A novel dragon-king approach to forecasting catastrophic rock slope failures at Preonzo (Switzerland) and Veslemannen (Norway)

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Catastrophic rock slope failures pose great threats to life and property, but remain difficult to predict. Over the past decades, great efforts have been devoted to develop and deploy high-precision monitoring technologies to observe unstable rock slope movements. However, only a limited number of large rock slope failures have been so far successfully mitigated. Here, we present a novel predictive framework that can quantitatively assess the slope failure potential in real time (Lei et al. 2023). Our method builds upon the physics of extreme events in natural systems: the extremes so-called "dragon-kings" (e.g. slope tertiary creeps prior to failure) exhibit statistically different properties than other less intense deformations (e.g. slope secondary creeps) (Lei & Sornette 2023). We develop robust statistical tools to detect the emergence of dragon-kings during rockslide evolution, with the secondary-to-tertiary creep transition quantitatively captured. We also construct a phase diagram characterising the detectability of dragon-kings against "black-swans" and informing on whether the slope evolves towards a catastrophic or slow landslide. We test our method on real datasets, demonstrating how it might have been used to forecast the catastrophic rockslide events at Preonzo (Switzerland) and Veslemannen (Norway). Our method, superior to the conventional velocity threshold approach, can considerably reduce the number of false alarms and identify with high confidence the presence of true hazards of catastrophic rock slope failures. Our work adds a new conceptual framework and operational methodology with a significant potential to reduce landslide risks and support existing early warning systems.

References

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