.

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