Developing X-band corner reflectors for multi-technological monitoring of ground displacement in alpine environments

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INTRODUCTION

Satellite-based synthetic aperture radar (SAR) has gained in popularity amongst geoscientists over the last decade, and can now be considered an established and operative remote sensing tool. In particular, multi-temporal differential interferometric SAR (DInSAR) has received attention due to the ability to detect and monitor ground displacements along the line of sight in mm or cm accuracy. DInSAR processing allows the assessment of displacements over wide areas by analysing the phase differences from a set of SAR images. The main benefits of DInSAR over traditional surface deformation measurements is the ability to carry out investigations over large areas at relatively low costs. There are several recent examples of SAR applications to different processes including landslides (Calò et al., 2014; Schlögel et al., 2015; Wasowski and Bovenga, 2014) and rock glaciers (Liu et al., 2012; Papke et al., 2012). More general introductions to the methodology are provided elsewhere (Pasquali et al., 2014; Rosen et al., 2002). Multi-temporal DInSAR is frequently being carried out using the Permanent or Persistent Scatterers (PS) technique, which relies on the identification of phase stable targets in stacks of SAR images. Large numbers (e.g. >1000) of PS can easily be found in settlement areas where infrastructure features are widely available. However, in remote areas can be difficult to find natural targets (e.g. larger blocks or rocks) which can be used as PS, leading to the need to install artificial corner reflectors (CR) which can be identified on SAR imagery. Here, we report on the development and application of a newly developed CR for X-band based multi-temporal DInSAR, which has been specifically designed for the use in alpine conditions and is already suited for additional data validation techniques, e.g. by GPS. The CR is the result of several research projects, i.e. AlpSlope (2002-2005), ProAlp (2006-2009), Lawina (2009-2012) and SloMove (2012-2014).

STATE OF THE ART

A comparison of different CR is presented in Figure 1. Due to the radar cross section, traditional C-band CR (Fig. 1a) have a trihedral side length of approximately 70 cm, while X-band CR can be as small as 24 cm (Fig. 1b and c). However, the aforementioned CR have some limitations regarding their usage in remote locations and alpine environments. We therefore designed a new type of CR (Fig. 1d) which is well suited to SAR applications under tough conditions. All of the pictured CR have been tested extensively on Corvara landslide in South Tyrol, except for the one developed by Bovenga et al. (2012) which essentially represented a starting point for the design of our new CR.

RESULTS

Our new CR has been designed to be used with X-band radar data as for example provided the COSMO SkyMed CSK® satellite. In contrast to conventional CR, the new CR is extremely lightweight and can easily be transported with a backpack. Installation of the new CR is simple because it only relies on one pole, which makes it easier to fix it into soil, rock and ice. Moreover, the inclination and orientation can easily be adjusted which might be necessary if ground movements displace the CR. The plates of the trihedral are made of perforated aluminium plates, which decreases the weight, but also helps minimising wind resistance and facilitates snow melt and run-off of melt water. An additional arm is attached behind the trihedral to accommodate a GPS antenna for periodic validation measurements. Thereby, the CR can easily be used for data validation by GNSS techniques which can be difficult for natural PS.

CONCLUSIONS

The new CR have been tested on rock glaciers and landslides in alpine environments in Switzerland and Italy and have proven to be efficient and robust. Ground displacement caused by rock glacier and landslide activity have successfully been assessed and validated with periodic differential GPS measurements.

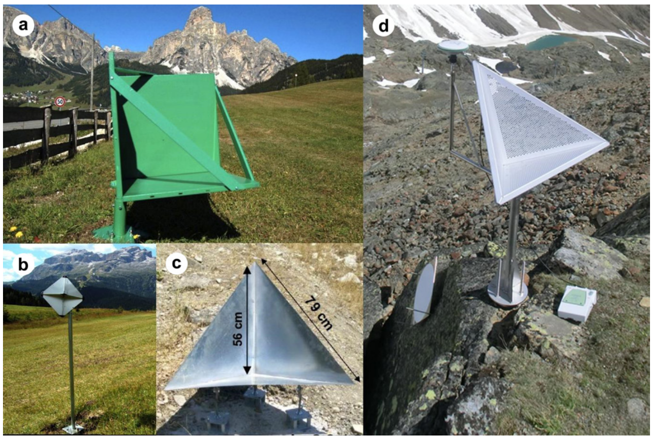

Figure 1. Different types of corner reflectors (a) conventional C-band reflector; (b) nautical reflector; (c) X-band reflector (Bovenga et al., 2012); (d) newly developed X-band reflector with included GPS attachment.

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KEYWORDS

DInSAR; Monitoring; corner reflectors; landslides; rock glaciers

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