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ISPRS Journal of Photogrammetry & Remote Sensing 59 (2005) 212–221

PHOTOGRAMMETRY & REMOTE SENSING

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Application of multi-temporal high-resolution imagery and GPS in a study of the motion of a canyon rim landslide

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Received 1 March 2004; accepted 2 February 2005
Available online 14 April 2005

Abstract

Change detection techniques using co-registered high-resolution satellite imagery and archival digital aerial photographs have been used in conjunction with GPS to constrain the magnitude and timing of previously undocumented historical motion of the Salmon Falls landslide in south-central Idaho, USA. The landslide has created natural dams of Salmon Falls Creek, resulting in the development of large lakes and a potential flooding hazard. Rapid motion (cm/year–m/year) of the relatively remote landslide was first reported in 1999, but significant horizontal motion (up to 10.8 m) is demonstrated between 1990 and 1998 by measuring changes in the locations of ground control points in a time-series of images. The total (three-dimensional) motion of the landslide prior to 2002 was calculated using the horizontal (two-dimensional) velocities obtained in the image change detection study and horizontal-to-vertical ratios of motion derived for the landslide in 2003–2004 collected from a network of autonomous GPS stations. The total historical motion that was estimated using this method averages about 12 m, which is in agreement with field observations.

Keywords: Landslide; GPS; Geohazard; Quickbird; Aerial photographs

1. Introduction

Mass wasting in remote areas is often difficult to detect and monitor, but it can have a substantial impact on local natural resources. In the case of canyon-rim landslides, the activity can impact populated areas downstream through the construction and failure of landslide dams. The analysis of historical landslide activity in remote areas and predicting future related failures is difficult, but can take advantage of the extensive archival aerial photography that is available for many areas (Casson et al., 2003). Furthermore, a combination of image processing methods and detailed global positioning system (GPS) monitoring can provide a

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0924-2716/$ - see front matter © 2005 International Society for Photogrammetry and Remote Sensing, Inc. (ISPRS). Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.isprsjprs.2005.02.001

powerful tool for analyzing the detailed mechanics of landslide motion (Coe et al., 2003; Mora et al., 2003). Here, we present a study of a remote landslide in southern Idaho, USA, that combines change detection using high-resolution remote sensing imagery with detailed GPS measurements to determine the detailed history of motion.

Salmon Falls Creek is a 0.85–8.5 m^3/s (30–300 cfs) tributary to the Snake River in south-central Idaho. Its canyon is typically "v"-shaped, about 100 m deep and 250 to 500 m wide over most of its length, but in a 4 km section of the river known as "Sinking Canyon", it widens dramatically to well over 1 km (Fig. 1). The canyon floor in this area

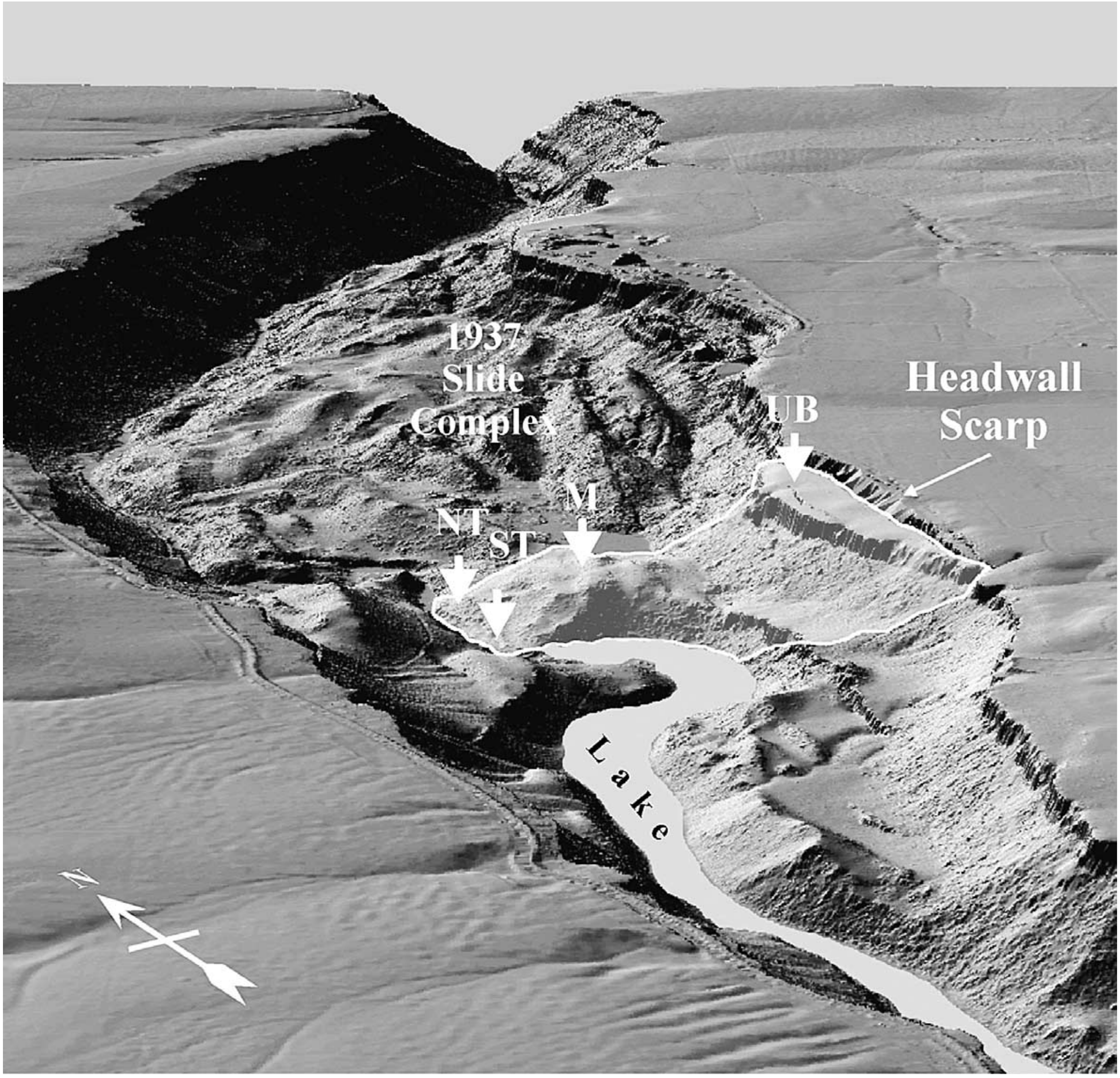

Fig. 1. Perspective view of Salmon Falls Creek Canyon digital elevation data, showing the "Sinking Canyon" area, and the Salmon Falls landslide (outlined). This section of the canyon is anomalously broad (>1 km) compared to the narrower, "v"-shaped profile that is more typical of the canyon (top). The lake at bottom center was created by the damming of Salmon Falls Creek by the landslide, and is a possible flood hazard, if the dam should fail. GPS stations ST (South Toe), NT (North Toe), M (Middle), and UB (Upper Block) are indicated with arrows.