Multi-Temporal Landslide Volumetric Analysis and Suitability Evaluation of Multi-Sourced Dems in an Area Hit by Wenchuan Earthquake

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Abstract

The 2008 Wenchuan earthquake in Sichuan, China, dramatically changed the terrain surface by inducing large numbers of landslides covering an estimated area of about 811 km^2 (Dai et al., 2011). In the following years storms triggered thousands of debris flows across the entire mountainous region, among which several were much larger than expected. The temporary shelters, roads and reconstructed buildings were damaged or destroyed in a number of locations. The triggering mechanism of the debris flows were concluded as the entrainment of the loose materials created by the co-seismic landslides(Tang et al., 2011; Xu et al., 2012). Many studies were carried out, however the volume the landslides over large areas was only estimated by the area-volume relationships(Dai et al., 2011; Parker et al., 2011; Tang et al., 2016; Xu et al., 2013). Volume measurement was only done on a few large landslides through drilling bore holes and applying geophysics methods. The trend of the total loose material volume change over the years remains unknown.

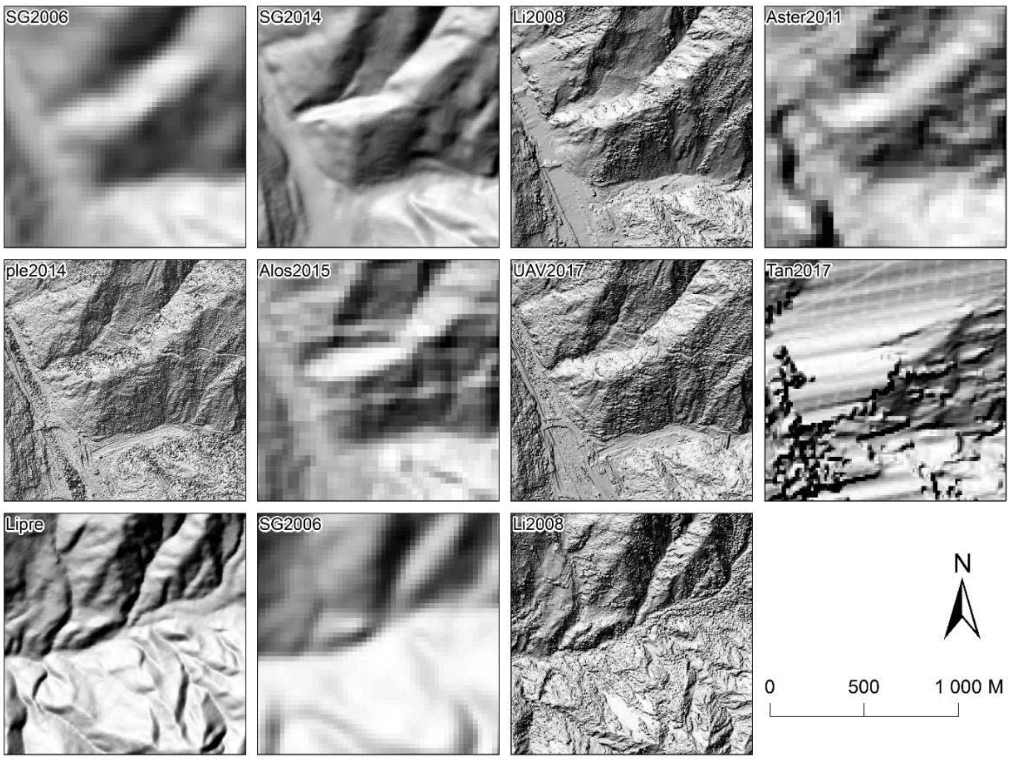

Figure 1 The hillshaded DEMs. The **sources are: Stereo satiate images with ground survey(SG2008, SG2014); LiDAR(Lipre, Li2008); Aster GDEM 2(Aster2011); Pleiades stereo images(Ple2014); Alos World3D (Alos2015);** UAV photogrammetry(UAV2017); TanDEM-X (Tan2017).

We have managed to collect nine DEMs(Figure 1) to study their suitability for volumetric analysis and to estimate the displaced material volume change caused by co-seismic and post-seismic landslides. The DEMs were taken at different years and from different sensors. The area around Yingxiu and Longchi town, where we previously mapped our multi-temporal inventories(Tang et al., 2016), was selected for this study due to the best data availability. The resolution of the DEMs ranges from 1 m to 30 m, including free access, commercial and self-collected ones. A simple method to register the DEMs horizontally and vertically was proposed. It was concluded that the commercial satellite data, Pleiades stereo images, and the self-collected UAV photos created the best elevation models which were comparable to our LiDAR DSM. A minimum of 10 meters sensor resolution was recommended to quantify the landslide volume based on our test results. Within a limited good data overlapping area of 16.9 km^2, the trend of the volume change was analyzed(Figure 2). The estimated volume loss from the period of 2008 to 2014 was 78% of the amount was gained from the co-seismic landslides. The change was not significant from 2014 to 2017 and the new landslides which were not initiated on pre-existing co-seismic landslides did not have an impact on the volume dynamic. A volume gain caused by vegetation recovery was observed as well. The results calculated from the DEMs were compared with the area-volume relation presented by Guzzetti et al. (2009), showing a large uncertainty on individual landslides but a reasonable total volume.

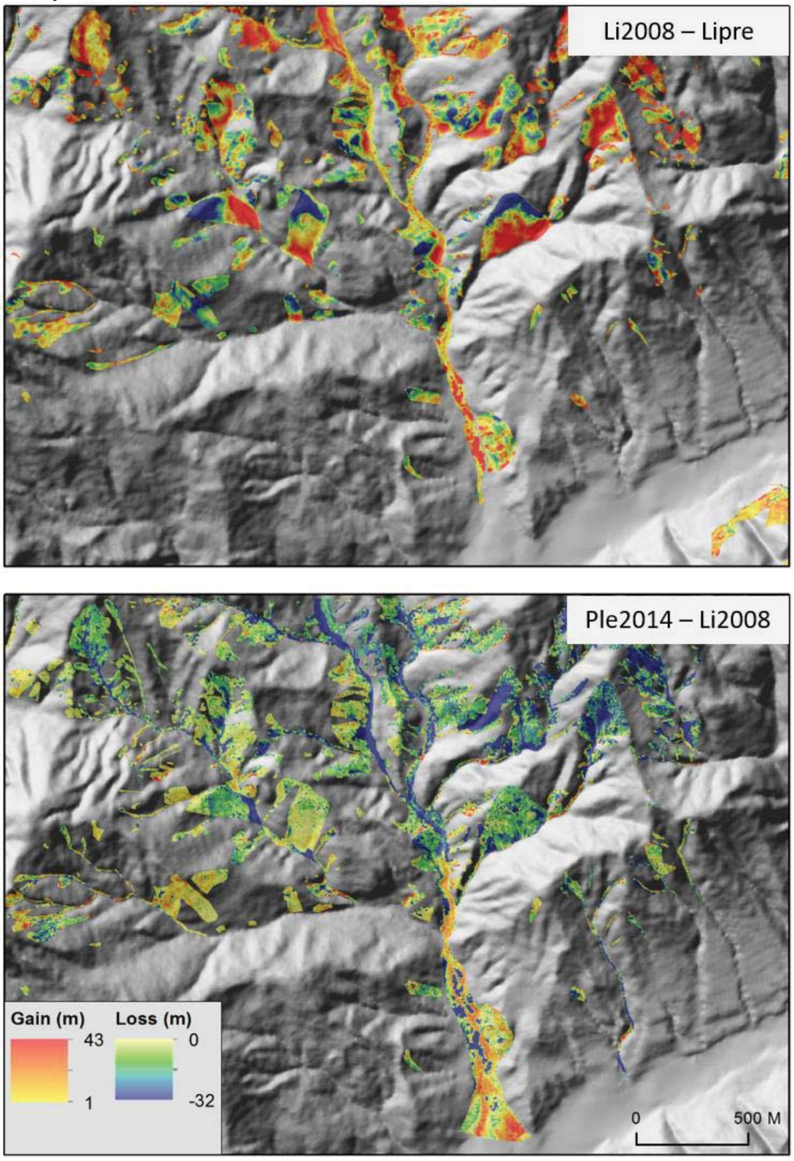

Figure 2 The volume change analysis. Li2008 and Lipre are a DSM and a DTM sourced from LiDAR, being collected in 2008 and pre-earthquake period. Ple2014 was generated from a pair of Pleiades stereo images collected in 2014. Li2008 – Lipre shows the volume change by co-seismic landslides. Ple2014 – Li2008 shows the loss caused by the intensive entrainment which caused debris flows, as well as some gain caused by deposition and vegetation growth.

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