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5.1 Introduction

The objective of this study is to characterize slope deformation as a result of static and dynamic forces, using the most current geodetic technologies that measure active ground surface displacement. New and improved methods for geodetic and remote data collection, such as continuous GPS, and Interferometric Synthetic Aperture Radar (InSAR) allow for a level of primary site characterization and eventual landslide risk assessment that was previously not possible. These technologies need to be incorporated into current practice and tested. Active landsliding across the Lawrence Berkeley National Laboratory (LBNL) site and the greater Berkeley Hills region, California, has been the object of many investigations over recent decades, though the mechanisms of currently mobile, slow moving slides are still poorly understood. Previous studies suggest that a trend in landslide mobility is associated with regional climate and active tectonic conditions in addition to the local geologic setting. A first focus of this project is therefore to study the spatial and temporal distribution of active Berkeley Hills landsliding in relation to local precipitation and ground shaking events by a careful observational program. This program includes the instrumentation of individual landslides with permanent continuously streaming GPS stations, and regional monitoring of slope surface deformation by InSAR time series analysis. Subsequently, the mechanisms of some of these slow moving landslides will be modeled, integrating our surface observations with previous subsurface investigations and monitoring.

5.2 Setting

As part of the northwest trending California Coast Range geomorphic province, the Berkeley Hills are an uplifted block of Jurassic to Tertiary sedimentary, volcanic and metamorphic rock formed during regional transpression related to the active plate margin 1-2 million years ago. Now largely overlain by Quaternary colluvial and alluvial deposits, this generally highly fractured, intensely weathered, moderately soft rock is prone to landsliding. In addition to the geologic setting, studies suggest a trend in Berkeley Hills landslide mobility associated with regional climate and active tectonic conditions (Alan Kropp and Associates, 2002; Hilley et al., 2004; Quigley et al., 2010). Today, over 500 landslide-related geologic and geotechnical investigation reports are available for LBNL and the Berkeley Hills alone, and form a solid background to this project.

5.3 Methodology

Two state of the art geodetic sensing technologies form the primary modes of data acquisition in this project: high rate, continuously streaming, Global Positioning Systems (GPS) and space-born Interferometric Synthetic Aperture Radar (InSAR). These methods are complementary in that GPS provides discrete ground surface displacement measurements with millimeter scale accuracy and precision, while InSAR time series analysis produces spatial averages at decimeter resolution with subcentimeter precision. Combining these methods allows for spatial and temporal distribution analysis of ground surface displacements due to landsliding in relation to local precipitation and ground shaking events. By incorporating these surface observations with previous investigations and monitoring, the landslide mechanisms can then be modeled.

5.4 Project Status

The first phase of this project has been to instrument individual landslides with autonomous, continuously streaming GPS stations, collecting readings at 1Hz for average daily solutions and a 5Hz buffer in the case of seismic activity. Each device has been specifically designed for permanent installation as a stand-alone station and made to capture actual landslide displacement at depth. Anchored on deep-seated reinforced concrete foundations to avoid the effects of surficial disturbance, the stations are solar powered and equipped with a wireless antenna for remote access. Since January 2012, five such stations have been successfully installed at LBNL and one at the University of California Blake Garden on the Blakemont Landslide. Four additional sites in the Berkeley Hills are in the process of being developed. With the concurrent development of this GPS network, InSAR time series analysis has also begun. Satellite-based Radar images for InSAR time series analysis are available for the Berkeley Hills region dating back to 1992 and have already been the object of several studies as shown in Hilley et al. (2004) and Quigley et al. (2010).
5.5 Preliminary Results

Since January 2012, the first 6 continuously streaming GPS stations (LRA 1-6) have been producing daily solutions. Highlighted here are stations LRA 1-3 located on the same landslide at LBNL. While historical ground surface displacement related to this landslide has yet to be characterized and quantified, it is well defined as shown in the 1935 air photo in Figure 2.9 and has been the object of extensive subsurface investigations. Already, a clear signal at each of these 3 stations is apparent, showing down-slope displacements of up to 2cm and directly related to local precipitation. Time histories of daily solutions at stations LRA 1-3, from mid January through mid May 2012 are illustrated in Figure 2.10 and plotted against cumulative rainfall (solid line). Here, the daily solutions for each station’s North and East baselines (circles and triangles respectively) are taken with respect to a fixed station (P224) several kilometers to the South and are shown to be moving down-slope to the west and southwest, accelerating during rainfall events.

5.6 Acknowledgements

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5.7 References

