Deep-seated, slow-moving landslides and landscape evolution

In many mountainous regions, slow-moving, deep-seated landslides are responsible for the bulk of hillslope erosion and in doing so create distinctive topography. However, active monitoring of landslides is often limited to historic timescales and sparse observations from their surfaces, making it challenging to infer their role in shaping landscapes at timescales and locations outside of such direct observations. Here, we report a synthesis of several recent studies that use novel data analysis and mathematical modeling techniques to examine the effects of deep-seated landslides on evolving topography over longer timescales and broader spatial extents. With LiDAR-derived topographic data we first demonstrate that as deep-seated landslides deform they generate topographic roughness at the meter scale, which can be used to accurately and semi-automatically map landslides over broad swaths of terrain. Second, we implement a numerical landscape evolution model and find that over longer length scales of hundreds of meters or more, and timescales greater than thousands of years, deep-seated landslides subdue roughness by inhibiting the formation of steep, well-defined ridges and valleys. Feedbacks between landslide motion and water table-driven weathering exert a strong control on landslide style and the resulting hillslope form. Last, we extend detailed surface observations of landslide deformation from repeat aerial stereo imagery to the subsurface in order to infer landslide thickness and frictional or rheological properties, which opens up a wide range of inaccessible landslides to remote study. Taken together, the studies outlined above provide a suite of novel tools that will continue to improve our understanding of landslide response to changes in climate, land use, and tectonic forcing over a wide range of spatial and temporal scales.