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Accurate Landslide Dating Using Sentinel-1 and Sentinel-2 Data in Google Earth Engine

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Landslides are movements of earth, rock, or debris across a slope, triggered by natural factors such as intense rainfall, earthquakes, or erosion processes, as well as human activities like deforestation or land use changes. Monitoring landslides is crucial for assessing their magnitude and frequency, and for early detection of potential landslide activity.

New methods for landslide monitoring rely on satellite remote sensing, enabling continuous observation of large areas and tracking changes in vegetation, soil, and terrain through optical and radar imagery, enabling efficient, cost-effective, and timely detection and analysis of landslides.

A key aspect of landslide monitoring is determining the trigger moment of a landslide. This information is essential for developing predictive models, identifying vulnerable areas, and improving risk management strategies. However, satellite-based landslide dating faces challenges, especially cloud cover, which can limit optical imagery and reduce the number of usable images, complicating landscape monitoring and analysis. This limitation can be overcome by using satellite radar imagery, which penetrates cloud cover and complements optical satellite monitoring.

In this work, we propose an innovative approach for accurately determining the trigger moment of a landslide by combining optical (Sentinel-2) and radar (Sentinel-1) data, processed using Google Earth Engine (GEE). GEE is an advanced cloud-based platform for processing and analyzing large amounts of satellite imagery.

Analysing Sentinel-2 images allows for the identification of sudden vegetation loss or changes in soil structure, which can be linked to landslide triggers. Abrupt changes in vegetation indices help to identify the time window during which the landslide occurred.

Sentinel-1 radar sensors detect variations in backscattering, which help refine the time window and improve the accuracy of landslide dating.

The effectiveness of integrating Sentinel-2 and Sentinel-1 satellite data within the GEE environment is tested using a database of known landslides. Applying the proposed procedure demonstrates improved accuracy in landslide dating, providing more precise time windows for events. By combining Sentinel-2 and Sentinel-1 data, the method significantly reduces dating errors.

This approach not only enhances the precision of determining the time window of landslide events but also opens new perspectives for continuous monitoring and risk management in remote or hard-to-reach areas. Conducting large-scale analyses in vulnerable and poorly monitored regions represents a significant step toward more timely and efficient landslide management.

Furthermore, GEE's shared scripting environment allows the creation of reproducible workflows, enabling other researchers to replicate and build upon the analysis, further advancing the use of satellite-based landslide monitoring.

KEYWORDS Landslide, dating, Google Earth Engine, Sentinel-2, Sentinel-1

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