HOW WELL DO TERRAIN OBJECTS DERIVED FROM PRE-EVENT DIGITAL ELEVATION MODELS SPATIALLY CORRESPOND TO LANDSLIDES?

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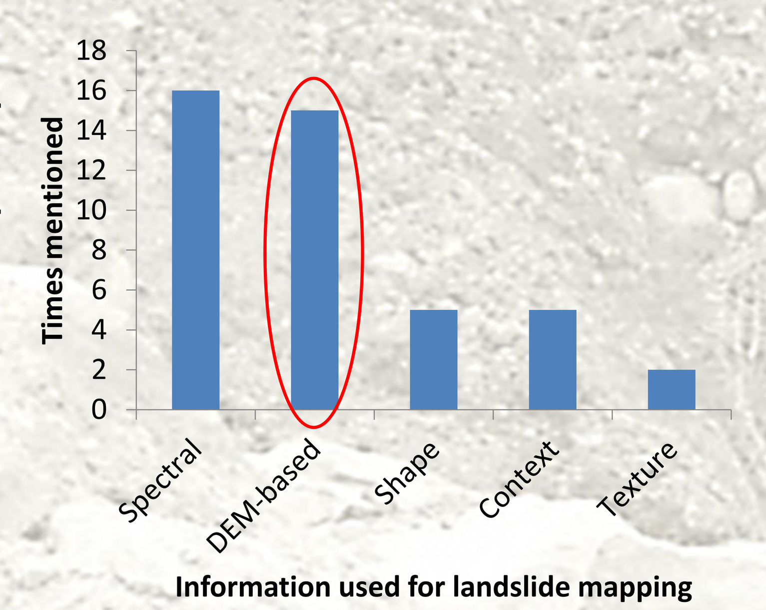
Background

In Earth Observation (EO) based landslide mapping digital elevation models (DEM) and derived terrain objects (e.g. landforms) and terrain variables (e.g. slope, curvatures) are commonly integrated with optical satellite images to map landslides and to classify landslide types. Ideally, the EO data and the DEM should document the same state of the environment, i.e. data should be acquired at similar points in time.

However, this is rarely the case, since EO data is being produced at higher temporal frequencies than DEMs. Consequently, the DEMs used for automated landslide mapping are often outdated, i.e. they are significantly older than the EO data. This leads to the problem that the DEM does not represent all the landslides that are present in the optical images.

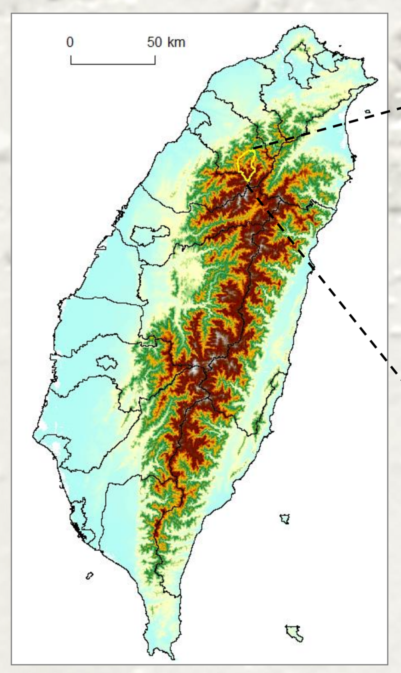


Aim

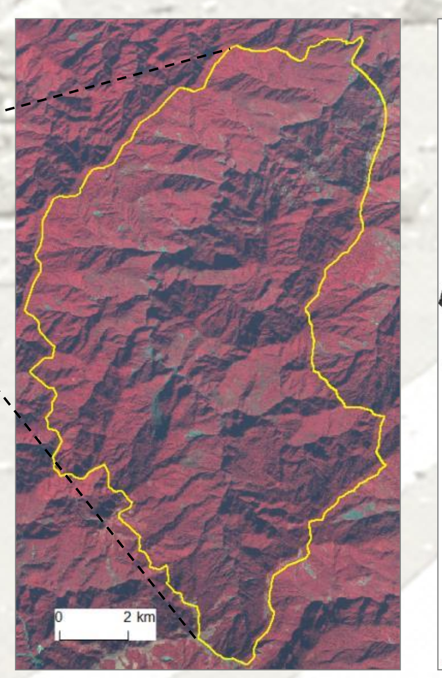
The aim of this study is to analyze how well terrain objects that are derived from a pre-failure (outdated) DEM spatially correspond to landslides.

Study area & data

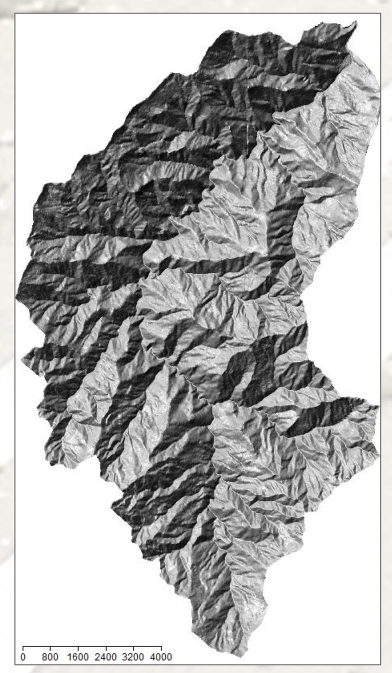
The study area, the Baichi catchment, is located in Northern Taiwan, and covers about 120 km². Elevation ranges from 1,000 to 3,000 m.a.s.l. The area is frequently affected by landslide events, mainly caused by heavy rainfalls during typhoons.



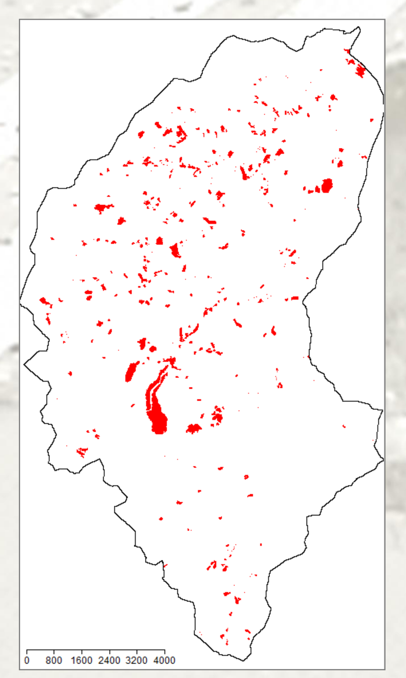
Topography of the island of Taiwan



Study area Baichi



5 m DEM derived from orthophotos taken in 2002 and 2003 (relief-shaded view)

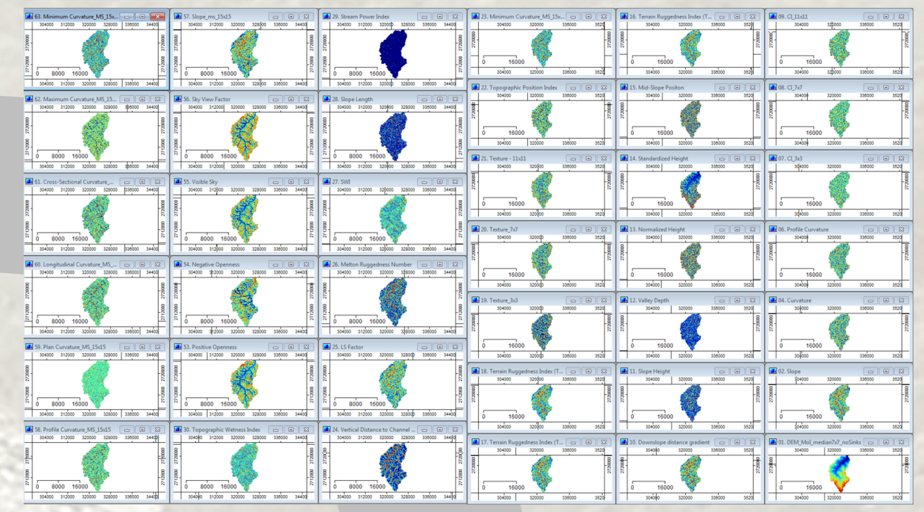


Landslide inventory Manually orthophoto-delineated landslides from 2004 and 2005 (n = 463)

Methodology

1) Calculation of 40 terrain variables

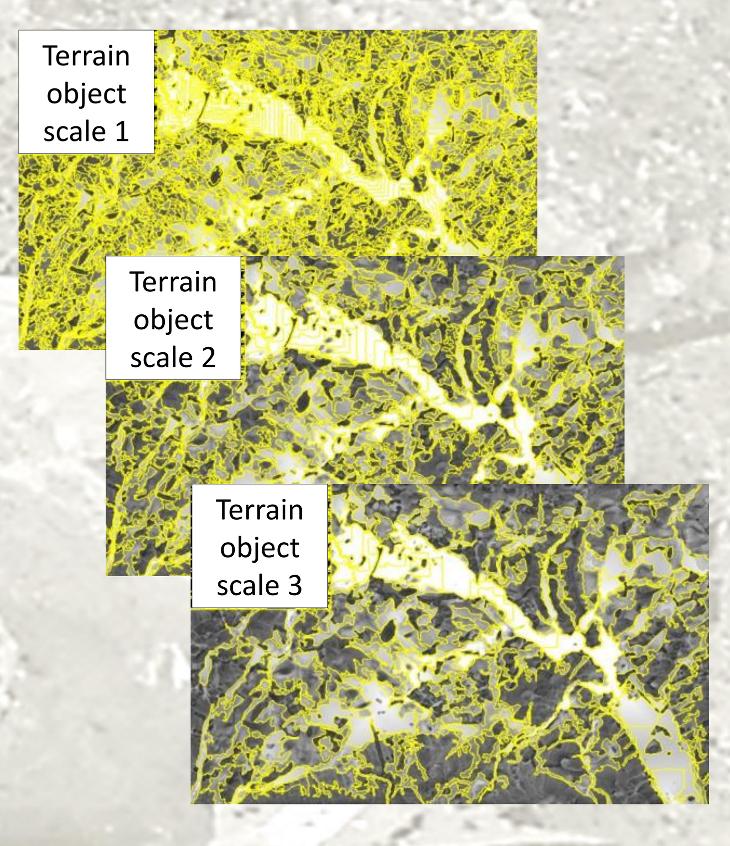
Based on the pre-failure 5 m DEM basic (e.g. slope, curvature) and more complex terrain variables (e.g. terrain wetness index, Slope Length Factor (LS factor)) were computed.



2) Generation of terrain objects for each variable

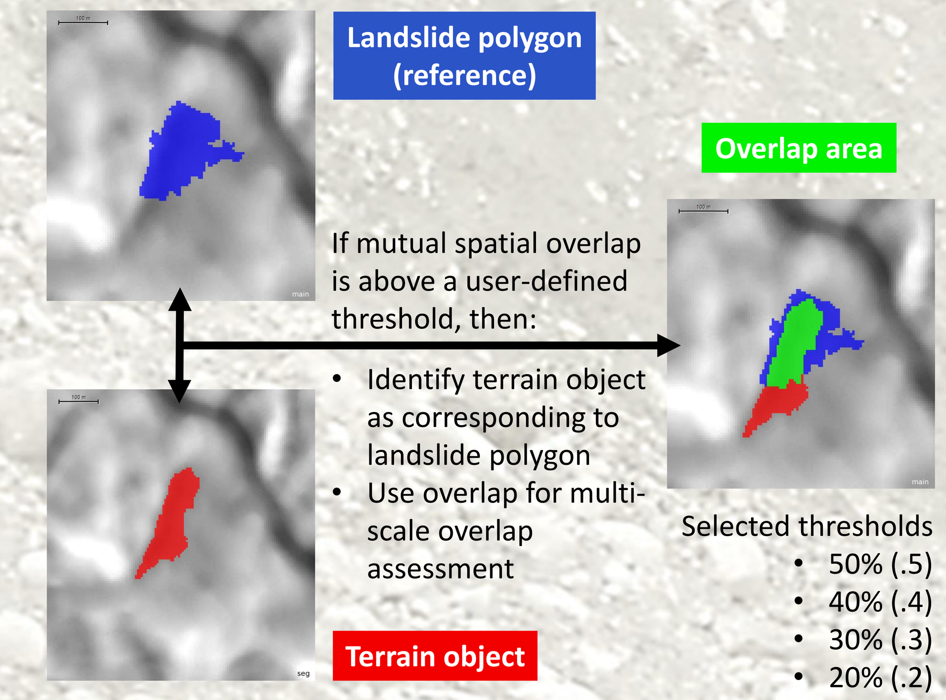
The multiresolution segmentation (MRS) as implemented in eCognition was applied to partition each terrain variable into consecutive coarser scales of terrain objects. MRS applies region-growing to merge neighboring grid cells with similar values to objects.

The statistical method of local variance was employed to identify the three most significant terrain object scales for each variable.



3) Identification of terrain objects corresponding to landslides

The mutual spatial overlap between terrain objects at each scale and reference landslide polygons was calculated. Based on selected thresholds the corresponding terrain objects were identified.



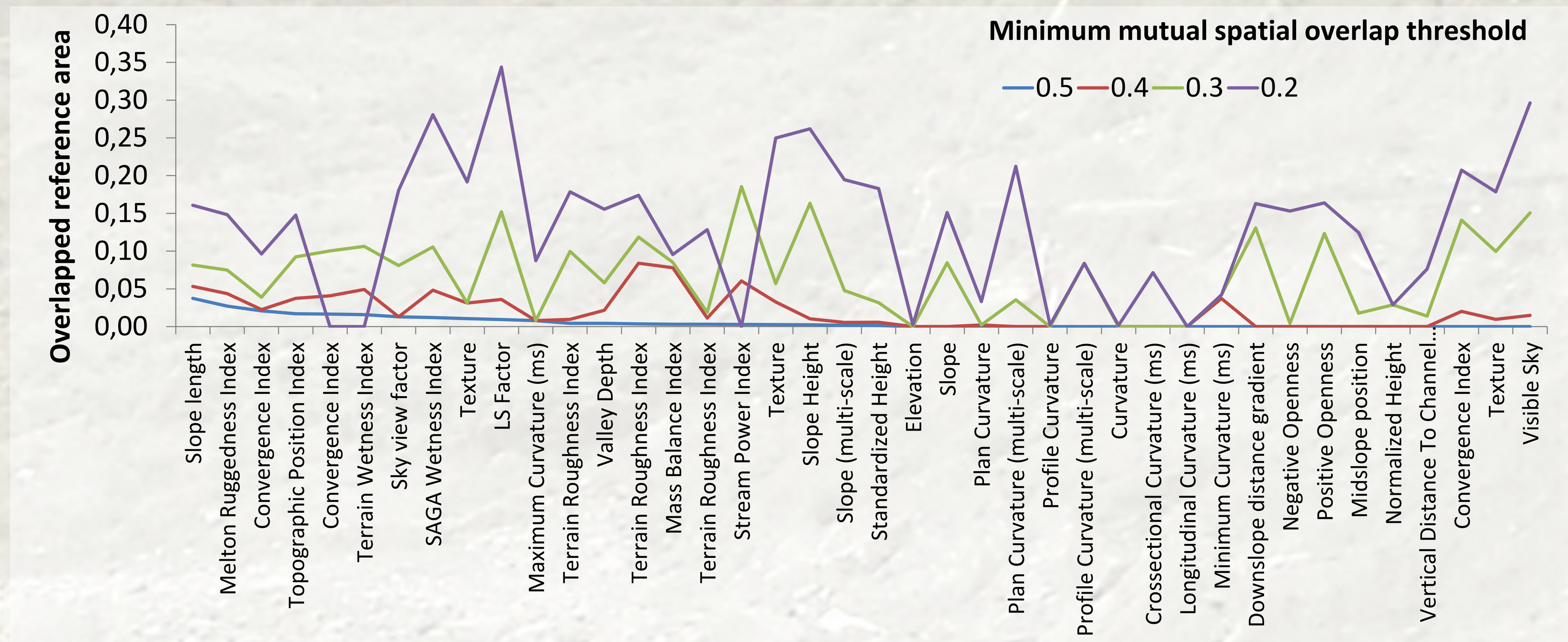
4) Calculate the percentage of overlapping reference landslide area

The corresponding terrain objects at the three scales were merged into one dataset. The merged objects were intersected with the reference polygons to eventually compute the percentage of the overlapped reference area.

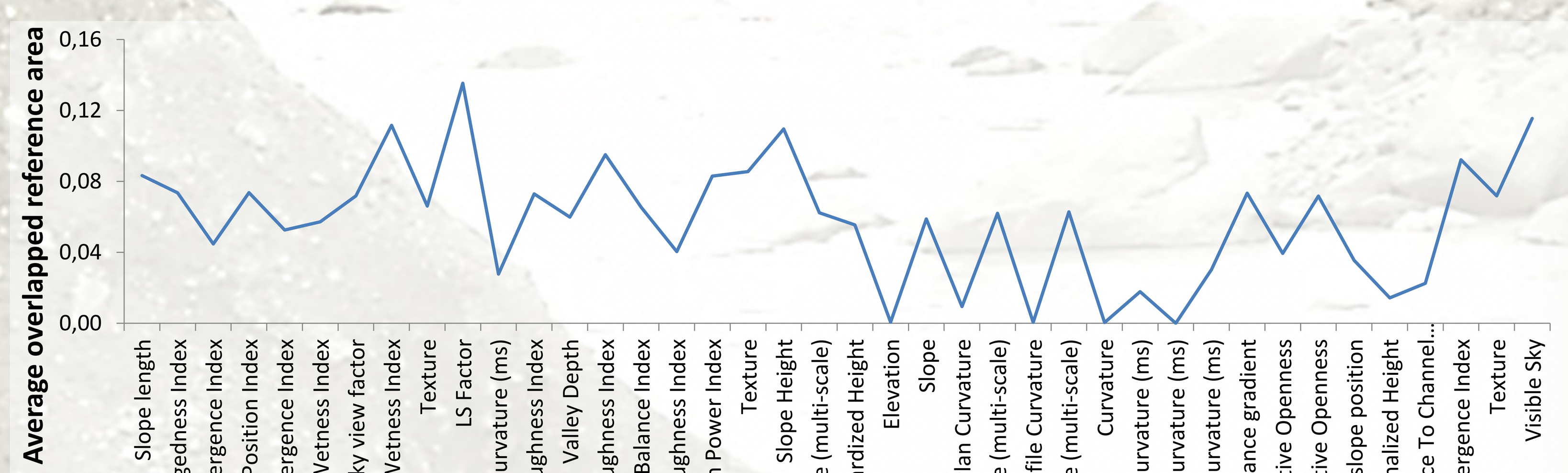
Results & Discussion

The diagrams below show the percentage of the total landslide reference area that is overlapped by the corresponding terrain objects, i.e. the set of merged objects that fulfilled the respective minimum mutual overlap threshold (step 4 of the methodology).

The higher the threshold, the fewer landslides were overlapped by the terrain objects, regardless of terrain variable. Highest agreements between reference landslides and terrain objects (up to 35%) were achieved for the Slope Length Factor (LS Factor), Visible Sky, and Slope Height.



When averaging the produced spatial overlaps over the four thresholds, similar conclusions can be drawn: obviously, LS Factor objects have the most predictive power with respect to landslide mapping.



Conclusion

This study demonstrated that terrain objects based on pre-event DEMs generally have a limited landslide predictive capacity. However, some terrain variables generated significantly higher spatial overlaps with reference landslides. In cases where no post-event DEM is at hand, especially these variables should be preferred as auxiliary layers for automated EO based landslide mapping.

FWF Der Wissenschaftsfonds.

Acknowledgements

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Project facts

Title: Integrated Semi-Automated Landslide Delineation, Classification, and Evaluation | **Akronym:** iSLIDE | **Funding agency:** Austrian Science Fund (FWF)| **Duration:** 03/2013 – 08/2015 | **Website:** islide.zgis.net

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