Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., referee comment RC1
https://doi.org/10.5194/esurf-2021-41-RC1, 2021

Comment on esurf-2021-41

Anonymous Referee #1

Referee comment on "Temporal changes in the debris flow threshold under the effects of ground freezing and sediment storage on Mt. Fuji" by Fumitoshi Imaizumi et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-41-RC1, 2021

General comments

The manuscript (MS) deals with the role of (a) ground freezing and (b) sediment storage in debris-flow triggering and how rainfall thresholds are affected. Relatively long records (~50 years) of debris-flow observations in a Japanese gully are combined with ground-freezing periods estimated from a model, and sediment storage volumes estimated from LiDAR measurements or aerial photographs. While the role of sediment storage was less revealing, the authors found ground freezing to alter rainfall thresholds significantly and explain it with different infiltration rates depending on if the ground is frozen or unfrozen. The MS discusses an important topic with possible impacts both on the development of early warning systems and climate change impact assessments in cold debris-flow prone regions.

The MS is generally well written and structured. The data sets provide a good basis for the research on the influence of climate on debris-flow activity. The author’s approach in estimating ground-freezing periods and connecting it to debris-flow triggering is original and promising. However, the analysis and discussion on other potential reasons for differences in rainfall thresholds are missing and therefore I had difficulties in believing the findings. The main reasons concern the following:

- Seasonality in rainfall. I assume that the frozen periods mainly fall in spring and autumn. Are rainfall event characteristics also different in these seasons compared to summer? You could either estimate rainfall thresholds for your data split into seasons. They may look similar as the ones you already obtained and then you could argue that you obtain the same thresholds when splitting into frozen and unfrozen. Another way would be to show histograms of rainfall characteristics (e.g. mean intensity) for frozen and unfrozen periods. If they look similar, you know that the shift in rainfall threshold is not introduced by seasonal characteristics.

- Antecedent rain/wetness and snowmelt. Another reason for lower ID thresholds could be the antecedent conditions. Antecedent rainfall and snowmelt are probably the most important control. Analysing antecedent rainfall can be done from your data. Are there snow depth measurements to constrain the melting season?

- Uncertainties. They can be quite large, especially if based on only a few points. With CSI you have an objective measure to estimate ID-thresholds, which is good. However, when you calculate ID-thresholds with different data (frozen & unfrozen), the significance of these differences is unclear. Because some of these thresholds were estimated based on few triggering events, the thresholds can be very sensitive to individual data points. Ideally, you would assess uncertainties e.g. with bootstrapping. However, I realize that such an analysis is not useful for e.g. Fig 9c, where you have quite a few points. Hence, it would be useful to show uncertainties at least where there are e.g. >10 triggering events.

These points would need to be clarified in order to convincingly show the relevance of ground freezing on debris-flow triggering. Then I see it as a very valuable contribution to Esurf. Furthermore, there were some unclarities in the methods and the data sets used. Further comments related to this and other minor issues are listed below.

Specific comments

- 41: I think you mention wildfires as an example for the sensitivity of hydrological parameters (e.g. infiltration rate) but the connection is not clear when reading. If wildfires are not relevant for cold regions, which you focus on, I would focus on the hydrological properties of cold regions.
- 40-48: Is the hydraulic conductivity the main difference from frozen to unfrozen periods? What is the role of water storage capacity?
- 58: What process drives sediment production?
- 86: 2737 mm y^{-1}
- 132: please specify, within 1 calendar day or within 24 hours?
- 137: Could you add a marker in the figure to show JMA station?
- 141: TM (Fig. 1d)
- 143: It is not ideal to match air with ground surface temperature. Could you please state how this affects your extrapolated temperature?
- 143: Please explicitly state which model you are using and add some description regarding the main assumptions, required input, output, why was it developed or for what is it usually used? For which spatial and temporal scales is it usually used?
- 149: Eq 1 & 2, please add the independent variable to the equation (e.g. T(t)) and units. Now it is difficult distinguish between variables and parameters. Do cf and cm vary with time?
  Although you cite the equations, it would be helpful if you would state the assumptions behind it. Is this the degree-day method you mention before? The meaning of cf and cm are not clear to me.
- 177: Caine (1980) was the first to use ID thresholds to my knowledge, so I would add the reference. You should also have "rainfall" somewhere in this sentence.
- 183: How do you know if there was snow or not?
- 187: I don't understand the reasoning for choosing 24 hours. First, I don't think the gully is much larger than other debris-flow prone gullies, or if so, please provide a comparison. Second, is it clear that water has to be concentrated from a large area from the headwaters, are debris flows triggered by runoff in this site? The chosen time period is not irrelevant because it affects the number of non-triggering rainfall events, thus also the CSI and thus the rainfall threshold.
- 194: 5 x 10 m or 5 x 5 m?
- 202: Looking at Figure 1 I have some troubles imagining the channel deposit dropping

to zero. How is the justified? Is it really zero and the bedrock with outcropping bedrock or is it just the lowest value?

- 209: What are the expected consequences of these inherent errors?
- 210: Please explain why you decided to determine two thresholds. Are there indications for that with <350'000 m^3 supply is the limiting factor?
- 215: Table 1, could you add the dates of the aerial photographs here? It is not easy to follow in the text when which data was obtained. I think the text does not refer to the table.
- 230: Figure 3. Could you add markers to dates with photograph/Lidar observations?
- 249: Could you please add markers for debris flows/slush avalanches?
- 258: How did you calibrate? What measure did you optimize? I can't judge your model performance from this section, only visually from Fig. 5.
- 264: If it is a physical parameter, I guess it should have some unit, right?
- 268 – L. 280: Unfortunately, I don't see how this section fits into the story. Why do you only show one example of channel change? What happened to the other Lidars? How can you generalize from this figure that all debris flows sourced from channel deposits?
- 283-387: These two result sections are very clear (with reservations mentioned in the general comments).
- 349: If you say what was not considered, please also mention what your model considers.
- 354: This is true for the ridge, but aren't wind and incoming solar radiation conditions different in the creek? Can you say something about the distribution of snow within the creek?
- 356: What is your definition of "significantly different"?
- 377: Figure 10. In the light blue frozen layer, are the pores filled with ice? Nice schematic!
- 394: why is this ratio controlling the movement?
- 431: I think a detailed explanation is required for why the underlying data is not publicly available
- Figures 1 & 6 are missing coordinates