Monitoring of the main scarp of the Potoška planina landslide (Karavanke Mountain, NW Slovenia) using terrestrial laser scanning (TLS)

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INTRODUCTION

The monitoring of landslide dynamics is an important task in the investigation of landslides. To determine the dynamic of the main scarp of the Potoška planina landslide it was crucial to observe changes through time such as surface changes and estimation of transported volume.

The landslide Potoška planina is situated in the Karavanke mountain ridge above the settlement Koroška Bela. The landslide covers an area of approximately 300 m × 750 m and spreads between 1450 m.a.s.l. at the crown and 1125-1130 m.a.s.l. at the toe. The broad area of the Potoška planina has very complex geological and tectonic settings and is known to have experienced severe debris-flow events in the recent geological past. Tectonically, the area is characterized by the Sava and Periadriatic fault zones and is dissected by numerous faults associated with the two main faults. Due to unfavourable geological and tectonic conditions the Potoška planina is very prone to different types of slope mass movements. The main scarp of landslide is formed in the scree below the vertical slope of limestone (Main scarp in Figure 1) and is subjected to different rockslide movements and to runoff of the scree material. The main body of landslide is presumed to be slow-motion slip; meanwhile the toe of the landslide represents the zone of accumulation (toe of the landslide in Figure 1) and is the most active part of landslide that could be mobilized into debris flow. The sliding mass mainly consists of heavily deformed Upper Carboniferous and Permian clastic rocks which consist of alternating shale, quartz sandstone and conglomerate and is covered with a large amount of talus material and slope sediment.

METHODS

In order to determine the dynamic of the Potoška planina landslide and to ensure the continued assessment of landslide activity the periodical monitoring of visible surface changes through time has been established using flexible and reliable monitoring methods. In the past the dynamic of the Potoška planina landslide has been investigated at its toe, which represents the most active part of landslide. The dynamics of the toe has been monitored since July 2013 using two independent monitoring techniques, the UAV photogrammetry using structure-from-motion (SfM) and multi view stereo (MVS) photogrammetric techniques and the tachymetric measurements. Additionally, to obtain reliable extent and to understand dynamic of the landslide it was also necessary to provide periodical monitoring in the main scarp of the Potoška planina landslide. The main scarp has been formed in the scree below very steep slope of limestone and covers an area of 270 x 170 m. The main scarp consists of large amount of talus material that is highly prone to instability and represents the source area of sliding mass. According to extent of the main scarp, configuration of the site and the surface conditions and with aim to determine near-real time reliable superficial displacement rates and changes in the surface topography including analysis of the discontinuity sets and fold axes, scanning of the main scarp of the Potoška planina landslide have been performed using terrestrial laser scanner (TLS) in different acquisition periods. The geodetic network consisting of nine points, stabilized in the solid rock, was established around the major scarp to provide uniform georeferencing of the point clouds from different periods. The coordinates of all points in the network were measured with tachymeter. To determine the coordinates in the national coordinate system, four points were measured with GNSS. So far, two data

acquisitions using TLS technology were performed in June 2014 and June 2015.

RESULTS

The first comparison between DEMs was used to evaluate surface changes and estimation of transported volumes. The comparison showed that the total area of ablation within the study site is 8153 m² (~28% of analysed area), meanwhile the total area of accumulation is 20771 m² (~72% of study site). It can be seen that the dominant ablation was in the middle part of the study area where the elevation had subsided by 0.1 to 0.3 m (Figure 1); meanwhile the sediment accumulation was observed at the foot zones. The assessed volume of the eroded surface material is 1461 m³ and of the accumulated material is 629 m³.

CONCLUSIONS

In this study, the main scarp of the Potoška planina landslide that represents the source area was observed. To determine the dynamics of this part it was crucial to observe changes through time such as changes in elevation and changes in volume. According to extent of the main scarp, configuration of the site, the scanning using terrestrial laser scanner (TLS) in two data acquisition periods were performed.

Considering that the Potoška planina landslide lies on the outskirts of the village Koroška Bela, which occupies an area of 1.02 km² and is densely populated (with more than 2,200 inhabitants), the landslide could represent a huge hazard to inhabitants and public infrastructure (i.e., a major railway, local road and steel factory). According to the unfavourable geological conditions, historical debris-flow events and past observations of slope (in) stability, the continuous observation of the dynamics and behaviour of the Potoška planina landslide is necessary.

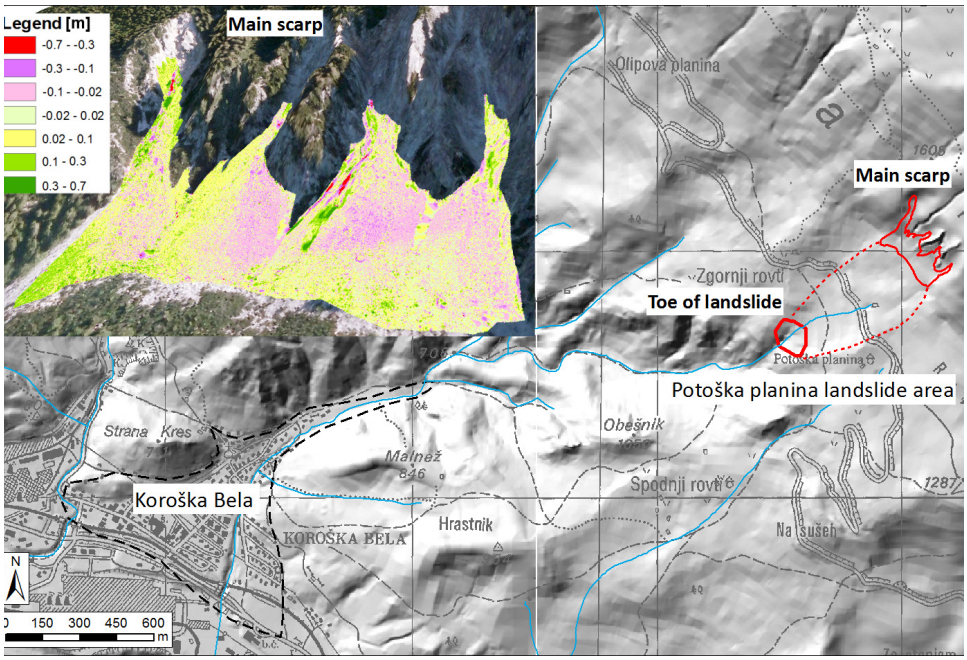

Figure 1. Shaded relief map of the Potoška planina landslide and broad area showing the main scarp and the toe of landslide. Detail in the upper left corner shows elevation-difference (z-axis) map obtained by subtracting DEM 2014 from DEM 2015. The topographic data in Figure 1 (including digital elevation model 5 m x 5 m for the shaded relief map; orthophoto and digital elevation model 1 m x 1 m for the 3D visualisation of the main scarp) were provided by Ministry of the Environment and Spatial Planning, 2015 and Surveying and Mapping Authority of the Republic of Slovenia, 2015.

KEYWORDS

Potoška planina landslide; monitoring; landslide; main scarp; terrestrial laser scanning (TLS)

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