Object-based Integrated Landscape Change Analysis: Synergy of multi-temporal LiDAR and very high resolution orthophotos

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Object-based Integrated Landscape Change Analysis: Synergy of multi-temporal LiDAR and very high resolution orthophotos

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Motivation

Active landslides affect a landscape in three ways: **1. land cover change** (LCC), **2. topographical change**, and **3. above ground biomass (AGB) change**. Managing and prevention of active landslides requires up-to-date information of these changes in time and space in high detail and accuracy. We designed an integrated workflow in eCognition 9.2 that adequately uses the synergy of very high resolution orthophotos and LiDAR data to quantify these changes of a active landslide near Doren, Austria using automated object-based image analysis (OBIA). The synergy is especialy usefull in overcoming shadow effects, dealing with small open spots in the forest and other LiDAR-based errors.

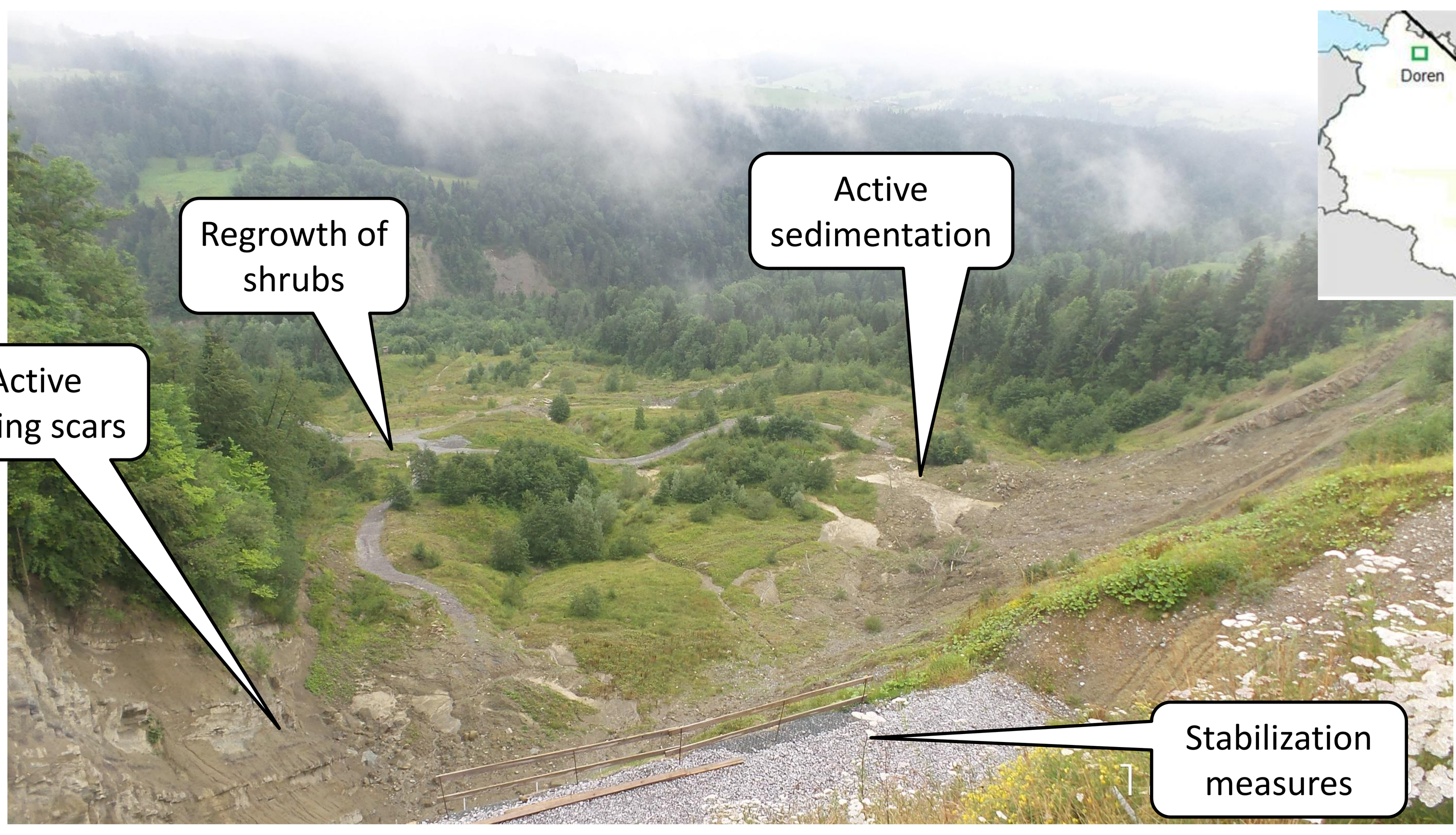
Analysis approach

LiDAR data (2006 point density: 2/m^2; 2012: 4-8/m^2) is used in combination with multi-temporal orthophotos (resolution: 12,5cm). Synergy is used to improve land cover classification accuracy. Land Cover Classification consists of two routines:

(1) Stratified membership classification based on feature space optimization.

(2) Fuzzy-logic improvements based on context, geometry, spectral and elevation characteristics.

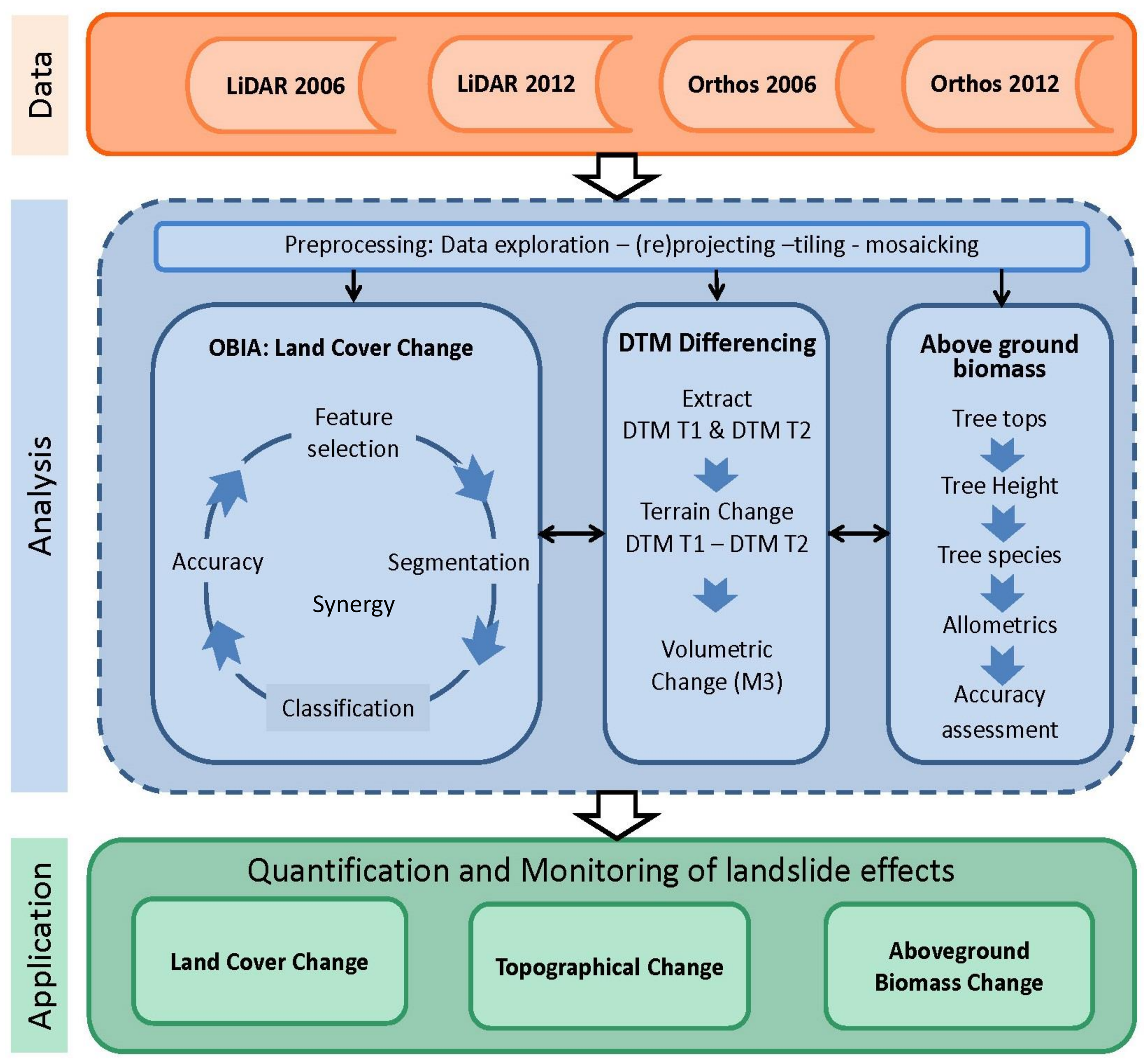
To compare the added value of data synergy, three scenarios were calculated (**S1-S3**). **S1** is based on orthophotos only, **S2** on LiDAR data only and **S3** is the data synergy scenario.



Active landslide near the village of Doren in Vorarlberg (Austria)

Generic workflow (diagram right) for analyzing spatio-temporal effects of landslides on the landscape (photo left), in particular changes in:

1. **Land Cover** (in %)
2. **Volume** (in m^3)
3. **Above Ground Biomass** (in kg)



Main results

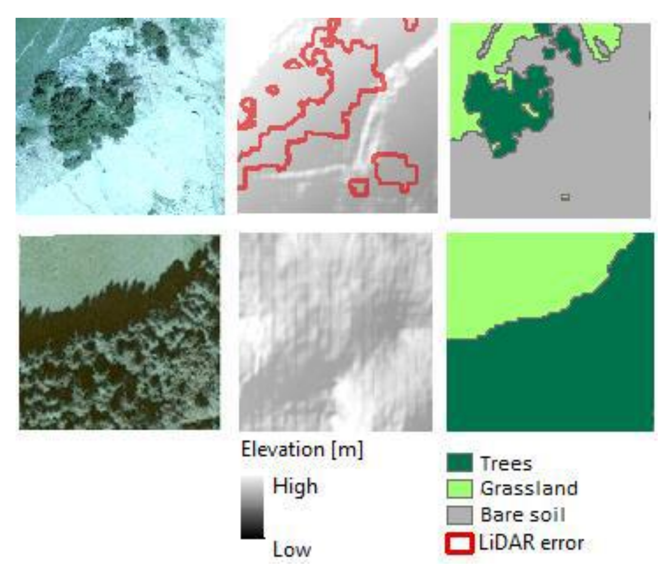
1. Land Cover Change (see map below)

S1. Classification based on orthophotos resulted in miss-classification of spectrally similar objects (e.g. forest and grassland).

S2. Classification based on LiDAR resulted in miss-classification of objects with similar elevation (e.g. grassland and bare soil).

S3. Synergy resulted in improved overall classification accuracy of all land-use classes.

Accuracy	2006	2012
S1 - Orthophoto only:	76%	75%.
S2 - LiDAR only:	65%	64%
S3 - Synergy	90%	91%.



Examples of classification improvements from data synergy.

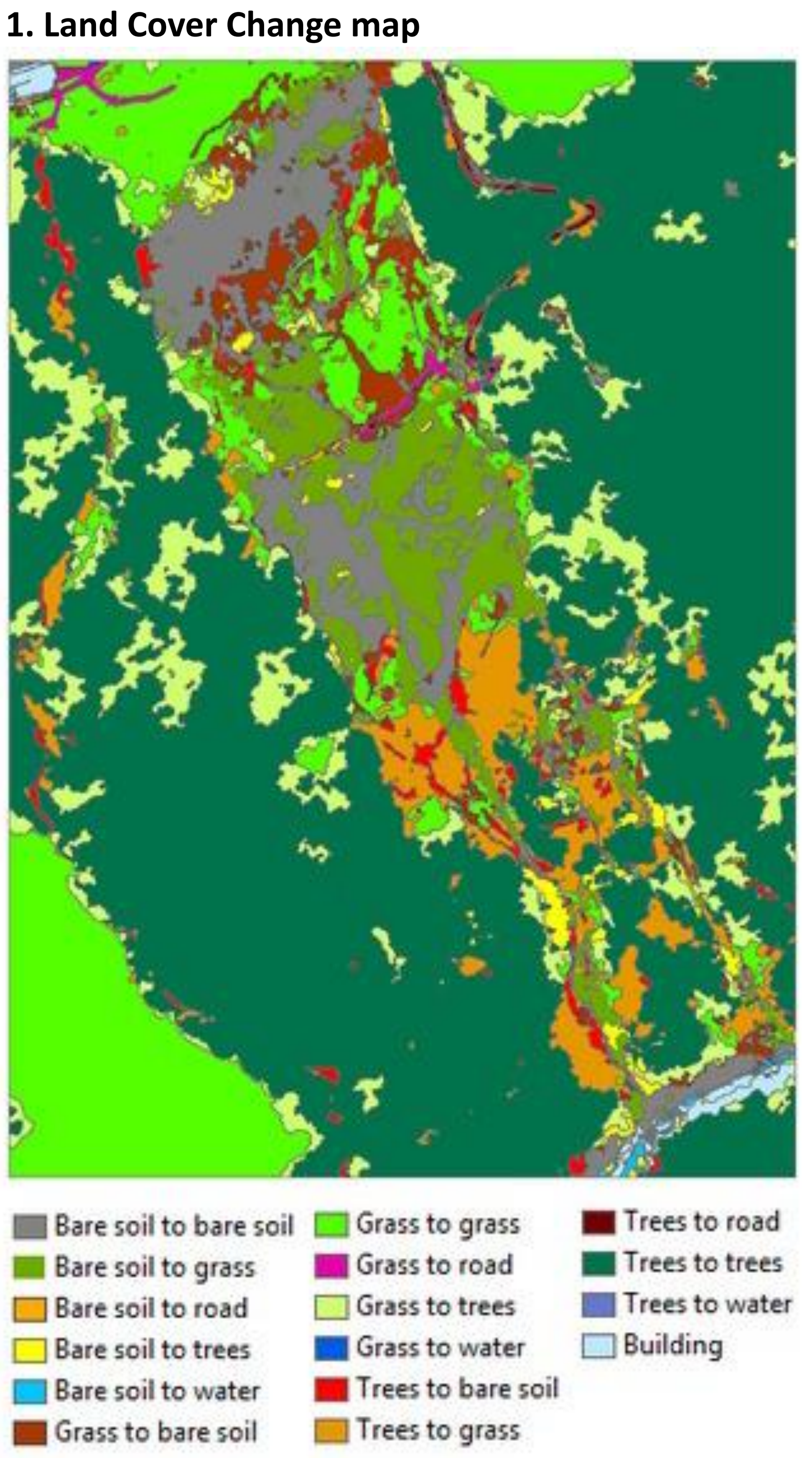
2. Topographical Change (see map below)

Volumetric changes (in m^3) are represented in three classes: 1. Removal of material (in red); 2. No change (in yellow); 3. Deposition of material (in green). The resulting patterns reflect the landslide dynamics: in the upper part zones of deposition and no change which suggests slide-type movements, which is in accordance with known observations. Lower, forested areas are influenced by flow-type accumulation under forest.

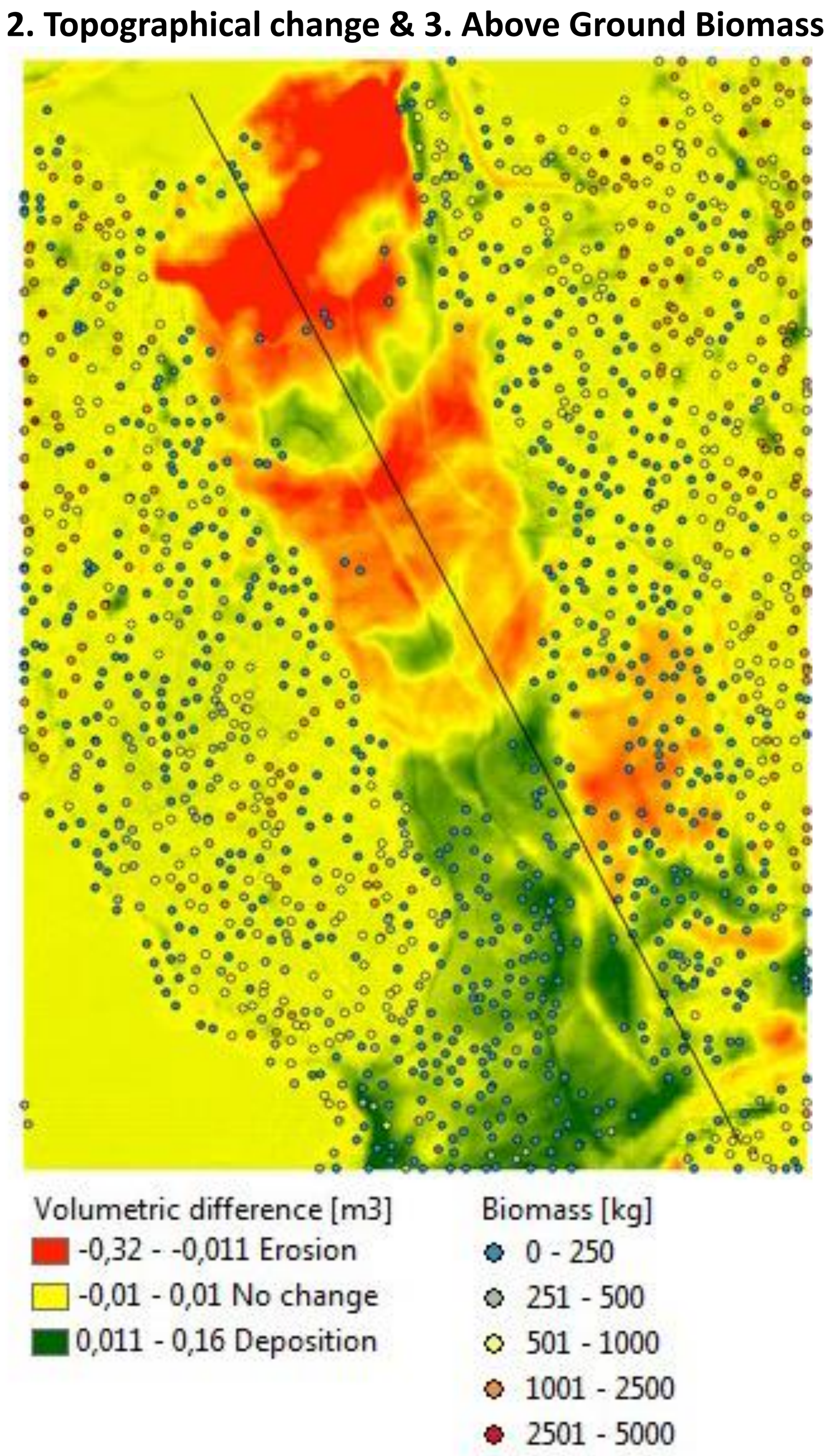
3. Above Ground Biomass (see map below)

Small trees (biomass < 250kg) occur on or close to the lower depositional toe of the landslide, along the edges of forest stands and at canopy openings. Trees of> 1000 kg occur mainly in the middle of forest stands and are not affected by the landslide.

1. Land Cover Change map



2. Topographical change & 3. Above Ground Biomass



Remarks

- The quality and resolution of the LiDAR data and orthophotos is high, but differences in point densities, the applied filtering and interpolation techniques may cause error propagation.
- Three errors were detected, related to shadows and LiDAR-based confusion between Land Cover classes. Although synergy solved most of the errors, the effect of different acquisition dates of orthophotos and LiDAR is present.
- The combined results of the LCC, topographical and biomass change show patterns that align well with the behavior of large landslides. In our case, a striking phenomenon is deposition below forested area in the lower toe area, without causing total removal of trees.

Main Conclusions

1. The synergy of orthophotos and LiDAR-based information improved the object-based segmentation and classification results of Land Cover Change by 18% (2006) and 27% (2012).

2. Three types of classification errors (shadow effects, small open spots in the forest and LiDAR-based errors) were removed, by using spectral, DTM and CHM information.

3. Detailed patterns of stable areas and areas with removal and deposition of material were detected on the landslide, which likely correlate to slide-type and flow-type processes.

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