Responses to the referee’s comments are provided below. The referee’s comments are in bold-faced text. The responses are in plain text with relevant in-text locations provided (underlined text) and added/modified details in the manuscript quotes (red text).

Anonymous Referee #2

Main comments:

1. **Data quality/relevance - The authors discuss some limitations of InSAR data and mention that the quality of the post-failure InSAR results is expected to be lower than that obtained from the thinner stack of the pre-failure radar acquisitions. This is correct, but since you compare the InSAR results from two different periods, I think the issue of data quality deserves more attention.**

   The points raised by the referee are amplified and addressed below:

   1.1. **The precision of InSAR measurements depends also on the environmental conditions and the adopted coherence threshold (cf. Wasowski and Bovenga, 2014a,b). For instance, after the Feb 2011 failure, the topography of the slope has changed with respect to the reference SRTM DEM. Significant change for InSAR processing and sensitivity to displacement? Representative prefailure and post-failure topographic sections of the landslide could help. Also, was the weather less rainy (dry) in the post-failure period with respect to the pre-failure time? Significant for the processing results?**

   Response: We agree that the three sources – topography, precipitation / soil moisture, and coherence threshold – noted by the referee as having possible influences on InSAR precision are worth explicitly evaluating. To address these three possible sources of differential error between the pre-failure and post-failure stacks we have added: 1. two paragraphs in section 6.4 (‘Sources of uncertainty’) in the main body of the paper; 2. text in the captions of Figs. 8 and 10; 3. two display items to the Supplement; and 4. several lines of text to the Supplement.

   Additions to main paper:

   We have added two paragraphs to section 6.4 to provide a conservative estimate of InSAR precision and the limited role of topographic and moisture change: “The HDS-InSAR processing chain is complex and includes many non-linear steps, which greatly complicates development of an accurate error approximation model. Both the pre-failure and post-failure stacks have good baseline diversity, allowing relative errors between them to be approximated by first-order estimates from the square root of the number of scenes (32 vs. 12). In the absence of a rigorous model, we assume that error is conservatively as large as twice for the thinner stack. We approximate the errors as 3 mm/a and 6 mm/a, respectively, for the pre-failure and post-failure stacks.

   Due to the structure of the HDS-InSAR processing chain, differing environmental conditions between the two stacks – namely topography and moisture (cf. Wasowski and Bovenga, 2014,

2015) – have minimal effects. The reference digital terrain model (DTM) is used only for an initial topographic correction; stack processing solves for height error relative to the reference DTM and provides a new elevation solution for each of the two stacks (Supplement), which improves terrain representation. Topographic correction of the post-failure stack thus accounts for landslide-induced terrain changes, which were greatest in the source area (Fig. 10B). Temporal soil moisture variability is unlikely to affect phase by more than 100° (Rabus et al., 2010), which equates to approximately one-third of an interferometric fringe or 0.9 cm for the sensor used here. Comparison of precipitation records in the 30 months before and 10 months after the 2011 Pampahasi landslide indicates that long-term precipitation amounts during the pre-failure and post-failure stacks were comparable. Spatial moisture gradients are a more substantial error source (Rabus et al., 2010), but major differences in a single scene are exotic events that are removed during stack processing."

The relevant references (Wasowski and Bovenga, 2014, 2015; Rabus et al., 2010) have been added to the reference list:

"Rabus, B., When, H., and Nolan, M.: The importance of soil moisture and soil structure for InSAR phase and backscatter, as determined by FDTD modeling, IEEE T. Geosci. Remote, 48, 2421–2429, doi: 10.1109/TGRS.2009.2039353, 2010."

"Wasowski, J., and Bovenga, F.: Investigating landslides and unstable slopes with satellite Multi Temporal Interferometry: Current issues and future perspectives, Engineering Geology, 174, 103–138, http://dx.doi.org/10.1016/j.enggeo.2014.03.003, 2014."

"Wasowski, J., and Bovenga, F.: Remote sensing of landslide motion with emphasis on satellite multitemporal interferometry applications: an overview, in: Davies, T. and Shroder, J.F. (Eds.), Landslides Hazards, Risks and Disasters, Academic Press, Amsterdam, Netherlands, 345-403, https://doi.org/10.1016/B978-0-12-396452-6.00011-2, 2015."

We have added a sentence to the subsequent paragraph of section 6.4, which discusses the approximation of 3D displacement from RADAR line-of-sight displacements, to reflect additional error represented in the approximation of the full motion vector from LOS motion: "Additional error is thus introduced in the conversion from measure one-dimensional (LOS) displacement to approximate three-dimensional (true) motion."

As suggested by the reviewer, Fig. S2 from the Supplement of the original submission will be moved to the main paper. We prefer not to expand panel B of this figure to cover the entire 10-month post-failure period of InSAR coverage. Such expansion would greatly compress the time axis of the plot, making antecedent conditions in the month leading up to the 2011 Pamaphasi landslide difficult for the reader to decipher. We have instead added two display items to the Supplement (see below).

We have added a sentence to the caption of Fig. 8 to reflect additional error represented in the approximation of the full motion vector from LOS motion in panel B: "The right axis is approximate, given that additional error is introduced from conversion from LOS to true motion."

We have added a sentence to the caption of Fig. 10 to further clarify the degree of topographic changes due to the 2011 landslide event and thus the magnitude of difference between post-failure terrain and the pre-failure reference DTM: "…, which depicts the generalized pre-failure terrain. Dashed and solid line work in the source area (0 to ~150 m x-axis distance) represents, respectively, pre-failure topography and post-failure topography based on terrain changes measured in the field using a handheld laser rangefinder. Terrain lower on the failed slope changed comparatively little during the landslide; solid line work beyond ~150 m x-axis distance is thus generally representative of both the pre-failure and post-failure topography."

Additions to Supplement:

A table and a figure will be added to the Supplement to show that precipitation during the 10-month post-failure window (March through December 2011) was generally characteristic of the same months in the pre-failure window (March through December in each of 2008, 2009, and 2010). These new display items are now referenced in the discussion of the main paper in a brief comparison of pre-failure and post-failure precipitation conditions (see 'Additions to section 6.4' above).

The two additional supplemental display items noted above are complemented in the Supplement by a brief description of pre-failure and post-failure precipitation conditions: "Despite the high variability of short-term precipitation evident from eyewitness accounts of rainfall intensity and from daily precipitation records, the longer term (monthly to annual) amount of precipitation before and after the 2011 landslide was similar. Precipitation during the 10-month post-failure period (March to December, 2012) totalled 282.2 mm and ranged on a monthly basis from 0 to 127.6 mm. These conditions are typical of March-to-December precipitation in each of the three years fully covered by the pre-failure InSAR stack (i.e. 2008, 2009, and 2010: 0 to 137 mm monthly; 235 to 366 mm 10-month total; 282 mm 10-month mean)."

We have added a sentence in the processing overview provided in the supplement to specify the stack thickness beyond which statistics are more robust: "The HDS-InSAR processing approach generates stronger statistics for stacks of approximately 15 or more scenes."

1.2. Fig 6b, which shows the distribution and average annual velocity of HDS (measurement points) for the pre-failure period, indicates some "noise" (especially southern part) in the data (areas where different velocity points are mixed together). Perhaps it would be useful to show a similar figure for the post-failure period. If not, to give an idea of the precision of the results obtained for the pre- and post-failure, you could consider estimating the mean velocity standard deviations for the two periods (cf. Wasowski and Bovenga, 2014a,b).

Response: Showing similar graphics (HDS points and interpolated linear deformation map) for the post-failure period is an excellent suggestion. Instead of creating a new, separate figure, we have opted to modify Fig. 6 to include these post-failure graphics for the sample area. Representing both the pre-failure and post-failure stacks in this single figure parallels the structure of Fig. 7 and will allow the reader to directly compare results from the two InSAR stacks. The updated figure is further supported by several text modifications outlined below:

We have added text to the first paragraph of section 5 to clarify the sources of noise in HDS and how these have minimal impact on the interpolated linear deformation maps used to analyse slope activity in the Pampahasi area: "Furthermore, the interpolation weighting suppresses very localized HDS clusters that differ greatly from the average (Supplement). These small-scale variations – whether representing surficial movement or noise from uncorrected phase unwrapping errors – are consequently inconsequential to large-scale patterns described below."

Figure 6 caption: We have updated this caption to reflect the addition of the post-failure HDS results and the linear deformation map, we have added text to highlight the noise in HDS results and its reduction the linear deformation maps: "Localized variably in HDS results (panels A and B) is supressed by linear deformation interpolation (panels C and D)."

We have added text to section 4.7 of the supplement to clarify how the interpolation suppressions of very localized variations of HDS values: "Small HDS clusters (fewer than five points) receive no weight during interpolation, resulting in suppression of much of the localised (smaller than several metres by several metres in the case of the RADAR resolution we processed) variations that might be noise resulting from phase unwrapping errors."

In light of the expansion of Fig. 6, we have opted not to estimate mean velocity standard deviations for the pre-failure and post-failure periods (citing Wasowski and Bovenga, 2014a, b) as a way to indicate the precision of the two stacks.

1.3. Finally, we know the InSAR are relative in both time and space. You indicate the Master scene in the Supplement (for both pre- and post-failure stacks), but the location of a reference point (area) in space is not specified, unless I missed it. This could be relevant considering the generally marginal (changing?) stability of the land in the study area.

Response: Our method does not have a spatial reference point, but rather uses a commutative reference area made up of all areas detected as non-moving at scales <10 km; movement on scales larger than 10 km are removed during atmospheric filtering. Quantified motion is thus not absolute, but rather relative to this 'non-moving' background area. Consequently, the question of a specific spatial reference is not relevant. The reviewer's comment highlights that we had not effectively conveyed this aspect of the processing. We have made the following additions to remedy this:

Methods additions:

The first sentence of section 4.5 in the supplement has been expanded to read: "We applied differential InSAR (D-InSAR) to determine time-series phase statistics and to identify phase differences on scales greater than ~10 km, which are presumed to be atmospheric phase contributions."

We have added a sentence to the final paragraph of section 4.6 in the supplement specifying use of a cumulative reference area as follows: "Instead of a single spatial reference point or region, phase changes in HDS-InSAR are determined relative to a cumulative reference area comprising all areas lacking movement on scales <10 km, with broader scale motion having been removed by atmospheric filtering."

2. **Interpretations and conclusions - I can follow you for the most part, but remain somewhat uncertain about the postulated broad significance of the observed postfailure creep acceleration (enhanced activity).**

The various points on this topic made by the referee are addressed below (points 2.1 to 2.2):

2.1. One reason is that the quality/precision of pre- and post-failure measurements is not the same and perhaps difficult to assess (cf point above).

Response: We agree that the exact quality of the both pre-failure and post-failure InSAR stacks is difficult to assess. However, our conservative estimates of their precisions as, respectively, 3 mm/a and 6 mm/a (see point 1.1 above) are below the long-term displacement rates across much of the Pampahasi area. We have added additional text to the end of the second paragraph of section 6.4 to clarify this: "Because the average displacement rates across much of the Pampahasi area exceeds the simplified error estimates, the displacement patterns documented here are generally reliable."

2.2. Then, the conclusion regarding the post-failure creep acceleration is based just on this one specific case. On the basis of the literature review and their own data, Wasowski and Bovenga (2014a,b) indicated that InSAR seem to preferentially capture creep of deep slides, seasonal accelerations of large landslides and post-failure ground instability (settlements, volumetric changes). For some deep landslides/materials, these settlements and volumetric changes can be significant. Could it be that these phenomena are (in part) responsible for the apparent enhanced activity or displacement acceleration measured in the 10-month post-failure period?

Response: Benefits of HDS-InSAR include its improved preservation of spatial resolution compared to other InSAR techniques and its optimization for spatially uncorrelated ground motion (described in section 3.2). These aspects make it particularly well suited for characterizing high spatial frequency ground motion and thus spatially irregular displacement patterns generated by localized landsliding (in both the presence and absence of more regular, large-scale displacements patterns resulting from deep-seated landslides). Consequently, the displacement maps we present are less biased to large, deep-seated landslides than are maps produced using conventional InSAR methods. To clarify this, we have added the following:

Section 5 (end of first paragraph: "The displacement maps record deep spatially regular slope movements as well as shallower more variable movements, but their differentiation requires consideration of displacement patterns and may not always be clear."

Section 7.2 (second paragraph): "Furthermore, such techniques enable more comprehensive detection and characterization of landslides of different depth and size. Preferential detection of deep landslides by InSAR (Wasowski and Bovenga, 2014, 2015) reflects the typically large spatial regularity of their displacements. Shallow instability, especially in areas of variable micro-topography, generates spatially irregular ground motion that is more difficult to detect. HDS-InSAR's optimization for locally variable ground motion particularly improves the characterization of shallow landslides and thus reduces biasing toward deep-seated instability."

By 'settlement' we presume that the reviewer means post-failure compaction of the debris and thus are questioning whether the enhanced ground displacements in the post-failure stack could be the result of compaction, rather than displacement along failure zones/surfaces. Compaction may be possible in some places. However, much of the area involved in the 2011 event (particularly areas that maintain coherence in the post-failure stack) underwent minimal transport and thus minimal bulking. Consequently, very minimal compaction is possible and the majority of the surface movements most likely reflect true landslide displacements. To clarify this, we have added text to section 5.2 (second paragraph): "Given the limited transport, and thus bulking, across most of the area of the 2011 landslide (Fig. 2A) and the occurrence of abundant surface displacement beyond it limits (Fig. 2B), ground motions following the event should largely represent mass movements as opposed to soil settlement or compaction."

3. **Figure S2. The precipitation record… - this figure is important and I suggest moving a possibly modified version from the Supplement to the main article. It could be good to extend the precipitation data to the entire 10-month post-failure period covered by InSAR data.**

   Response: We have moved this figure from the Supplement to the main paper. Expanding panel B of this figure to cover the entire 10-month post-failure period of InSAR coverage would greatly compress the time axis of the plot, hindering display of antecedent conditions in the month leading up to the 2011 Pamaphasi landslide. To quantify both pre-failure and post-failure precipitation, we have also added the display items mentioned in point 1 above to the Supplement, which will clearly represent precipitation during the 10-month post-failure window (March through December 2011) as well as precipitation during the pre-failure period (2008-2010).

Minor issues:

4. **page 2, line 20: "coherence" – might want to explain or at least say interferometric coherence.**

Response: This is a good point and adds clarity. The text now specifies: "…interferometric coherence."

5. **page 2, line 29: "over much of the landslide area" – this seems too optimistic if one looks and Figs 7 and 9.**

   Response: We have modified to text to better reflect that displacement fields in some areas, particularly in the post-failure InSAR stack, could not be quantified interferometrically: "…over large portions of the landslide…".

6. **page 3, line 13: "up to 50 km"? Is this correct?.**

   Response: The value of 50 km^2 is correct. The end-Pleistocene Achocalla earth flow (southernmost landslide deposit in Figure 1B) is the largest landslide in the La Paz area. This failure produced the Achocalla basin directly south of La Paz, which is floored by less mobile, proximal debris (~40 km^2). More mobile, distal debris flowed over 20 km down Río La Paz, producing a long debris tongue (~10 km^2). We have updated the text to direct the interested reader to a short report on this specific landslide (Dobrovolny 1968), which provides a general description of the landslide and conservatively estimates the volume of the failure material as 2.7 km^3. "…including deposits of large (up to 50 km^2; Dobrovolny, 1968) paleolandslides…"

   The relevant reference has been added to the reference list: "Dobrovolny, E.: A postglacial mudflow of large volume in the La Paz valley, Bolivia. US Geological Survey Professional Paper 600-C, 130–134, 1968."

7. **Page 8, line 15: "(~2.6 cm:…)" – Shouldn't it be 1.3 cm?.**

   Response: The value '2.6. cm' was a typographic error. It should be '2.8 cm'. Aliasing will occur when ground motion between successive RADAR acquisitions causes a shift exceeding the sensor's wavelength. Because the two-way travel of waves must be considered (incident beam and reflected beam), the line-of-site threshold for producing temporal aliasing is one-half of the sensor's wavelength (5.6 cm for RADARSAT-2). We have corrected the value and added additional text so that the sentence reads: "…from aliasing where displacement rates are greater than the detection threshold of RADARSAT-2 (~2.8 cm LOS [equivalent to a two-way travel distance for RADARSAT-2's 5.6-cm wavelength] over 24 days)."