Reviewer's report on manuscript egusphere-2026-2565

A robust multi-indicator framework for landslide early warning using complementary statistical physics-based diagnostics

This manuscript develops a robust multi-indicator framework for landslide early warning using three complementary statistical physics-based diagnostics: velocity b-value tracking, dragon-king detection, and log-periodic power law singularity (LPPLS) time-to-failure analysis.

1. Re. velocity b-value tracking. A time series of b-values are progressively estimated from the slope velocity data up to each 'current' time by a profile likelihood method induced from an inverse gamma probability distribution for the slope velocity. Temporal dynamics of the b-value time series estimates is used to identify the state of slope by three indicator states 0, 1, nd 2. This diagnostics is sensible but should be formulated or explained clearly in a quantitative and measurable way.

   (a) As the b-value declines, slope movements generally tend to enter into a higher indicator state. But the threshold of the b-value for determining each indicator state is different for different landslide and at different time. Is it possible to normalize the b-values so that standardized thresholds can be established?

   (b) If continuous decline of the b-value is an indication of the slope entering into a more hazardous state, the manuscript should provide specific diagnostics about how long the temporal derivatives of the b-value estimates continue to be negative when one can decide the slope enters into State 1 or State 2.

   (c) The time derivatives of the estimated velocity b-value are pretty smooth (see Figures S1, S4 and S7), suggesting they were obtained by some curve smoothing technique. The authors should describe how these smooth curves are obtained.

2. Re. dragon-king detection. Description of this diagnostics is not clear.

   (a) Anderson-Darling distance $A^2(\xi)$ given by equation (2) is used to identify candidates of velocity outliers. There is no explicit involvement of ξ at the right-hand side of (2). Is ξ involved in $F(\cdot)$ implicitly? If yes, make it explicit.

   (b) There should be a critical value for each given significance level, by which the test statistic (4) can be used to identify velocity outliers. Please explain how the critical value for (4) is determined.

   (c) The p-value based on the block test statistic (5) is determined by Monte Carlo simulations. Please provide details on how the Monte Carlo simulations are carried out.

3. Re. LPPLS-based time-to-failure analysis. It is understood that the LPPLS-based diagnostics is not used alone for identifying the slope state indicators, rather it is used to support and reinforce the interpretations drawn from the other two diagnostics.

   (a) That the seven parameters denoted as $\boldsymbol{\theta}$ are estimated by minimizing the sum of squared residuals given in (S10) suggests tha LPPLS model specified by equation (6) or equivalently (S9) is a general regression model. This means a random error term is missing in (6) and (S9), which should be added.

   (b) What optimization method is used to estimate the three nonlinear parameters based on (S12)?

   (c) The top two plots in Figures S3, S6 and S9 each has a shaded band covers the plotted time series. What are they?