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Dynamics and physics-based rainfall thresholds for a deep-seated landslide

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The Hooskanaden landslide is a large (~600 m wide × 1,300 m long), deep (~30 – 45 m) slide located in southwestern Oregon, United States. Since 1958, it has had five moderate/major movements that catastrophically damaged the intersecting U.S. Highway 101, along with persistent slow wet‐season movements and a long‐term accelerating trend due to coastal erosion. Multiple remote sensing approaches, borehole measurements, and hydrological observations were integrated to interpret the motion behaviors of the slide. Pixel offset tracking of both Sentinel‐1 and Sentinel‐2 images was carried out to reconstruct the 3D displacement field of the 2019 major event, and the results agree well with field measurements. A 12‐year displacement history of the landslide from 2007 to 2019 was retrieved by incorporating offsets from LiDAR DEM gradients and InSAR (Interferometric Synthetic Aperture Radar) processing of ALOS and Sentinel‐1 images. Comparisons with daily/hourly ground precipitation reveal that the motion dynamics are predominantly controlled by intensity and temporal pattern of rainfall. A new empirical threefold rainfall threshold was therefore proposed to forecast the dates for the moderate/major movements. This threshold relies upon antecedent water‐year and previous 3‐day and daily precipitation, and was able to represent observed movement periods well. Adaptation of our threshold methodology could prove useful for other large, deep landslides for which temporal forecasting has long been generally intractable. The averaged characteristic hydraulic conductivity and diffusivity were estimated as 6.6×10^{-6} m/s and 6.6×10^{-4} m^2/s, respectively, based on the time lags between rainfall pulses and slide accelerations. Hydrologic modeling using these parameters helps to explain the ability of the new rainfall threshold.