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Application of Kalman filter to reproduce displacement pattern along with the unknown soil properties of slow-moving landslides

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Landslides display heterogeneity in movement types and rates, ranging from creeping motion to catastrophic acceleration. In most of the catastrophic events, rocks, debris, or soil can travel at several tens of meters per year speed, causing significant cost in life losses, infrastructure, economy, and ecosystem of the region. In contrast, slow-moving landslides display typical velocities scaling from few centimeters to several meters per year. Although slow-moving landslides rarely claim life losses, they can still cause considerable damage to public and private infrastructure. Sometimes these slow, persistent landslides eventually lead to catastrophic acceleration, e.g., clayey landslides are prone to these transitions. Such events need to be detected by Early Warning Systems (EWS) in advance to take timely actions to reduce life and economic losses. Several approaches are proposed to forecast the time of failure; still, there is a need to improve prediction strategies and EWS's.

Here we present state and parameter estimation for a simplified viscoplastic sliding model of a landslide using a Kalman filter approach, which is termed as an observer problem in control theory. The model under investigation is based on underlying mechanics (physics-based model) that portray a landslide behavior. In this model, a slide block is assumed to be placed on an inclined surface, where landslide (slide block) motion is regulated by basal pore fluid pressure and opposed by sliding resistance governed by friction, cohesion, and viscosity. This model is described by an Ordinary Differential Equation (ODE) with displacement as a state and landslide material and geometrical properties as parameters. In this approach, known parameter values (landslide geometrical parameters and some material properties) and water table height time-series are provided as input. Finally, two illustrative examples validate the presented approach: i) a synthetic case study and ii) Hollin hill landslide (Uhlemann et al., 2016) field data.

In both examples, displacement, friction angle, and viscosity are well estimated from known parameter values, water table height time-series, and displacement measurements. In the simulation results for the Hollin Hill field data, it is observed that friction angle almost remains

constant while viscosity varies significantly through time.

Uhlemann, S., Smith, A., Chambers, J., Dixon, N., Dijkstra, T., Haslam, E., Meldrum P., Merritt, A., Gunn, D., and Mackay, J., (2016). Assessment of ground-based monitoring techniques applied to landslide investigations. *Geomorphology*, 253, 438-451. doi:10.1016/j.geomorph.2015.10.027.