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Testing failure surface prediction methods and deposit reconstruction for the landslides cluster occurring during Talas Typhoon (Japan)

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Talas Typhoon hit Japan from 2 to 5 September 2011. It induced more than 70 deep-seated landslides in Kii peninsula. The hi-resolution topography of these landslides have been acquired by aerial 1 m LiDAR digital elevation models (DEM) before (pre-DEM) and after (post-DEM) the events (data from Nara prefectural Government and the Kinki Regional development Bureau of Ministry of Land, Infrastructure, Transportation, and Tourism). This extraordinary opportunity allows us to test methods to construct failure surface geometries, buried valley topographies and/or to rebuild deposits surfaces. We tested the sloping base local level method (SLBL) on 5 deep seated landslides which occurred during Typhoon Talas (Akatani, Kitamata, Nagatono, Shimizu and Akatani-East; see Chigira et al., 2013). The SLBL corresponds to a quadratic surface with a constant second derivative in all x-y directions. This curvature can be based on the knowledge of the length of the landslide and its maximum thickness.

We used mainly hillshade DEM, slope maps and Coltop schemes to define the limits of landslides and to interpret their structures. Different attempts were performed to reconstruct the failure surface and deposits depending on a priori knowledge. Basically the morphological features extracted from the pre-DEM were used to delineate the limits of the landslides. The curvature of the failure surface was obtained by "expert" interpretations.

The failure surfaces obtained using SLBL are in good agreement with the failure surface observed on the post-DEM. The results are improved when (1) they are adjusted to obtain similar estimate of the volume deduced by Chigira et al. (2013), and when (2) the contours of the landslides used comes from an interpretation of both post and pre-DEM. In order to obtain the expansion coefficient some of these landslide, the missing volume of the deposits (by river erosion) were calculated using inverse SLBL. The coefficient of expansion ranges from 13% to 30%. The reconstruction of topography before the landslides in the scar or below the deposits gives also reliable results.

Even if in many of the above cases the failure surface is controlled by structures (faults, joints, bedding, etc.), the quadratic surface used in SLBL seems to be a suitable solution to fit failure surfaces. If the structures are controlling large parts of the surface of failure, usually several of them are participating to the failure surfaces. It seems that this network of surfaces tends to adopt quadratic shapes when combined. Looking at other landslides or rockslide scar profiles around the world, the quadratic shape appears as very relevant.

These study shows the efficiency of the SLBL method as a tool to estimate quickly the failure surface without a lot of knowledge. Preliminary investigations indicates that failure surface are roughly close to quadratic surface.

References:

Chigira M., Tsou C.-Y., Matsushi Y., Hiraishi N., Matsuzawa M. 2013.Topographic precursors and geological structures of deep-seated catastrophic landslides caused by Typhoon Talas. Geomorphology 201, 479-493