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Assessing and monitoring urban landslide hazards - integrating geophysics, remote sensing, and wireless sensor networks

Sebastian Uhlemann, Sylvain Fiolleau, Stijn Wielandt, and Baptiste Dafflon
Lawrence Berkeley National Laboratory, Berkeley, USA

Growing urbanization is pushing communities further into areas of known landslide hazard, elevating the risk posed to these communities. Hence, there is an increasing need to develop approaches that can characterize and monitor landslide hazards in urban areas. Here, we present recent developments in the rapid characterization of the landslide hazard using geophysics and remote sensing to parametrize hydromechanical models to assess probability of failure across a site in the highly populated Berkeley Hills, California. Calculating slope gradient from LiDAR, and estimating soil thickness from ambient seismic noise measurements, and total cohesion from vegetation distribution, we include the spatial variability of some of the most critical soil parameters in our hazard assessment. The results highlight various areas of elevated landslide hazard. Focusing on one such area, we used geophysical monitoring data to link changes in subsurface properties with slope instabilities, and found that rainfall induced increases in pore pressure drive slope deformation. Changes in seismic properties occurred up to 5h before actual soil displacements commenced. To monitor the hazard across the entire study site and to further increase our understanding of their triggering factors, we developed and installed a dense wireless network of deformation, soil moisture, and pore pressure sensors. Using machine learning, we use this data to predict subsurface conditions critical to slope failure. We show that short-term predictions are comparably accurate, while long-term forecasts fail to predict sudden changes, mostly due to a lack of training data. The data obtained from these studies is starting to be incorporated into site management with the aim of mitigating the landslide risk.