*The authors are very grateful to the Editors and Associate Editors for the kind consideration and possible publication of our article in the Natural Hazards and Earth System Sciences. The authors would like to thank all reviewers for suggesting improvements for the manuscript. Point-wise reply/answer to each comment is provided below (comments are shown in **green bold font**, answers are shown as black font). All suggestions have been addressed, but still, the authors are open for further explanations and cooperation in term so manuscript improvement. Furthermore, the authors appreciate the editors and reviewers for the timely handling of the review process. After evaluation of the reviews we have the clear idea of the how to perform the corrections in order to improve our manuscript. This mainly includes:*

- *Rewriting the introduction in order to highlight the novel aspect of the manuscript because in the present form, the novelty of the work is not noticeable clearly visible (rewriting according to the reviewer 2 suggestion)*
- *The literature review will be moved into material and methods sections (according to the reviewers 2 suggestion, shorten a little however will be kept because as the reviewer 3 stated this is a strong part of the introduction)*
- *According to the reviewer 2 suggestion, time series of the PS points will be presented together with the discussion about presented deformation mechanism*
- *According to the reviewer 1, some sentences will be rewritten to improve readably and some confusing aspect (thresholding, slope reprojection, PS technique limitation etc.) will be deeply discussed.*

*Authors*

*REVIEWER 3*

***POINT 1 The main goal of this manuscript is to present the updated state of activity of landslides in Małopolskie municipality, a rural area with sparse urbanization in the Polish Flysch Carpathians, based on InSAR results. At a glance the manuscript seems to be a good case study, carried out according to state-of-the-art methodologies published and highly cited in the specialist literature. However, after a careful reading, it comes out that there is no element of novelty in both the InSAR processing & post-processing methodology and contribution to advance the field of landslide studies.***

*You are right that this methodology has been applied by many authors. However, in presented paper we would like to grab all various aspects in one comprehensive study.*
*Firstly, some authors use only one geometry of SAR images (ascending/descending) but here we used both. Additionally, in this study, we showed that using one SAR geometry is not appropriate approach due to the limitation of side looking SAR geometry and terrain characteristic (slope/aspect). In some cases, ascending geometry is appropriate to investigate specific landslide and, in some cases descending images are required rather than ascending ones. Therefore, there is a need to investigate both geometries.*
*Moreover, in this study, we presented some advantages of both Sentinel-1A/B data processing with 6-days revisiting time. This allows to increase a coherence and therefore increase the PS points density. This is a novel aspect of the paper, previously not presented- comparison between Sentinel-1A and Sentinel-1A/B data processing in terms of PS points density and therefore landslide activity state updating.*
*Furthermore, even though some paper presented already PSI utilization for activity state updating, this is the first paper which shows landslide activity state updating in a region in Poland. This region is specific in comparison to study areas investigated in other papers (rural areas with extensive*

*agriculture). This specificity will be emphasized in the revised version of the manuscript. Therefore, the results which are presented for another and characteristic study case may be interesting and beneficial for scientific community. Moreover, this is a first presentation of Sentinel-1 data application to estimate the landslide activity state in Polish Carpathians, (the PS interferometry technique has been previously applied in monitoring Carpathian landslides by Perski et al., 2010, 2011. However, in different study area but due to the high temporal decorrelation, resulting from vegetation cover and short wavelength (X-band), it was only partially successful (Perski et al., 2009; Perski et al., 2011). This is mostly related to low PS density due to the TerraSAR-X data application. Therefore, exploitation of C-band (Sentinel-1) and L- band (ALOS PALSAR) data bring more advantages, especially in rural areas of Carpathians mountains and in our opinion this finding should be presented for scientific community. Moreover, inspired by reviewers, we will provide, in the revisited version, also critical discussion of the method used supported by accuracy analysis.*

*Perhaps we did not appropriately underline all novel aspects in introduction section of our manuscript. We will improve it while revising this manuscript.*

***POINT 2 The area where this manuscript could bring in a novel contribution could be the improved knowledge about local landslides in Małopolskie and the risk that they pose to population, buildings and infrastructure.***

*As mentioned in previous point, we will try to rewrite introduction section in order to underline novel aspects of the manuscript, because due to not clear enough introduction, the novel aspect of the paper is not clearly noticeable. We will also try to extend discussion about landslide activity and risk in Małopolskie municipality according to your suggestion. Thank you.*

***POINT 3 However, despite the field validation, it is difficult to relate the conclusions achieved by the authors based on InSAR processing and analysis with the challenges that this area in the Polish Carpathians is experiencing. So in general I believe that this manuscript (and the research behind it) requires more work to be publishable. Further detailed comments are reported below.***

*According to the reviewer suggestion connected with issues related to landslide in Małopolskie municipality, in revised version of the manuscript, we can include additional analysis connected with building and infrastructure destructions investigated in field (there is an official report for the damage). We can compare this destruction map with estimated in this paper expected damage rate by Mansour et al. (2011),*

***POINT 4 Abstract It can be improved by removing redundancies (e.g. lines 12-13 vs 18), making explicit the cause for 7 landslides out of the total 50 that could not be confirmed, and highlighting the novel contribution with regard to either methodological approach or knowledge about local landslide issues and the risks that they pose (see also what the authors state at lines 84-87).***

*This issue will be corrected while revising the manuscript.*

***POINT 5 Introduction The strength of this section is for sure the wide and comprehensive literature review. Key and relevant papers are cited. However, although at line 72 the authors start listing the objectives of the manuscript, it is not clear how these objectives relate to the literature reviewed in the previous paragraphs. In which way is this manuscript novel (if it is) compared to the cited literature?***

*In our opinion, when compare our research with these listed in introduction section, we evaluated landslide activity state **in wider and comprehensive way.** Namely, many aspects have been jointly analyzed which in some papers are sometimes missing. To give more details about the difference between these works and our research we draw a couple of differences between our paper and peppers mentioned in introduction section.*

***DIFFERENCES WITH STUDIES MENTIONED IN LITERATURE***

*Bianchini et al. (2012)→ (1) there ERS/Envisat data has been used and here we present deep investigation of various Sentinel-1 data; (2) Radar geometry and terrain orientation has not been evaluated and also velocity has not been reprojected into the slope direction (3) assessment of the possible hazard and damage has not been presented (4) field verification with damage evidences has not been shown.*

*Bianchini et al. (2013)→ (1) they utilized ALOS data, besides ALOS data we applied also Sentinel-1 data for both satellites with different orbit geometries; (2) in contrary to that work, landslide intensity has been additionally evaluated and landslide damage map has been generated; (3) in contrary to that work, deep discussion about specific landslides, PS points and field investigation is presented.*

*Cigna et al. (2013)→(1) only descending images are utilized from ERS, Radarsat 1 and 2 in this paper while in our case ALOS ascending and Sentinel ascending and descending geometries are used (2) in contrary to that work, radar geometry and terrain orientation has not been evaluated (3) in contrary to our work, assessment of the possible hazard and damage has not been presented (4) in contrary to our work, field verification with damage evidences has not been shown, only google earth/google street map images*

*Del Ventisette et al. (2014)→(1) Envisat and ERS descending images have been used while in our case ALOS ascending and Sentinel ascending and descending geometries are used (2) in contrary to that work, landslide intensity has been additionally evaluated and landslide damage map produced; (3) in contrary to that work, we provide deep discussion about specific landslides, PS points and field investigations.*

*Barra et al. (2016).--> (1) 14 Sentinel-1 ascending images while in our case ALOS ascending and Sentinel ascending and descending geometries are used (2) in contrary to this work, different approach than PSI matrix has been utilized (3) in contrary to this work, no landslide intensity has been evaluated (4) in contrary to that work, field investigation has been performed and presented.*

*Kalia (2018) →(1) only 66 descending Sentinel-1 images while in our case ALOS ascending and Sentinel-1 ascending and descending geometries are used (2) in contrary to that work, assessment of the possible hazard and damages has not been presented (4) in contrary to that work, field verification with damage evidences have not been shown.*

***ADDITIONALLY, BESIDES THE DIFFERENCE BETWEEN MENTIONED PAPERS, THIS WORK PRESENTS:***

*-first wide and comprehensive exploitation of Sentinel-1 images when comparing to (Kalia, 2018; Monserrat et al., 2016; Barra et al., 2016)*

*-various aspects to improve reliability of PS points have been carried out (sensitivity index, reprojecting into slope direction)*

*-first landslide activity state evaluation in presented region in Poland. This region is unique and one of the most landslide affected areas in Poland.*

*-first Sentinel-1 data application in landslide activity state estimation in Polish Carpathians.*

*-first presentation of launching second Sentinel-1B satellite in terms of increase of PS points density*

*Maybe, we did not accurately describe and underline this novelty in the introduction section. Thus, we will improve the introduction to show these differences when revising our manuscript.*

***POINT 6 The feeling is that the authors primarily wanted to ensure that their methodology was aligned with the literature.***

*Through such extensive literature review connected with application of PSI based matrix approach we would like to provide current state of the knowledge rather than ensure our approach with these presented in literature. However, based on your previous comments, we will use this literature review to emphasize and to leverage our investigations. Thus, as mention previously, this issue will be improved in introduction when revising our manuscript and according to other reviewers' suggestion this literature review will be probably moved into the method section.*

***POINT 7 Figure 1: it is not clear whether the landslides mapped are those from the pre-existing inventory, i.e. prior to the update based on InSAR. The caption should be more explicative***

*These landslides are prior to the update based on InSAR. This is written as plain text in manuscript: "The study area covers the surrounding hills of Rożnów Lake (Fig. 1). This figure shows the landslide distribution within the study area as well their predefined activity states." Additionally, we will add this explanation in figure caption when revising our manuscript.*

***POINT 8 Methods The methodology is in general correct because it largely relies on well-established and accepted methodologies. However, it is difficult to see it framed within the specific geological, geomorphological and environmental features of the study area landscape. Therefore, although they may be correct, the rationale for the implementation of some of the assumptions is difficult to understand. At what extent the knowledge of the local landslides helped the authors to shape and adapt the methodology?***

*We use methodology being compilation of the methodologies presented by other authors dealing with landslide investigation by using PS interferometric processing. Based on Cigna et al., 2013, PSI-based methodology can be only applied for landslides with very slow dynamics, such as deep-seated gravitational slope deformations, creep, and rototranslational slides, flows, and complex landslides, as long as their velocities do not overcome the above-mentioned rates (Cigna et al., 2013). We investigated carefully, if landslide which we are dealing with are in this type of the movement. We investigated documentation from field investigation, which was created by well-experienced geologists in the study area. Based on this, we stated in the Materials and methods section that "Among the study area diverse landslide types exist including translational, rotational or combined rock-debris slides and typical debris slides". However, to improve our manuscript, we will add also information that this method can be used for slow moving landslide according to the previously mentioned literature and we will clarify that we investigated the type and speed of the movement of landslides within our study area.*

*You stated that the rationale for the methodology implementation is difficult to understand. However, this rationale is widely presented in literature and there are not many parameters which depend on* *"knowledge of the local landslide ". The fundamental "knowledge of the local landslide" depend on the velocity speed/intensity. This is strongly related with PSI interferometric limitation which is described in manuscript (not appropriate for fast movement). For this we investigated landslide documentation and characterization and based on this, we assessed that landslide within our study area are slow and extremely slow and therefore we can apply PSI based methodology. Besides this, we do not need any other geomorphological characteristics of the landslide etc. because PSI-based matrix approach depends of PSI-estimated velocity thresholding. This thresholding has already been used by abundant number of authors. Below, we present thresholds used by various authors and thresholds used in our study. Generally, when selecting the thresholding values, we followed the recommendations of widely cited papers, where also landslides are slow and extremely slow moving (please see below)*

1) *Landslide activity threshold*
   $v_{LOS}$= *-1.5mm Envisat, → Del Ventisette et al. (2014)*
   $v_{LOS}$= *-2mm, Envisat, →Bianchini et al. (2013)*
   $v_{slope}$ = *-5mm, Envisat, →Bianchini et al. (2013)*
   $v_{slope}$ = *-5mm, ERS, Radarsat 1&2, → Cigna et al. (2013)*
   $v_{slope}$ = *-10mm, Sentinel-1 → Kalia (2018)*
   *Since for* $v_{slope}$ = *-5mm is usually applied, we decided to use this threshold.*
2) *C value threshold of 0.3 (PS with C smaller that need to be removed)*
   *C=0.3 used by Kalia (2018)*
   *C=0.3 used by Bianchini et al. (2013)*
3) *Threshold to distinguish slow up to extremely slow mowing landslides*

*In general, in literature tree various threshold exists to distinguish slow moving and extremely slow-moving landslides.*

*Righini et al.2011 used vLOS=-10mm,*
*Bianchini et al. (2012) used vLOS=10mm*
*Cigna et al. (2013) used vslope =13mm.*
*Kalia (2018) used vslope =16mm.*

*As can be observed higher threshold are used in case of* $v_{slope.}$ *(velocity reprojected into the steepest slope). In our study, we decided to used* $v_{slope}$ *=16mm similarly as Kalia (2018) but the most important reason is that this threshold is presented in well-know, old and widely respected literature (4218 citations) of Cruden and Varnes (1996). They stated that extremely slow landslide has velocity < 16 mm/yr and very slow landslides (16 mm/yr < velocity < 1.6 m/yr). Having considered abovementioned issues, we decided to applied threshold of* $v_{slope}$ *=16mm.*

4) *Number of points used to estimate velocity and*
   *4 points within landslide body → Bianchini et al. (2013); Cigna et al. (2013)*
   *3 points within landslide body → Cascini et al. (2013)*

*Based on the majority and to be more confident, we decided to used 4 points*

5) *way to estimated velocity average/clustering*

   *average → Bianchini et al. (2012); Bianchini et al. (2013); Cigna et al. (2013)*

   *clustering → Kalia (2018)*

*Besides these parameters there is no other which need to be adjust to the geological or geomorphological conditions.*

*Summarizing, we will specify the issue connected with the "need of knowledge of local landslide characteristic" when revising our manuscript.*

***POINT 9 With regard to PSI, some key information are missing in the text (or I was not able to find myself), e.g. the location of the reference points selected during the processing.***

*Thank you for this comment, the location is really not included in text. We will, of course, add the reference point location in the figures 7 a,c,e where PS velocity is presented.*

***POINT 10 Figure 3: there is a typo in Feretti et al.; it should be Ferretti et al. Furthermore, in the text***

*These minor typos will be corrected during the manuscript revision.*

***POINT 11 I did not find the explanation of the rationale followed by the authors for processing first Sentinel-1A data only and then Sentinel-1A + Sentinel-1B data together. Would not it be better to process directly Sentinel-1A + Sentinel-1B data together? What is the advantage of this approach?***

*The rationale explanation to your question and our way of interferometric processing is that:*

(1) *Sentinel-1B data has been launched on April 24, 2016, thus Sentinel-1B data for the years 2014-2016 has not been available yet (only data from Sentinel-1A satellite are available for this period). When the second satellite Sentinel-1B has been launched (April 25$^{th}$, 2016), it was available to use both satellites images in interferometric processing. Therefore, for year 2017 we used both satellites for PS processing.*

(2) *Additional objective of this study was to answer the question: What is the advantage of the launch Sentinel-1B satellite in terms of PS points density? Thanks to this strategy, we were able to answer this question in manuscript as "However, it was demonstrated that increasing the temporal sampling rate in view of launching the second Sentinel 1 satellite provides higher PS density and, ipso facto, more landslides could be investigated by means of PSI. We were able to investigate the landslide activity states of 130 and 205 landslides by using one Sentinel satellite and two satellites, respectively. It is significant progress in comparison to the first attempts with the application of PSI technique using TerraSAR-X and ERS-1 data in this study area (Perski et al., 2010, 2011) that failed due to disturbing vegetation cover" (lines 410-415)*
*Of course, we can marge these two data stacks into one interferometric processing, however we believe that these two processing strategies tangibly show that application of two satellite can increase PS density almost double it and therefore, we can get more information about deformation. This is direct recommendation to the scientific community dealing with PS processing, especially in rural areas with low coherence and small PS point density. In such area, we should take advantage of both satellites with a short revisiting time to get higher PS point density*

***POINT 12 More in general, what is the impact of each satellite dataset on the state of activity?***

*As previously described, these two separate PS processing (first by using from only Sentinel-1A image and second by using Sentinel-1A and 1B data), allow us to evaluate the effect of revisiting time on PS* *coverage. When only Sentinel-1 data is used, revisiting time is 12 days while in second strategy is 6 days. This directly decrease temporal decorrelation and therefore increase coherence. Higher coherence means higher PS points density. Therefore, in conclusion section lines 227-250 we can find "In general, applying the PSI approach in rural areas is challenging. However, the results of this study prove that increasing the temporal sampling rate in view of launching the second Sentinel 1 satellite, provides higher PS density and, therefore, this technique can deliver useful information for landslide activity assessment. Sentinel 1A and Sentinel 1A/B were used for 130 and 205 landslides, respectively"*

*It can be observed in figure 9 where 20% of all landslide objects were updated by using Sentinel-1A while 38% where updated by using Sentinel-1A and 1B. This almost double increase is an important advantage.*

***POINT 13 Discussion I would have expected more linkage between the evidence gathered during the field validation and the InSAR data. When did the damages observed in the field happen? Is there a temporal association/correlation between the displacement showed by InSAR data and the damages?***

*Having observed Figures 11-15, where photos from field investigation were taken and PS points together with landslide extent are presented, we can notice a correlation between damages and PS points. Unfortunately, specific date of particular damage are not possible to be acquired because these need to make the interview with local inhabitants because such a damage cannot be dated based on remote sensing technique. In order to make more linkage between figures which represent PS points and photos take in the field, we present the table with time span if analyzed data and data when photos in the field have been taken. Unfortunately, this information has not been included in the manuscript, but if this will help to directly link field observation (photos) with PS results we will add this information in the revised manuscript of course.*

*Meanwhile, we have an access to official damage register for this region, however this is cumulative information, that is only roughly localized. Unfortunately, it cannot be used as the evidence for a particular landslide, but rather for the region.*

| | *Sensor used for activity evaluation in presented figure* | *Time span of analyzed data* | *Data of the field photos taken* |
|---|---|---|---|
| *Figure 11* | *ALOS* | *31/01/2008-27/12/2010* | *9/29/2010* |
| *Figure 12* | *Sentinel-1A+B* | *2/01/2017-31/12/2017* | *03/07/2018* |
| *Figure 13* | *Sentinel-1A+B* | *2/01/2017-31/12/2017* | *03/07/2018* |
| *Figure 14* | *ALOS* | *31/01/2008-27/12/2010* | *25/03/2011* |
| *Figure 15* | *Sentinel-1A+B* | *2/01/2017-31/12/2017* | *03/07/2018* |

***POINT 14 Given the current statements at lines 432-436, it is not clear how the authors assessed the degree of damage to buildings and infrastructure.***

*Actually, it is written in manuscript in line 432 "All landslides presented as examples of field verification, based on Mansour's thresholding, are expected to generate moderate damage to buildings and infrastructure." Thus, we followed Mansour's thresholding which is explain in section 3.2 as:*

*"Based on a literature review, a downstream investigation was performed and additional thresholds were set up in order to assess possible hazards related to buildings and infrastructure located in landslide areas. For this purpose, we applied the method proposed by Mansour et al. (2011), i.e., the threshold of 10 to 100 mm/yr as a minimum landslide velocity which can cause moderate damage to infrastructure and buildings. Velocity rates higher than 100 mm/yr can cause major damage to infrastructure and buildings. Landslide with velocity below 10mm we classified as landslide with minor expected damages. This thresholding has been adopted as an additional criterion in order to support environmental planning and management strategies to areas which can be characterized by high landslide hazard and, consequently, should be addressed to potential damages protection. In Fig. 10, possible damages caused by mass movements in the study area are presented for three diverse PSI processing results." (lines 300-310)"*

***POINT 15 Several minor typos throughout the text need to be corrected, e.g. - line 16: "filed" to be corrected into "field" - line 181: "Feretti et al." to be corrected into "Ferretti et al."***

*These minor typos will be, of course, corrected during manuscript revision.*