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Coseismic landsliding associated with the 2015 April 25th Gorkha earthquake, Nepal

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The characteristics of earthquake-triggered landslides have the potential to inform us about the ground motions during large earthquakes and the rock properties of the near surface environment. From the recent Mw7.8 2015 Gorkha earthquake in Nepal, we use satellite imagery to identify over 20,000 landslides that are associated with the main shock. While most landslides are located on steep hillslopes, we also present field measurements of alluvial terraces that have either failed or remained stable during the earthquake. We show how both hillslope and terrace failures can be used to better understand the earthquake. These local, site-specific surveys and analyses of alluvial terraces can be used to constrain co-seismic peak ground acceleration (PGA) and large landslide inventories can be used to gain insight into regional patterns of strong ground motion.

Our regional landslide mapping reveals two principal patterns: (1) landslides are concentrated in the steep Greater Himalaya in the north, with conspicuously fewer landslides in the moderately-steep Lesser Himalaya in the south, and (2) within the Greater Himalaya, landslide density increases from west to east across the rupture area. We have compared our observed map of landslide occurrence to predictions from forward models using hillslope angles, average rock strength, and PGA estimated from ground motion prediction equations (GMPE). The higher concentration of landslides in the Greater Himalaya compared to the Lesser Himalaya can be predicted by the models and explained by the steeper topography of the Greater Himalaya. However, these forward models do not reproduce the east to west variation in observed landslide density, which is lower than model predictions near the epicenter, and greater than model predictions toward the eastern limit of the rupture.

From limit equilibrium stability analysis of both failed and stable fluvial terraces, we constrain local PGA values in the eastern region of dense landsliding. We estimate higher PGA values than those predicted based on GMPE, which could in part explain the concentration of hillslope landsliding. An additional effect that may explain higher landslide density may be the concentration of high-frequency seismic energy, which is observed from high-rate GPS and teleseismic back-projections, since high-frequency spectra promote slope failure. Spatial variability in rock strength could also influence regional landslide distributions; this factor will be investigated with future shallow seismic and field observations.

If the observed rupture characteristics of the Gorkha earthquake are typical of large earthquakes in the Himalaya, concentrated landsliding could locally deliver coarse sediment to river channels. Over the long term, spatially focused delivery of coarse sediment may lead to steepened river gradients and higher erosion rates that vary along strike of the Himalaya, provided that coseismic sediment production is mobilized and transported efficiently during the interseismic period. Ongoing work includes evaluating river sediment grain size. If a spatial correlation between coseismic landsliding, increased sediment grain size, and elevated erosion rates can be shown, it would demonstrate a new example of tectonic-erosion coupling based on the seismic cycle and fault behavior.