Object-based time series analysis for landslide change detection using optical remote sensing imagery: Examples from Austria and Norway

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Remote sensing imagery constitutes a valuable and cost-effective source for mapping landslides and identifying landslide changes. Just as the availability and quality of remote sensing data steadily increases, so do the demands for extracting relevant geospatial (change) information in a semi-automated or even fully automated manner. Facing the large number of sensor systems and processing techniques, however, it is a challenge to determine a suitable approach for time series analysis of optical imagery. Object-based image analysis (OBIA) enables us to work seamlessly with multi-scale geospatial data by combining image processing and GIS functionalities (BLASCHKE, 2010). Geomorphological features can be treated as aggregates of pixels and grouped into homogeneous image objects, providing not only spectral properties, but also information on topological relationships, size and shape. Object-based change detection (OBCD) offers unique methods for exploiting high resolution (HR) and very high resolution (VHR) imagery to capture meaningful detailed change information in a systematic and repeatable manner (CHEN *et al.*, 2012; HUSSAIN *et al.*, 2013). Even so, existing object-based methods are often customized to specific data or study areas. There is still need for research to improve their transferability across different sensors and scales, particularly when investigating complex natural phenomena such as landslides (HÖLBLING *et al.*, 2015).

In this study an object-based time series analysis approach for detecting landslide changes in two different geographical regions is presented. The Austrian study site is located in the flysch of the Haunsberg area, approximately 10 km north of the city of Salzburg. This landslide-prone area has been known for a long time and is characterised by major landslides ("Fürwag landslide") that were particularly active during several years at the turn of the century (Fig. 1). For mapping the evolution of the Fürwag landslide, Landsat time series data from 1999 to 2003 is used. The second study site is close to the village of Flåm in the municipality of Aurland, western Norway (Fig. 2). The Flåm valley is a north-south oriented valley consisting predominantly of Precambrian gabbro-mangerite, gneisses and amphibolite overlain by phyllite and mica schist of Ordovician-Cambrian age, the latter section being of greater thickness on the eastern slope. Due to the structural differences and the disparity in resistance to weathering, landslide deposits show distinct difference in grain size and morphology. Landslide changes and debris accumulation areas as result of landslide activity are detected using aerial photographs from 2007 to 2014 with a spatial resolution ranging from 0.5 m to 0.1 m. The landslide changes are identified by comparing the transformation of feature values of segmentation-derived image objects between subsequent images. A major focus is put on the development of a method that is applicable to both study areas and the different data sets. Classification accuracies are assessed by a comparison to results from visual image interpretation, i.e. manually digitized reference polygons, to estimate the spatial overlap, under- and over-estimated areas.

The approach can be used for the regular update of landslide inventory maps. Moreover, findings from retrospective time-series analysis can provide useful information for predicting unstable areas prone to landslides and erosion. Such knowledge can be valuable for implementing prevention and mitigation measures to protect people and infrastructure.

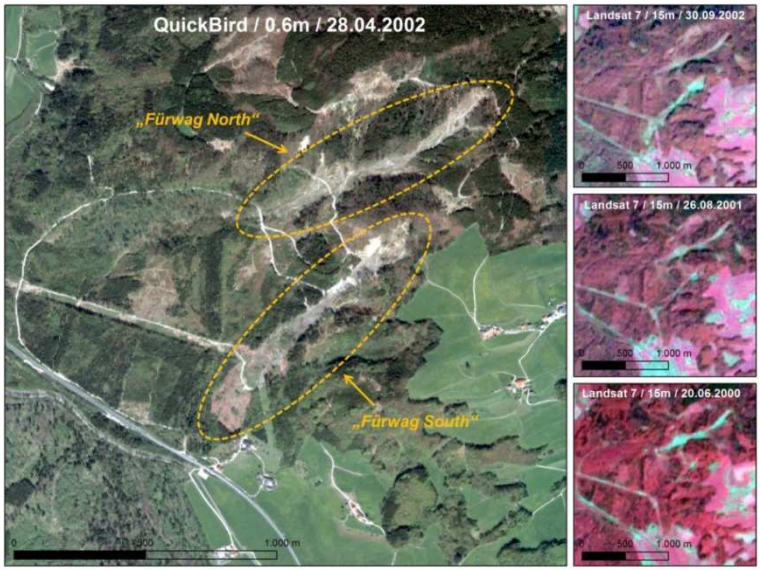

Figure 1: The Fürwag landslide in Austria. The two major landslides ("Fürwag North", "Fürwag South") are shown on a QuickBird image from 2002 for illustration purposes; corresponding Landsat 7 images from the years 2000, 2001 and 2002 that are used for time series analysis are shown on the right.

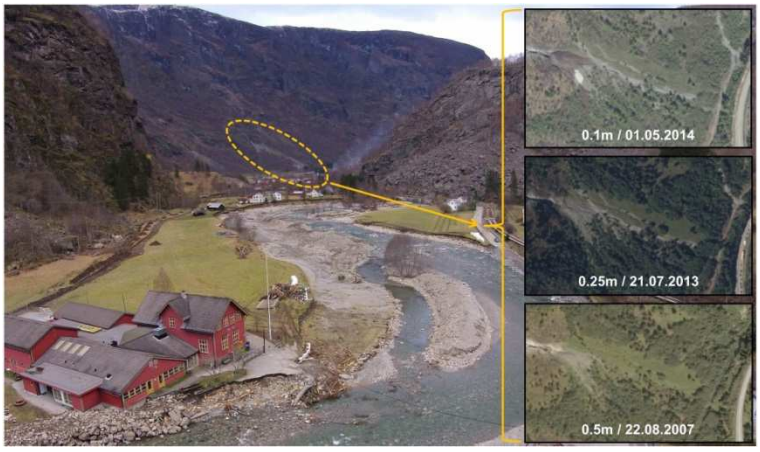

Figure 2: Photo (© Pål Ringkjøb Nielsen) from the Flåm valley and orthophotos from 2007, 2013 and 2014 showing changes in debris accumulation area.

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