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Monitoring and Analysis of Landslide-Glacier Interactions at the Great Aletsch Glacier (Switzerland)

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Valley glaciers have traditionally been expected to significantly influence the stability and movement rates of adjacent paraglacial landslides. However, detailed studies related to the mechanical and displacement interactions between glacier ice and unstable rock slopes are essentially non-existing. This project deals with a detailed in-situ investigation of the spatial variations of the displacement field of the Great Aletsch Glacier in the surroundings of a large active instability, called Moosfluh Landslide. The goals of this project are to assess the mechanical interactions between an active rockslide and an abutting valley glacier based on real field measurements and infer the impacts of glacier ice deformation on landslide dynamics. As most valley glaciers are currently strongly retreating due to global warming, uncovering significant numbers of pre-LIA slope instabilities, this detailed investigation has implications going far beyond academic interest.

The Moosfluh landslide is a Deep-Seated Gravitational Slope Deformation (DSGSD), with superimposed large (1-5 million m3) secondary rockslides formed in fall 2016, located near the currently retreating tongue of the Great Altesch Glacier (Kos et. al. 2016, Glüer et al. 2018, 2019). In August 2018 we have performed repeat UAV-based photogrammetric surveys during 74 hours and applied Digital Image Correlation (DIC) techniques to record high-resolution surface displacement vector fields of the landslide, stable slopes and adjacent glacier. DIC results show that the landslide toe is composed of two sectors with significant differences in displacement mean velocities (0.5 and 1.5 m in 74 hours, excluding rapid movements from detached blocks). Both landslide sectors induce clear deflections of the glacier vector field, moving with a velocity of about 0.3 to 0.4 m in 74 hours. This influence tends to be higher near the ice-contact boundary and decrease within a distance of about 100 m and 200 m from the rock slope instability. We investigate the viscous forces at the landslide/glacier contact using the multiphysics simulation software COMSOL and simplified analytical solution, assuming a vertical interface. These forces are then applied to a limit equilibrium landslide stability model representing the real geometry at the interface boundary, and quantitatively explore the true buttressing effects of valley glaciers on a fully developed slope instability. We show that a slope in critical stability conditions can respond strongly to a minor buttressing effect posed by a valley glacier occupying the landslide toe.

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