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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Automated object-based classification of rain-induced landslides with VHR multispectral images in Madeira Island" *by* S. Heleno et al.

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Dear Reviewer,

We thank you for your helpfulp comments that we believe will improve our manuscript. Please find bellow our answers to your comments.

Sincerely, Sandra Heleno

[Q] 1) if my understanding is correct, there is an ambiguity in the way the RBF function is selected among many kernel functions: do the Authors make use of information available in the validation areas (while the technique must be tuned only in the training

area) or not? If not, what is the sense to test solutions in the validation areas excluded during the training phase? "The RBF and degree 2 polynomial functions achieved the best prediction accuracy when checking with validation areas, and where used to further test, again by cross-validation between training and validation sets, the penalty and sigma parameters". That sounds like a posteriori choice but since this paragraph is not to me 100% clear, this point must be well clarified.

[A] We did not use information available in the validation areas to select the RBF function and its parameters. Instead, we used the same testing areas (inside the training areas) used for tuning of the segmentation parameters. Since these tests were performed in an expedite manner (using just visual inspection of the match between results and reference data in the training areas) we decided to confirm 'a posteriori' that we had made the best choice for kernel and parameters. This was indeed confirmed. Perhaps this was not clear in the submitted version. We will strive to improve the text in what regards these points.

[Q] 2) The selected area is small and it does not challenge the technique. In particular the validation areas count very few landslides and according to what I can see from the pictures, quite similar.

[A] The study area is about 3 per 5 Km in area. Although not very large, it is characterized by a high density of landslides occurred during this event ($\sim$13 landslides per km2). It is the region most intensely affected in this basin, located upstream from the capital city Funchal, where 45 people lost their lives in the disaster. It is also the place where more fieldwork was conducted, giving us confidence in the construction of reference data. The validation areas count a total of 85 landslides, comparing with about 115 in the training area. But as described in the manuscript (page 5643, line 15), only about 1350 objects were used in the training procedure, while the totality of objects (about 30 000 objects) in the validation areas were used for accuracy assessment. In what concerns the similarity of the landslides, we strove to choose our samples (both training and validation) as representative of the diversity of landslides occurring in the

setting. In particular, we took in consideration different solar illuminations, making sure to include differently oriented slopes in both training and validation sets.

[Q] This choice is actually a kind of habit for people dealing with OB because in heterogeneous environments the segmentation is really hard to control. Proof is the huge numbers of tries that the Authors had to carry out before finding the right set-up, set-up which is deeply driven by a pre-existing inventory. Even if the area is so small, still so many tries must be done to tune the segmentation. There are no comments on this in the discussion.

[A] To find a good set-up for segmentation we did in fact test several scale and merge parameters, evaluating visually the results in subsets of the training area. This is a common procedure in OBIA work, and it didn't take us much time. In what concerns the choice of kernel and parameters, we did it by conducting expedite tests in the same subsets of the training area. Again, it didn't take us long. The large number of tries referred by the referee probably concerns the sensitivity tests that we conducted 'a posteriori' to confirm that we had made the best choice. Such sensitivity tests were possibly unnecessary, but only after performing them we could be sure. We acknowledge that these aspects were not made clear by us and we are willing to improve the manuscript through clarification of these issues.

[Q] 3) the technique is to me so much pre-inventory dependent and the feeling I got is that without it, nothing can be done, in particular the choice of many parameters. That makes it far from being semi-automatic, since the interpretation of landslides must be done a priori. This point is not addressed in the discussion, and it makes weak some conclusions.

[A] We think this issue is now clarified in our answers to comments 1) and 2)

[Q] 4) I think some data are threaten with a bit of superficiality (or they are not well described), I include the use of pan-sharpened images without a measure of the error introduced by the process. . .

[A] Our option to fuse the panchromatic and multispectral bands was related with the occurrence in our study area of landslides with very small dimensions, making the use of very high resolution images a real necessity. Especially in our case, since we also intended to separate the source and transport areas within the landslides. A crucial step that defines the detail of the classification results is the segmentation process. Because of that, we conducted previous segmentation tests with the original and the pan-sharpened bands, which showed superior performance of the last (these tests were briefly described in page 5640, line 18 of manuscript). In our study area, we have measured the error introduced by the pan-sharpening process using the Spectral Quality Indices (SQI, varying between 0 and 1) computed by ENVI. The SQI values range between 0.88 and 0.96 for the 4 pan-sharpened bands. We agree with the reviewer that this information is useful to the reader and it should be included in a revised version.

[Q] . . . and the use of a pre-event dem. How much does the dem contribute? I'm not expert in landslide classification, but what I can see from the pictures is that classified source areas and run outs they seem simply to have two different radiometric responses while they should actually represent two different geomorphological processes. Here what the Authors call run out seem to be like some wash out areas where probably some material also deposit there (I don't see any deposition at the foot, but that can be because of the images) and not a well channelised structure. If changes occurred due to landslides, then the dem cannot intercept them because pre-event, if no changes occurred (and this seems to be the case because of the event type), it does not seem to me that the geomorphology of the territory can help.

[A] In what concerns the contribution of the pre-event DEM to the classification, we acknowledge the fact that we didn't discuss that aspect in the text. The DEM used was acquired before the land sliding event studied, so it is not used to detect changes caused by the 2010 event. Instead, it is used to provide unique geomorphic features of each segmented object to the classifier (such as slope, aspect and curvature) to assist

in the decision. In our case the use of this information was very useful for instance to diminish the ambiguity presented by objects with similar spectral characteristics located in flat areas, and we can state that the use of the DEM improved our results. We are willing to include this discussion in the manuscript.

[Q] A curiosity, why the difference in terms of colours between source and "run out" is so strong?

[A] The main reason is the occurrence (in the run-out areas) of disturbed and/or bended vegetation and superficial layers of soil, which display very different radiometry when compared with freshly uncovered deep soil (in the source areas). This was locally verified in fieldwork.

[Q] 5) Some conclusions are "ventured": this technique is probably less demanding than CD approaches because it makes use of one image (but for example CD can mitigate the problem of shadows...), but it seems to me that the tuning which must go through so many segmentations is really time consuming. anyway, there is not a comparison in this work, so it cannot be decided.

[A] The reason we argue that our technique is less demanding than the CD is the fact that it doesn't need rigorous co-registration between scenes acquired with different geometries, which in our case showed to be an unpractical and unfeasible procedure, due to the rough topography environment in Madeira island. We agree that our statement (which anyway referred solely to pre-processing tasks such as ortho-rectification and co-registration, and not to processing time), should not be presented in such a definite way, because it is dependent of the study area conditions.

[Q] In attached some punctual comments on specific topics. Just add that sometimes the quality of English should be improved or made a bit more "appealing". Please also note the supplement to this comment: http://www.nat-hazards-earth-syst-sci-discuss.net/3/C1926/2015/nhessd-3-C1926- 2015-supplement.zip

[A] We will make all necessary efforts to make our writing more appealing. We thank the reviewer the detailed notes in the supplement to this comment, which will be taken in consideration by us, and clarified or corrected as needed.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 5633, 2015.