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Detecting rapid mass movements using electrical self-potential measurements

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Rapid mass movements are a latent danger for lives and infrastructure in almost any part of the world. Often such mass movements are caused by increasing pore pressure, for example, landslides after heavy rainfall or dam breaking after intrusion of water in the dam. Among several other geophysical methods used to observe water movement, the electrical self-potential method has been applied to a broad range of monitoring studies, especially focusing on volcanism and dam leakage but also during hydraulic fracturing and for earthquake prediction.
Electrical self-potential signals may be caused by various mechanisms. Though, the most relevant source of the self-potential field in the given context is the streaming potential, caused by a flowing electrolyte through porous media with electrically charged internal surfaces. So far, existing models focus on monitoring water flow in non-deformable porous media. However, as the self-potential is sensitive to hydraulic parameters of the soil, any change in these parameters will cause an alteration of the electric signal. Mass movement will significantly influence the hydraulic parameters of the solid as well as the pressure field, assuming that fluid movement is faster than the pressure diffusion.
We will present results of laboratory experiments under drained and undrained conditions with fluid triggered as well as manually triggered mass movements, monitored with self-potential measurements. For the undrained scenarios, we observe a clear correlation between the mass movements and signals in the electric potential, which clearly differ from the underlying potential variations due to increased saturation and fluid flow. In the drained experiments, we do not observe any measurable change in the electric potential. We therefore assume that change in fluid properties and release of the load causes disturbances in flow and streaming potential. We will discuss results of numerical simulations reproducing the observed effect. Our results indicate that electrical self-potential measurements can observe rapid mass movements when the movement is large and fast enough to disturb the fluid pressure field significantly.