



# Innovative landslide disaster monitoring: unmanned aerial vehicle-deployed GNSS technology

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## ABSTRACT

Real-time monitoring technologies of surface deformation represented by the global navigation satellite system (GNSS) are essential for landslides early warning. Monitoring methods such as GNSS require on-site manual installation. Therefore, it becomes nearly impossible to deploy surface monitoring equipment when landslides are located in high mountain valleys that are challenging for personnel to access, and/or in hazardous situations. We propose an intelligent real-time monitoring and early-warning technology that employs an unmanned aerial vehicle (UAV) as a carrier to deploy GNSS equipment. A system was initially designed with five components: an adaptive sampling GNSS receiver, an intelligent cooperative network transmission module, UAV-dropped GNSS equipment, special delivery UAV, and an intelligent monitoring and early warning cloud platform. This new technology was applied to a real landslide in Gansu Province, China, in 2020. The mean absolute error of 30 days in the east, north, and upward directions were 1.2, 1.3, and 2.9 mm/d, respectively, comparing the deformation velocity between the traditional monitoring station and the UAV-dropped monitoring station. This observation facilitated the successful prediction of a landslide hazard on 27 January 2021, allowing for a timely alert to be issued. Collectively, the results of this study established that UAV-deployed GNSS technology can accomplish unmanned deployment of GNSS equipment for landslide monitoring to ensure early warning issuance in inaccessible and/or high-risk areas.

## ARTICLE HISTORY

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Global navigation satellite system; landslide; real-time monitoring; unmanned deployment; unmanned aerial vehicle

## 1. Introduction

Landslide disasters are widespread and recurring global disasters posing significant obstacles to infrastructure development and operations while also causing substantial casualties and economic losses. In China, approximately two-thirds of the land

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