Technical note

NGI

To:	Norwegian Water Resources and Energy Directorate
Attn.:	Brigt Olav Samdal
Copy:	
Date:	28 January 2013
Revision/Rev. date:	0
Document No.:	20120096-01-TN
Project:	SP4 – Snow Avalanche Research
Prepared by:	Matthew J. Lato and Regula Frauenfelder
Project manager:	Frode Sandersen
Reviewed by:	Helgard Anschütz

Main office:
PO Box 3930 Ullevål Stadion
NO-0806 Oslo
Norway

Trondheim office:
PO Box 1230 Pirsenteret
NO-7462 Trondheim
Norway

T (+47) 22 02 30 00
F (+47) 22 23 04 48

BIC No. DNBANOKK
IBAN NO26 5096 0501 281
Company No.
958 254 318 MVA

ngi@ngi.no
www.ngi.no

Using eCognition Definiens for automated detection of snow avalanche deposits from very high resolution optical imagery – New developments

Contents

BS EN ISO 9001
Certified by BSI
Reg. No. FS 32989

1 Introduction

The identification of snow avalanche deposits from high resolution optical satellite imagery had been the focus of the project "avalRS" which NGI, together with the Norwegian Computing Centre and Statens Veivesen, had carried out for the European Space Agency (2008-2011; e.g., Frauenfelder et al., 2011). The algorithms developed have produced variable results, often working well in certain situations and poorly in others. In 2011 using the object oriented image processing software eCognition, NGI developed two prototype algorithms on its own. The two algorithms were developed for (i) QuickBird satellite imagery, and (ii) Leica ADS-40 airborne imagery (cf. Lato and Frauenfelder, 2012).

As part of the continuation of this research program, the algorithms developed in 2011 were published in the journal 'Natural Hazards and Earth System Sciences' (Lato et al., 2012a) as well as presented at International conferences, e.g., at the "International Snow Science Workshop 2012" in Anchorage, Alaska (Lato et al., 2012b). Overall the developments have been accepted well within the community, the preliminary results demonstrate the possibility of numerous research and commercial applications.

In parallel with the publication and presentation of the research results in 2012, new satellite images containing snow avalanche deposits were tested with the algorithms in eCognition. An overview of the data, the region it represents, as well as a discussion of the results is included in this document.

1.1 Data collection platform

1.1.1 Quickbird

The QuickBird satellite is a multi band (near-infrared, red, green, blue, panchromatic), 11-bit digital sensor. The satellite was launched on October 18th 2001 by DigitalGlobe, at an orbit of 482 km; in October 2011 its orbit was lowered to 450 km. The QuickBird imagery has a multi-spectral pixel resolution of 2.44-2.88 m and a panchromatic pixel resolution of 0.61-0.72 m (website of DigitalGlobe, 2011).

1.1.2 Worldview

WorldView-1 is a high-capacity, panchromatic imaging system featuring half-meter resolution imagery. The satellite was launched in September 2007 and is operating at an altitude of 496 kilometers. WorldView-1 has an average revisit time of 1.7 days. The satellite is also equipped with state-of-the-art geolocation accuracy capabilities (website of DigitalGlobe, 2012)

2 Data processing

The optical satellite imagery has been processed in eCognition using algorithms developed in 2011 (cf. Lato and Frauenfelder, 2011; Lato et al., 2012). Although the algorithms were originally specifically developed for QuickBird satellite imagery and Leica ADS-40 airborne imagery the algorithms were employed as part of the research and development tasks.

3 Results

The results of the automated avalanche identification processing algorithm on a WorldView-1 image of the area of Loen (municipality of Stryn, Sogn og Fjordane, Norway) from April 12, 2010 are illustrated in Figure 1 and 2.
Figure 1 illustrates the processing using the algorithm designed for Leica ADS-40 data, while Figure 2 illustrates the results from the use of the algorithm designed for QuickBird data.

The raw TIFF image is over 250 MB and representing a spatial area of approximately 26 sqkm. To reduce the computational requirements, (i) the image was clipped in ArcGIS to focus on the mountainous snow-covered region, and (ii) the automated identification algorithms were employed using a 4x4 segmentation filter to reduce the overall number of pixels under analysis.

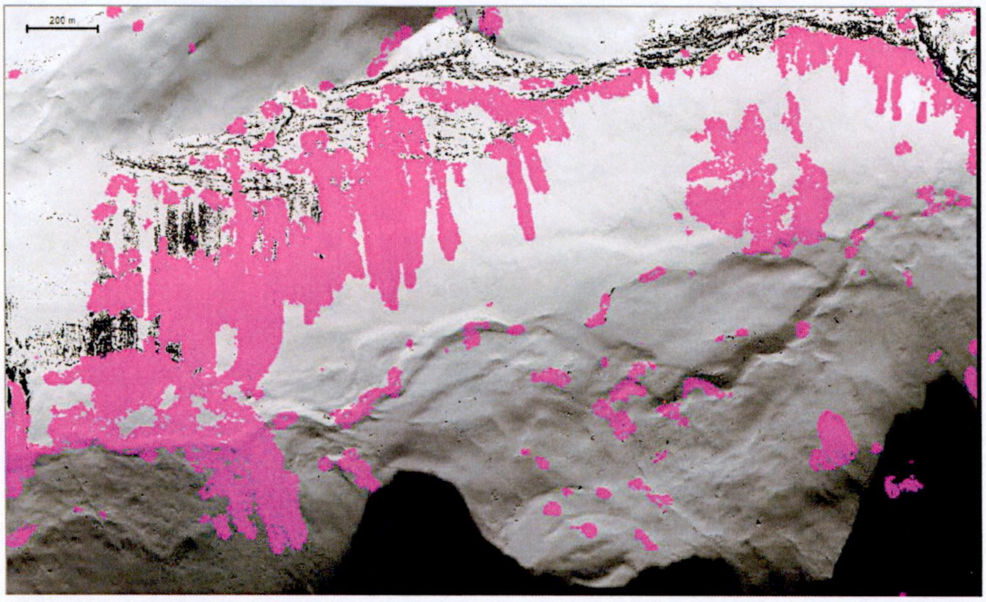

Figure 1: Identification of snow avalanches in a WorldView-1 image using an algorithm developed for Leica ADS-40 imagery.

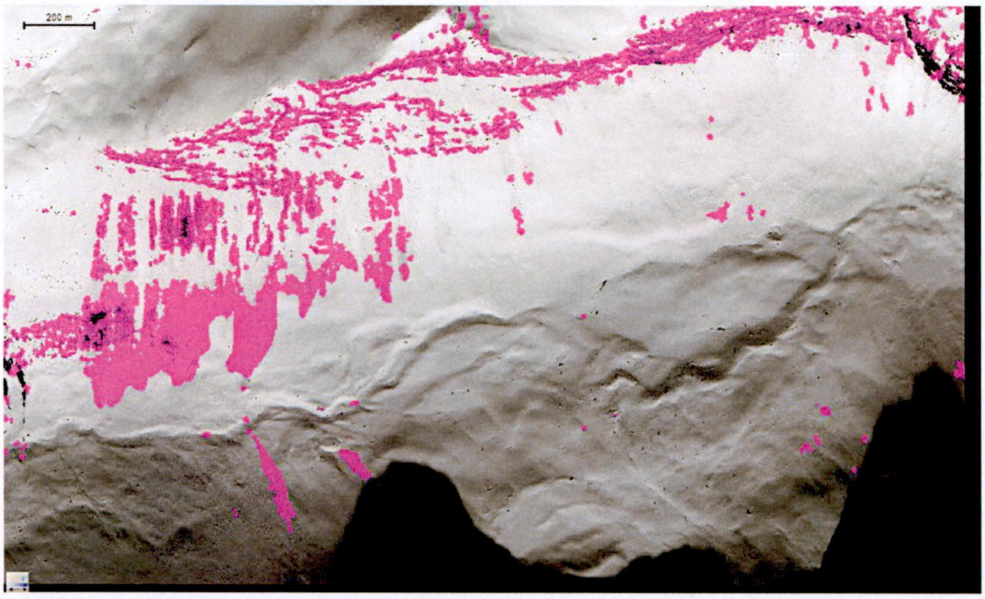

Figure 2: Identification of snow avalanches in a WorldView-1 image using an algorithm developed for QuickBird imagery.

The two algorithms produce distinctly different results. The Leica algorithm (Fig. 1) identifies most of the non-dirt avalanche paths but identifies numerous non-avalanche snow as avalanche snow (false-positives). Conversely the algorithm developed for QuickBird data (Fig. 2) captured many of the "dirty" parts of the avalanche while clearly missing numerous avalanches lacking considerable dirt contents (false-negatives).

4 Discussion

The results illustrated in the above section demonstrate the capabilities of computer-vision with respect to the identification of snow avalanches/snow avalanche deposits, especially considering the fact that the algorithms employed were not designed, let alone calibrated for the given dataset.

As the replication of human image recognition capability through computer-vision and object oriented image analysis is extremely complicated a discussion of false positives versus false negatives warrants significant discussion. The decision to make an algorithm aggressive with the possibility of producing conservative results versus a more relaxed process that results in liberal results must be evaluated and discussed. In some fields of application it might be sufficient to know the frequency/size distribution of snow avalanche activity within one order of magnitude, while in other application fields this would clearly not be sufficient. In general, it can be said that - depending on the needs of the end user - it is best to produce robust functional algorithms and then develop finer methodologies as more data are tested and more experience is gained.

The use of data-filtering tools can increase the accuracy as well as the efficiency of automated identification algorithms. By eliminating sections of the input images based on known content the focus of the avalanche identification can be concentrated on high-risk areas. Such masks can include slope angle, land coverage, known avalanche activity, etc.

A significant challenge encountered during the image processing tasks in 2012 was working with high bit-depth images, specifically 16-bit images. Unlike previous images, generally between 8- and 14-bit pixel depths, 16-bit images store the panchromatic colour information across a wider spectrum of values. This allows for more detailed information, specifically at the black end of the spectrum. However, when processed using the algorithms designed for QuickBird and Leica data the original 16-bit WorldView image was unable to be processed and had to be resampled to 8- to 14-bit pixel depths.

5 Conclusions

The research and development in 2012 primarily focused on the further testing and publication and presentation of the results of the snow avalanche identification algorithm research developed in 2011. As outlined in this report, new optical satellite imagery data were tested with the existing algorithms. The research completed in 2012 was well received by the international community. The successful preliminary implementation of the algorithms with new data revealed positive results. Although there remains future research, development, and testing to be completed, 2012 was a successful step forward in the research field of automated snow avalanche deposit identification.

Future research will, among others, investigate the advantages of working with different pixel depths, as well as how to optimize the handling of different images. Two distinct solutions will be to (i) down-sample the pixel depth from 16-bit to 12-bit or (ii) design new algorithms that can benefit from the added information.

Ackknowledgements

The research presented in this Technical Note has been supported by the Ministry of Petroleum and Energy (OED) through the Norwegian Water Resources and Energy Directorate (NVE) and by the International Center for Geohazards (ICG).

References

Frauenfelder, R., Solberg, R., Salberg, A.-B., Larsen, S.Ø., Bjordal, H. 2011. avalRS – Remote sensing derived avalanche inventory data for decision support and hindcast after avalanche events. Service Evaluation and Evolution Document – Deliverable 5 (D5): 28 pp. (http://dup.esrin.esa.it/prjs/Results/20120207131328.pdf)

Lato, M.J., Frauenfelder, R. 2012. Using eCognition Definiens for automated detection of snow avalanches from optical imagery. NGI Technical note: 11 pp.

Lato, M.J., Frauenfelder, R., Bühler, Y. 2012. Automated detection of snow avalanche deposits: segmentation and classification of optical remote sensing imagery. Nat. Hazards Earth Syst. Sci., 12, 1–14. doi:10.5194/nhess-12-1-2012.

Lato, M.J., Frauenfelder, R., Bühler, Y. 2012. Automated avalanche deposit mapping from VHR optical imagery. Proceedings, 2012 International Snow Science Workshop, September 16-21, Anchorage, Alaska: 392-394.

Kontroll- og referanseside/ Review and reference page

NGI

Dokumentinformasjon/*Document information*		
Dokumenttittel/*Document title* Using eCognition Definiens for automated detection of snow avalanche deposits from very high resolution optical imagery – New developments		Dokument nr/*Document No.* 20120096-01-TN
Dokumenttype/*Type of document* ☐ Rapport/*Report* ☒ Teknisk notat/*Technical Note*	Distribusjon/*Distribution* ☒ Fri/*Unlimited* ☐ Begrenset/*Limited* ☐ Ingen/*None*	Dato/*Date* 2013-01-28 Rev.nr./*Rev.No.* 0
Oppdragsgiver/*Client* Norwegian Water Resources and Energy Directorate		
Emneord/*Keywords*		

Stedfesting/*Geographical information*	
Land, fylke/*Country, County*	Havområde/*Offshore area*
Kommune/*Municipality*	Feltnavn/*Field name*
Sted/*Location*	Sted/*Location*
Kartblad/*Map*	Felt, blokknr./*Field, Block No.*
UTM-koordinater/*UTM-coordinates*	

Dokumentkontroll/*Document control*

Kvalitetssikring i henhold til/*Quality assurance according to* NS-EN ISO9001

Rev./ *Rev.*	Revisjonsgrunnlag/*Reason for revision*	Egen-kontroll/ *Self review* av/*by:*		Sidemanns-kontroll/ *Colleague review* av/*by:*		Uavhengig kontroll/ *Independent review* av/*by:*		Tverrfaglig kontroll/ *Inter-disciplinary review* av/*by:*	
0	Original document	RF	RF	HAn	HAn				

Dokument godkjent for utsendelse/ *Document approved for release*	Dato/*Date*	Sign. Prosjektleder/*Project Manager*
	28.01.2013	Regula Frauenfelder R. Frauenfelder

Skj.nr. 043