Automatic landslide detection from LiDAR DTM derivatives by geographic-object-based image analysis based on open-source software

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Landslides in Burgenland, Austria

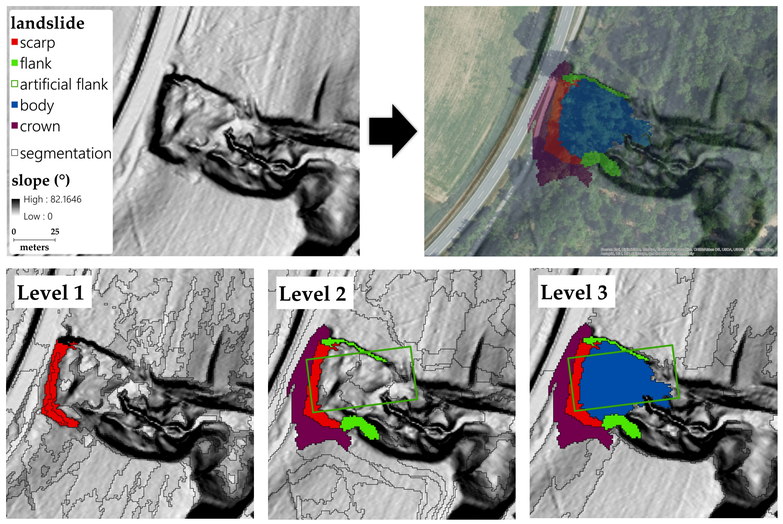
The Federal State of Burgenland is the most eastern province in Austria. The terrain is very prone to landslides which were visually mapped by AIT using high-resolution LiDAR digital terrain model (DTM) derivatives. Using the LiDAR DTM 148 landslides (178.86 ha) could be found in our study area (93.54 km²), 133 being located in forested areas.

However, the manual creation of landslide inventories is a very time-consuming process, especially for large areas. To speed up this process, new approaches emerged striving towards automatic detection of landslides in the last decade. These studies usually use a combination of optical imagery and terrain data, and are performed in commercial software packages such as ESRI ArcGIS, Definiens eCognition, or MathWorks MATLAB.

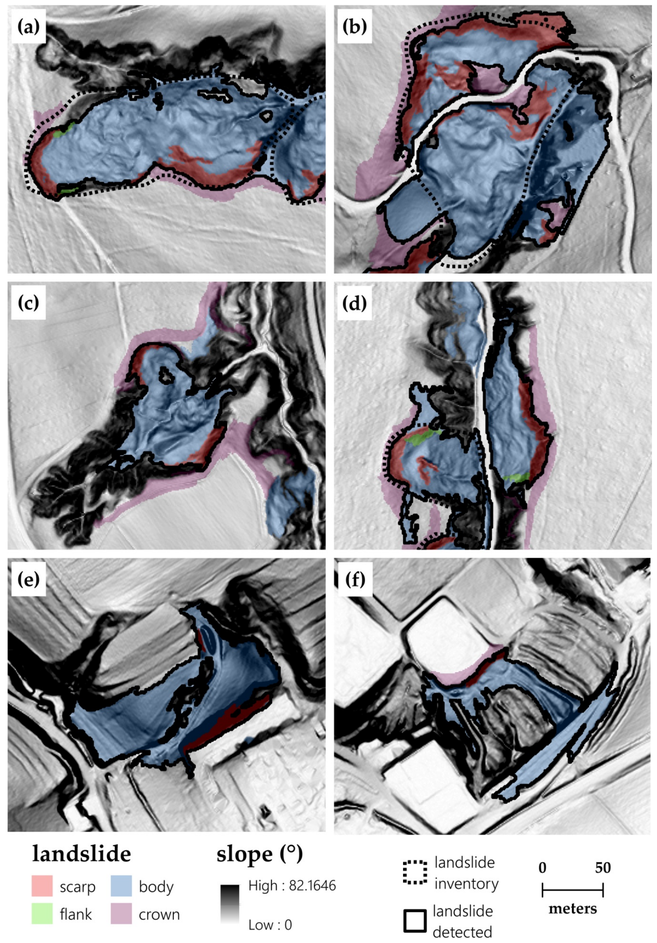
Our **objective** was to develop an automatic approach to detect landslides using only high-resolution LiDAR DTM derivatives and open source software, such as SAGA, GRASS GIS and R.

Concept of classification

Different landslide parts (scarp, flank, body) were detected in a three-level multiscale segmentation, and finally grown together. For the separability land surface parameters, textural features, and shape metrics were investigated. The detection was performed using data-driven thresholds derived by k-means clustering. "Optimal" segmentation scales were found by unsupervised segmentation parameter optimization.



Results



a-b: detected landslides in inventory. c-d: detected landslides outside of inventory. e-f: false-positive classification due to similar morphometric characteristics.

The accuracy of the detected landslides was assessed visually and in comparison to an existing inventory. This resulted in landslide detection accuracies of approximately 68.89% correctly identified landslide areas, and 65.54% correctly recognized total number of inventory landslides. Additionally, landslide areas of 22.31 ha were detected outside the inventory (plus of 12.47%). Around 95.71% of the correctly detected landslides were within forest areas.

Possibilities

With this approach it was possible to detect landslides under forested areas, where passive optical remote sensing imagery is limited. Furthermore, it contributes to a fast and objective support of the manual creation of landslide inventories. The appraoch is automatized in the free development environment R, will be freely acessible, is fully reproducible and replicable.

The combination of different open-source software in R creates a powerful tool for the detection of landslides:

GRASS GIS + SAGA System for Automated Geoscientific Analyses + TAUDEM 5 + R = *Lslide*

How to get the R package? https://github.com/raff-k/Lslide

Limitations

- data-driven thresholds are not easily transferable to other regions
- no differentiation between shallow and deep-seated landslides
- growing of landslide parts can be interrupted by artificial features
- focus was solely on *slide* and *flow* movements
- for large areas computationally intensive

Outlook

Future work will concentrate on the automatized classification of already existing landslide inventories (polygons), on the impact of different grid resolutions (2 x 2 m, 3 x 3 m, ...), on the resulting accuracy, and on finding descriptive and robust statistic parameters for the different landslide parts (scarp, body, flank) using textural features and land surface parameters calculated with different window sizes.

Further information

Knevels, R. (2017): Automatic landslide detection using high-resolution LiDAR DTM data. An object-oriented approach with open-source software in Burgenland, Austria. Masterthesis, Friedrich-Schiller-University Jena, pp. 106.

Leopold, P., Oblin, A. & G. Heiss (2015): Forschungsprojekt Massenbewegungen im Bezirk Oberpullendorf: Neubearbeitung der Gefahren-Hinweiskarte sowie Empfehlungen zur Flächenwidmung. Wien.

Petschko, H., Bell, R. & T. Glade (2016): Effectiveness of visually analyzing LiDAR DTM derivatives for earth and debris slide inventory mapping for statistical susceptibility modeling. – Landslides 13, 5, 857–872.