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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Deriving slope movements for an imminent landslide along the Jinsha river" *by* Wentao Yang et al.

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Point to point responses to Anonymous Referee #1 1. General comments: In the introduction part, I suggest to the authors to frame their work in a much more general context regarding: (i) using RS optical imagery in slope movement detection; (ii) comparing the type of the errors with the results of other methods; (iii) frame the risk assessment problem in a widespread context of landslide dammed valleys (not only by comparing with Baige 2018 event).

Response: We re-wrote the beginning two paragraphs of the Introduction part according to this suggestion. Now, in the first paragraph, we described the significance of monitoring landslide movement, especially those may dam rivers in a wider context.

In the second paragraph, we introduced mainstream methods to derive slope movement using remote sensing by referring more literature. We also mentioned the advantage/disadvantages of different methods. The following are the first two paragraphs of the revised Introduction (lines 29-50):

"[Paragraph 1] Landslides are major natural hazards in mountain regions and have been causing widespread disasters every year around the globe (Petley 2012; Zhang et al. 2020). Major landslides in remote mountain regions may pose serious threats to downstream communities by choking channels to increase risks of landslide-dammed lake outburst floods (Fan et al. 2020; Liu et al. 2019). For example, a hillslope near the Baige village had two landslides, damming the Jinsha River twice in 2018. The outburst floods caused widespread damage along its route and affected as far as Yunnan Province, > 500km from the landslides (Fan et al. 2019). In 2000, a super-large landslide dammed the Yigong River in Tibet and the outburst flood two months later caused widespread damages, including 5 main bridges, highways and communication cables in downstream areas (Shang et al. 2013). The breach of the 1786 landslide-dammed lake in the Dadu river consumed >100,000 lives along its route (Dai et al. 2005). Similar cases occur in many mountain regions in the world and detecting precursors before major landslides are crucial for preventing such disasters (Intrieri et al. 2018; Carlà et al. 2019).

[Paragraph 2]Remote sensing techniques have been an efficient way to monitor slope movement over large mountain regions (Du et al. 2020; Handwerger et al. 2019). Optical passive and microwave active radar remote sensing most frequently used tools to detect slope displacements. There are two kinds of mainstream methods to derive slope movement. SAR interferometry processing use the difference in phase images to derive subtle slope movement of a few millimetres (Intrieri et al. 2018; Samsonov et al. 2020). However, large ground displacements (e.g., a few metres), dense vegetation or long time intervals could lead to incoherence in phase images in these types of methods (Wasowski and Bovenga 2014). Image correlation methods (also referred as the pixel offset tracking) is another type of methods that use SAR amplitude or optical images to cross-correlating image patches to measure slope movement, which can derive sub-pixel ground displacements from 1/10 $\sim$ 1/30 of a pixel (Li et al. 2020). The later type of methods is good at detecting larger slope movements that are visible on images (Bradley et al. 2019; Lacroix et al. 2020). In recent years, image correlation methods have been proposed and widely used to detect sub-pixel slope displacements in optical images (Bontemps et al. 2018; Lacroix et al. 2019; Lacroix et al. 2018; Yang et al. 2020)."

2. The second part (here I suggest to use Methods instead Methodology) should be split in (i) Study area section (here I consider that a simple information regarding the main characteristic of the climate and V shaped valley is not enough to compare the both slopes – the authors must address a wide spectrum of conditional factors of a local assessment of mass movement - lithology, geohydrological conditions, land cover, anthropic influence etc.), (ii) COSI-corr method and (ii) Error assessment In the actual form.

Response: Thanks for this comment. Now the title of the second part is "2 Methods" and it has been split into three sub-sections: "2.1 Study area", "2.2 The COSI-Corr method" and "2.3 Error Assessment and postprocessing". In addition, we described other information of the study area, including lithology, land cover, geohydrological conditions, et al. Please refer to lines 59-71:

"The reported slope is $\sim$80 km downstream the Baige landslide (Fan et al. 2019) along the Jinsha River near Mindu town, Tibet Autonomous Region, bordering Sichuan Province (Figure 1a). The slope is located on the right bank of the Jinsha River. Similar to the Baige landslide, the geomorphology of this section of the Jinsha River is at the bottom of V-shaped valley. The elevation of the study area ranges from 2660m at the valley bottom to >4500m on the mountain ridge. This rough topography indicates strong fluvial incision against the rapid uplift of the Tibetan Plateau. We estimated the mean annual precipitation (MAP) by using the GPM v6 monthly precipitation (from

2001 to 2019) and found the MAP of this area is $\sim$665mm. The region is controlled by monsoon climate with >90% of the rain occurring from May to October. In addition, this area is tectonically active and active faults run through this slope from north to south. To the west of the faults are Upper Paleozoic strata, and to the east are Mesoproterozoic metamorphic rocks. Cracks and fissures on the slope are visible from the 15 m resolution pan-sharpened false colour Landsat 7 image acquired in 2001 (Figure 1b). These cracks and fissures may be relics of historic earthquakes or precipitations. This part of the slope has an aspect of the southeast, with azimuth between 112.5° and 157.5° (Figure 1c). This slope is mainly covered by grass and sparse shrubs and less affected by anthropogenic activities."

3. Results and Discussion parts seems to be a simple report. I suggest to enlarge these parts by using a set of similar papers and outcomes from the literature (here another major drawback of the manuscript - a weak framing in the bibliographical background). After these proposed major revisions, in order to increase the scientific soundness to an international level, I recommend the publication of the manuscript. Specific comments: a set of suggestions were made in the pdf file attached.

Response: Major revisions were done to the Discussion part. In this part, we tried to frame our work to a wider background by first mentioning the significance of our findings by citing related works. Now the revised Discussion has three parts. In the first two-part, we mentioned the importance of this work's two main findings: 1) a major slope movement was detected that may threat the Jinsha River and downstream communities; 2) a new strategy was applied to suppress background noise, which is related to other methods. In the second part, we reviewed some reported factors that may introduce errors in deriving slope movement and discussed our measures to reduce these uncertainties. Please refer to lines xx-xx for the re-wrote Discussion part:

"[Paragraph 1] Major landslides in mountains may dam river channels forming transient lakes, the breach of which can result in catastrophic floods to downstream communities (Dai et al. 2005; Fan et al. 2019; Liu et al. 2019). In this work, we examined a hillslope near Mindu town along the Jinsha River. We found the slope had significant movement from November 2018 to November 2019. Despite the area of the detected moving slope (715,577 m2 for displacements larger than 3 m) is similar with the area of the Biage landslide (830,624 m2), the width of the Jinsha River channel below the Mindu slope ($\sim$ 50) is half that of the Baige (>100 m, in Figure 7). Considering the similar morphology of both river sections, the collapse of the Mindu slope may pose a threat to downstream communities by blocking the Jinsha River. We call for further frequent monitoring of the hillslope with other tools, such as InSAR (Intrieri et al. 2018; Samsonov et al. 2020).

[Paragraph 2] There are a few strategies to suppress background noises in derived results, including selecting results with high signal/noise ratios (Lacroix et al. 2018; Yang et al. 2020), integrating redundant information in time series of images (Bontemps et al. 2018). This work introduced a new method to use slope aspect to filter out slope movement that is different from the aspect. This procedure could eliminate false slope movements and reserves true slope movement of the Mindu landslide.

[Paragraph 3] Many factors can influence the accuracy of slope deformation derivations by using image correlation methods, which includes errors during image orthorectification, different viewing angles of images, different illuminations, et al. (Stmpf et al. 2016; Yang et al. 2020). This work used Sentinel-2 L1C product, which is already orthorectified before distribution (Gascon et al. 2017). To correct for possible misregistration between base and master images, we used a stable zone to calculate image shifts. To reduce errors caused by different illuminations and viewing angles of images during acquisition, all images used for the first two Sentinel-2 image pairs are from similar dates of different years. To derive cumulative displacements, we used 19 base images in early 2018 to detect slope displacements in five target images in 2019."

Responses to other specific comments in the attached PDF

Page 1: 1) Line 2 "river" change to "River"

Response: The "river" in the title has been changed to "River". Corrections were also made throughout the manuscript.

2) Line 15-16. rephrase to avoid confusion between analized landslide and Baige landslide

Response: The sentence has been changed from "Along the 15 Jinsha river, this slope is located downstream the famous Baige landslide near the Mindu town, Tibet Autonomous Region."

to

"Near the Mindu town in the Tibet Autonomous Region, this slope is also located along the Jinsha River, $\sim$80km downstream the famous Baige landslide." (Lines 15-17)

3) Line 24 "could threaten the Jinsha river" try another expression

Response: The sentence has been changed from "We speculate it may continue to slide down and could threaten the Jinsha river."

to

"We speculate it may continue to slide down and dam the Jinsha River." (Line 24)

4) Line 29-30 "Landslides are major natural hazards in mountain regions and causing widespread disasters every year around the globe" rephrase

Response: The sentence has been changed to "Landslides are major natural hazards in mountain regions and have been causing widespread disasters every year around the globe (Petley 2012; Zhang et al. 2020)." (Lines 29-30)

5) Line 30-31 what kind of precursors (specify what kind of processes or/and phenomena); Rephrase "Continuous monitoring of mountain slopes before major landslides occur is crucial for landslide disaster prevention (Luo et al. 2019)."

Response: We changed the sentence and specified the type of precursors (lines 37-

38): “Similar cases occur in many mountain regions in the world and detecting precursors (such as slope movement) before major landslides are crucial for preventing such disasters (Intrieri et al. 2018; Carlà et al. 2019).”

Page 2

6) Line 33 delete “famous”. Line 37 “a level III response” this must be defined.

Response: This first paragraph of the Introduction in the last version has been removed.

7) Line 54 use Methods instead Methodology

Response: Now the title is “2 Methods”.

8) Line 57 the bottom position in a V shaped valley do not represent the geomorphology of a valley section.

Response: We added a few more sentences to explain the geomorphology of the region: (lines 61-63) “Similar to the Baige landslide, the geomorphology of this section of the Jinsha River is at the bottom of V-shaped valley. The elevation of the study area ranges from 2660m at the valley bottom to >4500m on the mountain ridge. This rough topography indicates strong fluvial incision against the rapid uplift of the Tibetan Plateau.”

9) Line 59 “the cracked slope and signs of the mass movement, characterized by a bare surface” the bare surface can be seen but craks and mass movement signs ... hard to be seen ... just after Google Earth image exploration in a detailed zoom ...

Response: On the upper side of the slope, we can see signs of tension cracks as the Fig. 1 (attached at the end of this file), which is probably caused by the movement of the slope and indicates mass movement.

10) Line 61 “monsoon climate” conditional factors of landslides do not refer just to general climatic settings

Response: We analysed the climate by using Monthly Global Precipitation Measurement (GPM) v6 data and added a few sentences (lines 63-65): “We estimated the mean annual precipitation (MAP) by using the GPM v6 monthly precipitation (from 2001 to 2019) and found the MAP of this area is $\sim$665mm. The region is controlled by monsoon climate with >90% of the rain occurring from May to October.”

Page 3

11) Line 74 “ (red rectangular in Fig 1b and 1c)” emphasize the red polygon on mentioned figures

Response: Thanks for pointing out this. We added a sentence in the caption of Figure 1 to explain the red rectangular: “The red polygons in b and c are the selected stable zone.”

Page 5

12) Line 144 “on the slope” rephrase

Response: This sentence is re-wrote. Now the new sentence is (lines 163-165): “Despite the area of the detected moving slope (715,577 m2 for displacements larger than 3 m) is similar with the area of the Biage landslide (830,624 m2), the width of the Jinsha River channel below the Mindu slope ($\sim$ 50) is half that of the Baige (>100 m, in Figure 7).”

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Fig. 1. 3-D view of the Mindu slope in Google Earth. Red arrows indicate tension cracks as the slope moved down. Light colour on the slope indicate fresh exposed substrate.