Reply on RC2

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Author comment on "Timing landslide and flash flood events from SAR satellite: a regionally applicable methodology illustrated in African cloud-covered tropical environments" by Axel A. J. Deijns et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-172-AC2, 2022

Dear reviewer #2, thanks for taking the time to review our manuscript. We hereby provide a preliminary reply to the main concerns. We will provide a full item-by-time reply, including the revised manuscript, once all the reviews are in and a decision is made by the editor

1.) Reviewer: I do not believe that the use of Time Series using SAR data to estimate the timing of an event can be considered a novel practice. Several attempts have been performed either using the phase, thus the displacement itself (see Intrieri et al., 2018), and Burrows, as correctly written in the manuscript. Besides, the methodologies here depicted are based on standard change detection based on the trends.

REPLY: To answer this concern, we would like to reiterate an answer provided to reviewer #1 as part of our reply. One of the strengths of the paper is in the use of a number of SAR data products that we deliberately tested within contrasting landscapes. This clearly allowed us to better understand the ability of different SAR products for detecting the timing of these interacting landslide and flash flood events within different landscape conditions and will help us when applying our methodology on a larger set of events. From an event timing detection perspective, however, we are the first one who use SAR to analyze landslides and flash floods together as being co-occurring and interacting events. This combination of geomorphic hazards is quite frequently leading to societal and environmental impacts that are more severe. However, such processes are usually studied in isolation, then leading to an underestimation of their impacts. One key step to study these combined processes together is to collect information on their temporal occurrence. However, these processes are almost never studied together and, so far, there has never been research dedicated to their combined temporal detection using radar satellite. The use of an unprecedented combination of SAR products, plus the approach of analyzing events containing both co-occurring and interacting landslides and flash floods explains our use of 'a new methodology' (as it is summarized in lines 556-560). In our revised manuscript, we will put more emphasis on the fact that we intentionally process landslides and flash floods together to make it clearer for the reader.

For the inserted reference, I assume you are referring to this one:

Intrieri, E., Raspini, F., Fumagalli, A., Lu, P., Del Conte, S., Farina, P., Allievi, J., Ferretti,

A. and Casagli, N., 2018. The Maoxian landslide as seen from space: detecting precursors of failure with Sentinel-1 data. Landslides, 15(1), pp.123-133.

In regard to this reference, I would like to highlight that we are not using ground deformation. And that using a deformation approach would be impossible given the high velocities these GH events have (shallow landslides and flash floods) Also, for each GH event we see very low coherence values that additionally provide constraints to using ground deformation. Burrows et al. (2022) have been developing a methodology to detect landslide timing using SAR, but specifically only using the amplitude product. We analyze an unprecedented combination of SAR products within contrasting landscapes for timing detection of co-occurring and interacting landslide and flash flood events. So, we therefore consider it a novel methodology.

Burrows, K., Marc, O., and Remy, D.: Establishing the timings of individual rainfall-triggered landslides using Sentinel-1 satellite radar data, Nat. Hazards Earth Syst. Sci. Discuss. [preprint], https://doi.org/10.5194/nhess-2022-21, in review, 2022.

2.)   Reviewer: Another aspect which should be clarified is related to the trend change threshold. Is there any quantitatively and standardized measure of the change which could be defined for each time series? How can be discriminated a change in the amplitude or coherence trends over the time? Is there a numerical thresholding? If so, how this is calculated, and this can be exported?

REPLY: The same issue is raised by reviewer #1. The explanation on this is addressed in lines 351-358. To derive the timing, we use a change detection package "rupture", that uses binary segmentation to derive the most significant change within the time series. The resulting variable is basically a point in time. In our revised manuscript, we will rephrase and expand a bit more on the binary segmentation approach to make the methodology clearer

3.)   Reviewer: I have also some concerns about the reference to both landslides and flaash flood. Do they behave at the same way in terms of amplitude and coherence? Results show very different timing detection results, however, from the time series analysis seems that this is mostly due to the size of the event. Is there any implication also considering the differences between flash floods and landslides (I would rather consider smaller flash floods since the source and the travel areas can be considered limited with respect to landslides.

REPLY: Thanks for addressing this issue. We would like to emphasize that we intentionally analyze landslides and flash floods as combined processes; hence the terminology GH events. Often, these landslides and flash floods co-occur and interact leading to more severe impacts (highlighted in line 41-48). We are interested in these GH events as a whole. We intend to use our developed methodology to automatically identify the timing of these GH events in contrasting landscapes, with a high uncertainty in timing (cloud-covered data scarce tropics). We are therefore not interested in their individual parts. This separate analysis of the landslides and flash floods within these GH events is therefore out of scope. We indeed believe that this combined aspect of the analysis must be better emphasized. In our revised manuscript, we will put more emphasis on the fact that we intentionally process landslides and flash floods together to make it clearer for the reader.

4.)   Reviewer: Besides, I see a very poor relationship with rainfalls which can be considered a very significant factor for the triggering of such events. Would you please

provide a comment?

REPLY: We added the monthly cumulative rainfall and the NDVI time series in order to better understand the seasonal cyclicity within the SAR data products time series. Process understanding is out of the scope of this manuscript. Note, that we can add that a spike in monthly cumulative rainfall time series is not necessarily found at the time of the GH event. First, peaks within daily cumulative rainfall do not necessarily lead to peaks within monthly cumulative rainfall, and second, the spatial resolution of our used satellite rainfall products is sometimes too coarse to detect local convective rainfalls that are associated with the GH events. See for example the works that have been carried out in our study area.

Monsieurs, E., 2020. The potential of satellite-rainfall estimates in assessing landslide hazard in Tropical Africa. Royal Museum for Central Africa and University of Liège PhD thesis.

Monsieurs, E., Kirschbaum, D.B., Tan, J., Maki Mateso, J.-C., Jacobs, L., Plisnier, P.-D., Thiery, W., Umutoni, A., Musoni, D., Mugaruka Bibentyo, T., Bamulezi Ganza, G., Ilombe Mawe, G., Bagalwa, L., Kankurize, C., Michellier, C., Stanley, T., Kervyn, F., Kervyn, M., Demoulin, A., Dewitte, O., 2018. Evaluating TMPA Rainfall over the Sparsely Gauged East African Rift. Journal of Hydrometeorology 19, 1507–1528. doi:10.1175/JHM-D-18-0103.1

Nakulopa, F., Vanderkelen, I., Van de Walle, J., van Lipzig, N.P.M., Tabari, H., Jacobs, L., Tweheyo, C., Dewitte, O., Thiery, W., 2022. Evaluation of High-Resolution Precipitation Products over the Rwenzori Mountains (Uganda). Journal of Hydrometeorology 23, 747–768. doi:10.1175/jhm-d-21-0106.1