Remote sensing as a tool for early recognition of mountain hazards

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INTRODUCTION

Today, remote sensing is key for the identification, quantification and monitoring of natural hazards. Recent developments in data collection techniques are producing imagery at previously unprecedented and unimaginable spatial, spectral, radiometric and temporal resolution. The advantages of using remotely sensed data vary by topic, but generally include safer evaluation of unstable and/or inaccessible regions, high spatial resolution, spatially continuous and multi-temporal mapping capabilities (change detection) and automated processing possibilities. Of course, as with every method, there are also disadvantages involved with the use of remotely sensed data. These are generally in relation to the lack of ground truth data available during an analysis and to data acquisition costs. Here we present the use of remote sensing for snow avalanche detection, exemplified by results from a test study carried out in Norway. During the winter season snow avalanches pose a risk to settlements and infrastructure in mountainous regions. In Norway, avalanches affect populated areas and parts of the transport network every year, leading to the damage of buildings and infrastructure and sometimes also to the loss of lives. Recreational use of the backcountry is augmenting and, unfortunately, an increasing number of fatal avalanche events involving backcountry skiers and snowmobile drivers are observed. Much of Norway is remote and knowing exactly where avalanches have taken place, or are likely to take place next, is often a challenge for the authorities. Novel applications using new Earth Observation satellite capabilities are, therefore, important new tools to tackle these challenges. Ongoing detection, mapping and characterisation of avalanches are important for expanding avalanche data inventories. These enable the validation and quality assessment of avalanche danger warnings issued by avalanche warning services.

METHODS AND RESULTS

Recent studies show that space-borne optical sensors as well as radar sensors (Synthetic Aperture Radar/SAR) can be used to detect and map avalanche debris (cf. Lato et al., 2012; Wiesmann et al., 2001; Malnes et al., 2013). Figure 1 shows the comparison between manually delineated avalanche outlines and results by an algorithm which automatically detects avalanche snow by segmenting and classifying very high-resolution optical

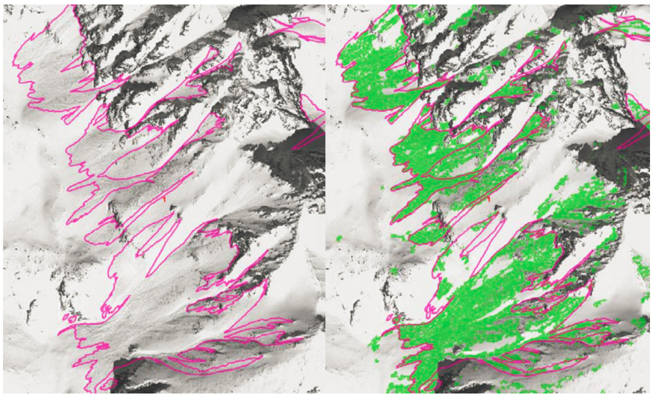

Figure 1. Qualitative comparison between expert avalanche mapping and performance of automatic image analysis algorithm. Left) manually digitized avalanche outlines (in pink) superimposed on raw image; right) manually digitized avalanche outlines (in pink) superimposed on the automatically classified avalanches (in green). Example from the Slovakian Tatra Mountains. (Satellite image: Copyright © DigitalGlobe/WorldView1; courtesy of Slovakian Avalanche Prevention Centre).

imagery. We used the software package eCognition, Version 9 (Trimble, 2014) to design the automatic avalanche detection algorithm. The eCognition software has the ability to use both spatial and spectral information when conducting an image classification, making it an ideal candidate for automated detection of snow avalanches from optical imagery. Figure 2 shows how we detect avalanche debris by using SAR data from the Radarsat-2 satellite. Avalanche debris in the runout zone can be clearly identified both in the pure backscatter data as well as when using a change-detection approach with two scenes acquired at different points in time but with the same image geometry. Malnes et al. (2015) showed that this approach also works on Sentinal-1 data. As the timeliness of data from the Sentinel satellites is unprecedented, these findings are an important step forward towards the operational use of earth observation data in avalanche forecasting.

CONCLUSIONS

The regions requiring avalanche forecasting in Norway are vast and it is hard to assess the snow pack stability over several thousand square kilometres, despite a good network of well-trained observers. The good spatial resolution and the large spatial coverage provided by the new satellites is seen as a much-needed and valuable source of information.

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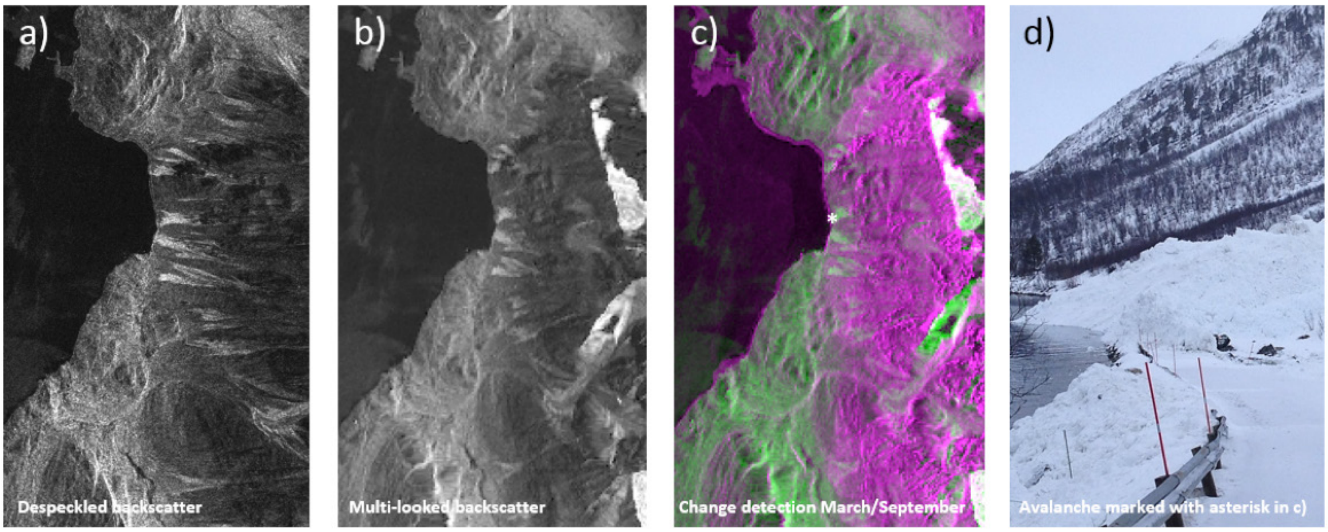

Figure 2. Avalanche detection using a Radarsat-2 imagery: Example from Urbukta, Sørfjorden, Northern Norway. a) Radarsat-2 Ultrafine mode despeckled backscatter image - March 23, 2014; b) Radarsat-2 Ultrafine mode multi-looked backscatter image - March 23, 2014; c) change detection between Radarsat-2 Ultrafine mode March 23, 2014 and Sept. 7, 2014; d) photograph of avalanche deposit marked with asterisk on panel c). Data/Image sources: a)-c) Copyright © MDA/NSC/KSAT (2014), d) Norwegian Public Roads Administration and www.nrk.no.

KEYWORDS

remote sensing; natural hazard monitoring; snow avalanches

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