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Extreme rainfall drives a slow-moving landslide to catastrophic failure

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Precipitation-induced changes in pore-water pressure can trigger a diverse range of landslide behaviors from slow sliding to catastrophic failure. Documenting the mechanisms that make landslides transition from slow to fast motion is essential for improving our ability to forecast catastrophic failure. Here we investigate the effects of large changes in rainfall, and thus pore pressure, on landslide motion. We use radar interferometry (InSAR) and hydrological models to characterize the behavior of the Mud Creek landslide, Central California Coast between 2012 and 2017. This time period is well-suited for studying the effects of rainfall on landslide behavior because there were significant changes in precipitation each year. Cumulative water-year precipitation increased from 0.6 to 1.56 m (long-term average $\sim$1 m/yr) between 2015 and 2017. The rainy season of 2017 was particularly notable due to a large number of strong atmospheric river events. We find that the Mud Creek landslide displayed slow motion with seasonal velocity changes driven by seasonal precipitation between 2015 and 2017. Average velocity increased from 7 to 51 cm/yr over this time period. After $\sim$5 years of documented slow sliding, the extreme rainfall of 2017 caused the Mud Creek landslide to fail catastrophically, which led to the destruction of California State Highway 1. We use a 1D diffusion model to estimate changes in pore water pressure within the landslide body and find that the pore pressure of 2017 significantly exceeded previous years and reached a maximum close to the time of catastrophic failure. We hypothesize that this large increase in pore pressure was able to overcome the stabilizing mechanisms that previously controlled the landslide motion. Pore pressure changes may have been further enhanced by the preceding drought, which likely increased rapid infiltration pathways such as deformation and desiccation cracks that can permit strong pore pressure change. Our results document a behavioral transition of the Mud Creek landslide and suggest that large changes in pore pressure can trigger catastrophic failure of landslides that previously exhibited slow and stable motion.