Geophysical Research Abstracts
Vol. 18, EGU2016-3737, 2016
EGU General Assembly 2016

Preliminary remote sensing assessment of the catastrophic avalanche in Langtang Valley induced by the 2015 Gorkha earthquake, Nepal

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A major earthquake, measuring 7.8 Mw, occurred on April 25, 2015, in Lamjung district, central Nepal, causing more than 9,000 deaths and 23,000 injuries. During the event, termed the 2015 Gorkha earthquake, the most catastrophic collapse of the mountain side was reported in the Langtang Valley, located 60 km north of Kathmandu. In this collapse, a huge boulder-rich avalanche and a sudden air pressure wave traveled from a steep south-facing slope to the bottom of a U-shaped valley, resulting in more than 170 deaths. Accurate in-situ surveys are necessary to investigate such events, and to find out ways to avoid similar catastrophic events in the future. Geospatial information obtained from multiple satellite observations is invaluable for such surveys in remote mountain regions. In this study, we (1) identify the collapsed sediment using synthetic aperture radar, (2) conduct detailed mapping using high-resolution optical imagery, and (3) estimate sediment volumes from digital surface models in order to quantify the immediate situation of the avalanched sediment.

(1) Visual interpretation and coherence calculations using Phased Array type L-band Synthetic Aperture Radar-2 (PALSAR-2) images give a consistent area of sediment cover.

Emergency observation was carried out the day after the earthquake, using the PALSAR-2 onboard the Advanced Land Observing Satellite-2 (ALOS-2, "DAICHI-2"). Visual interpretation of orthorectified backscatter amplitude images revealed completely altered surface features, over which the identifiable sediment cover extended for 0.73 km^2 (28°13'N, 85°30'E). Additionally, measuring the decrease in normalized coherence quantifies the similarity between the pre- and post-event surface features, after the removal of numerous noise patches by focal statistics. Calculations within the study area revealed high-value areas corresponding to the visually identified sediment area. Visual interpretation of the amplitude images and the coherence calculations thus produce similar extractions of collapse sediment.

(2) Visual interpretation of high-resolution satellite imagery suggests multiple layers of sediment with different physical properties.

A DigitalGlobe satellite, WorldView-3, observed the Langtang Valley on May 8, 2015, using a panchromatic sensor with a spatial resolution of 0.3 m. Identification and mapping of avalanche-induced surface features were performed manually. The surface features were classified into 15 segments on the basis of sediment features, including darkness, the dominance of scattering or flowing features, and the recognition of boulders. Together, these characteristics suggest various combinations of physical properties, such as viscosity, density, and ice and snow content.

(3) Altitude differences between the pre- and post-quake digital surface models (DSM) suggest the deposition of 5.2×10^5 m^3 of sediment, mainly along the river bed.

A 5 m-grid pre-event DSM was generated from PRISM stereo-pair images acquired on October 12, 2008. A 2 m-grid post-event DSM was generated from WorldView-3 images acquired on May 8, 2015. Comparing the two DSMs, a vertical difference of up to 22±13 m is observed, mainly along the river bed. Estimates of the total avalanched volume reach 5.2×10^5 m^3, with a possible range of 3.7×10^5 to 10.7×10^5 m^3.