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Natural Hazards and Earth System Sciences
Discussions
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Interactive comment on "Radar coherence and NDVI ratios as landslide early warning indicators" *by* Mylène Jacquemart and Kristy Tiampo

Anonymous Referee #2

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The authors present an approach to detect a landslide's transition from slow moving to catastrophically unstable. The approach combines radar (Sentinel 1) and optical (Sentinel 2) remote sensing using relative indices (i.e. comparing characteristics on and around the landslide) of interferometric coherence and NDVI to describe the transition of a landslide towards failure.

The manuscript is well written, figures well prepared, and the code is accessible on GitHub, which fosters the reproducibility of the method. In general, approaches towards a potential early warning of landslide failures are highly relevant and within the scope of NHESS. However, I have some concerns preventing this manuscript from publication in present form:

Major:

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The application of relative (landslide to non-landslide) indices:

- If one wants to use relative indices for early warning purposes the landslide needs to be known before the failure occurs. While large slow moving landslides are often known (especially in the vicinity of urban environment) it is not always known which part actually moves. However, this is required (at least approximately) if relative indices are used, otherwise the landlside-specific signal mixes with the non-landslide-reference signal and thus the ratio gets less pronounced.
- To analyze the relative ratio and its changes over time requires same or at least very similar conditions (e.g. land cover/use) for both regions. Otherwise the changes in the ratio can occur e.g. due to different use of the land. In many cases (at least that I have experienced) the land cover is actually different, e.g. agriculture, pasture in the surrounding and natural vegetation on the slow moving landslide, especially when the knowledge that a slow moving landslide exists at this place (wich is a requirement to apply the proposed approach) prevents people to use this site as agricultural area, because of the potential risk.
- Alternatively if the conditions are not the same the temporal behavior of the indices between these two areas need to be known (e.g. from a long-term reference period), and then a relative change to the typical behavior can be analyzed in regard to potential landslide acceleration. However, this can also only be applied if the reference behavior is similar throughout the years.

Further methodological aspects:

- The discussion and analysis for relation between coherence and NDVI needs to be elaborated in more detail. Assuming a decrease in NDVI is related to vegetation decrease, as done in this paper, we expect more coherence in the period related to NDVI decrease (please see Bai et al. (2020), Scientific Reports volume 10, Article number: 6749 (2020); https://www.nature.com/articles/s41598-020-63560-0). But this is not the case here and the coherence is decreasing in the period when we see a declining trend in NDVI. This is not surprising as several studies (e.g. Van doninck et al. (2012), Hydrol. Earth Syst. Sci., 16, 773–786, 2012, www.hydrol-earth-syst-sci.net/16/773/2012/ doi:10.5194/hess-16-773-2012) have shown that changes in NDVI can also be related to changes in soil moisture depending on the elevation (See Fig. 5 and other figures in Van doninck et al. (2012)). It seems that the NDVI changes that the authors observe here is more related to soil moisture change rather than vegetation change. Please elaborate more on this in the paper.

- Line 220: the amplitude time-series indicates that average backscatter ……….was slightly higher (ascending orbit) …… This is not surprising as the ascending geometry suffers from foreshortening. Due to this geometrical distortion in the ascending data, I would not focus on ascending data. Rather, please use amplitude time-series from both polarimetry channel. If soil moisture is the main contributor to the coherence decrease, we would probably be able to see it by comparing the backscattering between different polarization that we have for S1. The authors have mentioned this in the paper, but have not investigated this in detail.

The conclusions are drawn from a pilot study analyzing the behavior of a single landslide case only.

- The results of this pilot study show high potential to get early indicators of landslide failure. However, since it is not quite clear (as authors state by themselves) what the underlying processes are that allow to distinguish between normal accelerations and accelerations towards the failure it is absolutely not clear if this methodology is transferable to other landslides. Do you have any other examples to test your findings? If so, this would definitely strengthen your findings and raise the need to publish this manuscript. In your conclusion at L246f you also mention this need "... a more in-depth analysis of NDVI ratio and coherence ratio at multiple landslide sites is necessary to assess their full value."

Minor:

L20: ...are still the rare... (delete "the")

L23: "(InSAR) data is not without challenge due to imaging geometry complexities and tedious processing algorithms." This statement is quite general. Do you have any references for that statement? Since this is a major motivation why you propose a different approach than InSAR, please elaborate this part a bit more. What are the challenges? Are these challenges, which are challenging but can be solved or do these challenges really impede the use of InSAR in analyzing slow moving landslide accelerations.

L25 ff: This whole paragraph describes landslide inventory mapping (in terms of mapping post failure landslides), which is not related to the scope of this manuscript. Moreover, the selection of your references seems a bit arbitrary (for (semi-)automated landslide mapping you cite a single study out of many available studies evolved in the last two decades). Please cite review articles or maybe better skip this part, because as mentioned is not related to the scope of the manuscript.

Figure 4: Why do you indicate "the area the area from which the May 2017 failure originated" by a rectangle. Wouldn't the outline of the landslide as given in Figure 3 be more meaningful if you refer to the landslide area?

Figure5: It might be good to include the reference point also in the right plot. This would give a better insight on how the stable slope behaves in comparison to the other points.

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L 212: “The premise is that general environmental and atmospheric changes (e.g., vegetation cycles, meteorologic storms, ionospheric disturbances) affecting InSAR coherence should not vary between a landslide and its surrounding slopes.” This is true for the latter two, but as mentioned above vegetation cycles may vary between landslide body and surrounding.

Formula 5: Please elaborate more on the steps that you have done for calculating amplitude time-series. It is not clear if sigma in Formula 5 is just the simple mean of amplitude data or the mean value after corrections (calibration, speckle filter, terrain correction etc. . .)

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