Reply comments (AC2) for the interactive comments on "Multiple remote sensing assessment of the catastrophic collapse in Langtang Valley induced by the 2015 Gorkha Earthquake" by Hiroto Nagai et al.

The authors thank the anonymous referee #2 for his/her valuable comments. We will improve the manuscript according to his/her comments as following:

In this manuscript, the authors describe the use of different remote sensing approaches for the identification of the effects of the 2015 Gorka Earthquake. In my opinion, the topic is very interesting and suitable for this journal, but the manuscript could be considered ready for the publication only after major revisions. In the following some suggestions for the authors:

We will improve our manuscript especially to clarify what is already known for this hazard, what remote-sensing techniques which we used can identify for the mountain hazard, and what we can mention from the technique for this specific hazard.

Page 1 line 30: in the abstract the authors describe an avalanche and they introduce that the paper will be focused on it. After, in the introduction, they introduce the presence of avalanche, but also landslides and other gravitational processes. For the reader is not very easy to understand which what happened in this area and then to follow the authors in the description of their work. I suggest to rewrite the introduction and to describe better the effects of the earthquake. Starting from the avalanche it is important to define if it is an ice avalanche from glaciers or rock avalanche or another more complex phenomenon. A good definition of the effects of the earthquake is fundamental to give to lectors the possibility to evaluate the effectiveness of the approach proposed by the authors.

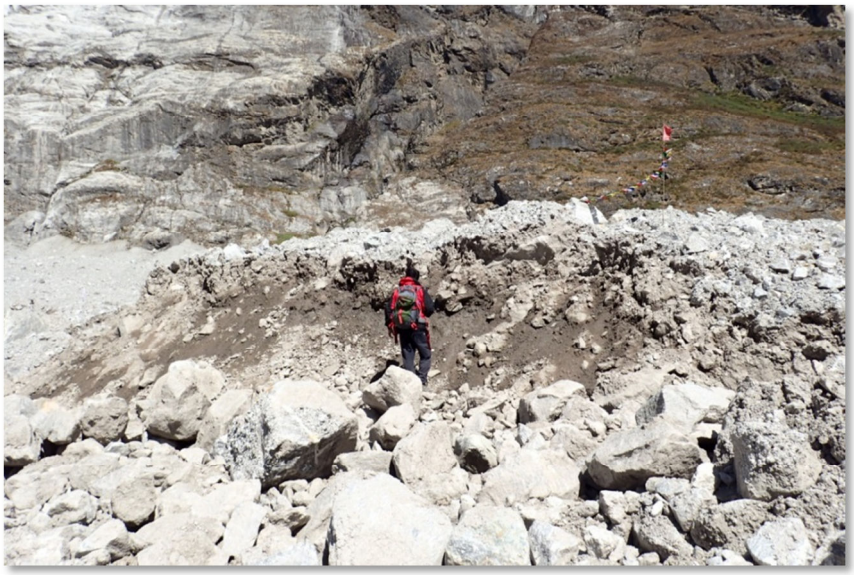
We are sorry for this complicated expression. Now most of the material is considered as an avalanche including numerous boulders (debris) and possibly involving glacier ice along the path.

Details:

At an early time, Kargel et al. (2015) defined this event as a landslide, but they also mentioned "co-seismic snow and ice avalanches and rockfalls" with an image of lower surface temperature observed by Landsat-8 thermal infrared sensor. Lacroix (2016) defined it as a debris avalanche composed mostly of ice and discussed its triggers around the mountain ridge above two glaciers. Fujita et al. (2016) saw sediment boulders on the surface including melting ice (following two pictures) and rapid surface lowering after the quake both by in-situ survey, suggesting that contained ice and snow were melting under the debris. Also

Fujita et al. (2016) concluded that extremely heavy snowfall before the quake increased its volume, coupled with a weather station data.

Therefore we think this event should be defined as “a catastrophic avalanche event including debris and glacier ice” in our introduction chapter. Our finding from interpretation of a high-resolution WV-3 image suggests several layers of the sediment. We will discuss more in detail what we can interpret from our remote-sensing data in the revised manuscript, coupled with those previous studies.



A picture on the sediment surface taken by H. Watanabe a member of an in-situ survey carried out for/by Fujita et al. (2016). [Date: Oct. 21, 2015]

A closed-up picture showing exposed and melting ice. [Date: Oct. 21, 2015]

Page 2 from line 7: The introduction describe what the authors want to describe in the manuscript, I'm not sure that the authors really satisfy this objectives. For this reason, I strongly suggest the authors to check the text and control that they describe all this topics.

We remove "The Langtang Valley is one of…in the future. [P02L05-L09]". In terms of describing our motivation, we already know that was a catastrophic avalanche event including debris and glacier ice which completely destroyed a mountain village (Kargel et al., 2015; Fujita et al., 2016; Lacroix, 2016). Here we would like to emphasize what was happened there (further information than just saying "avalanche") and what aspect can be identified using remote sensing techniques for such a catastrophic avalanche event. We will add here;

> *"Damage detection by remote-sensing SAR technique has been applied for urban damaged area (e.g. Kobayashi et al, 2011; Yonezawa and Takeuchi, 2001; Tamura and El-Gharbawi, 2015; Watanabe et al., 2016), but almost no case for huge-scaled mountain hazard was done. Then we apply the SAR technique of damage detection for the avalanche case. In addition, detail interpretation of the damaged area by means of high-resolution optical satellite imagery coupled with sediment volume estimation would suggest detail feature of this avalanche. In this study…"*

Page 2 chapter 2.1: the description of the study area is very short and poor. I suggest that the authors consider the possibility to improve both the geological and geomorphological aspect of the study area.

We will add geological and geomorphological information written by Shiraiwa and Watanabe (1991) and Shiraiwa (1994).

Page 4 chapter 3: this is the most important part of the paper, but it is also very hard to understand. Since it was not presented in the introduction a good description of what occurred in this area, now it is very critical for readers to understand what the authors have found. I suggest to rewrite this part of the article and to start the description from the evidence of the gravitational phenomena that caused the disaster and then to describe the effect in the lower part of the slope. One of the main limitation of this paper is that authors concentrate their description on the technical description of satellite images and results, but they did not pay too much attention to the description of the occurred events. I know that a correct reconstruction of the sequence of events is very hard, but I also think that if you want to present a methodology that use multiple remote sensing systems to describe the catastrophic collapse in Langtang Valley, at

the end is mandatory have a description of the collapse and the sequence of events reconstructed by authors.

> *What occurred in this area*

An avalanche including numerous boulders (debris) and possibly involving glacier ice occurred.

> *Rewrite this part of the article and to start the description from the evidence of the gravitational phenomena*

We think that already-known information, not our work, should be written in the introduction or involved in the discussion chapter. Therefore we will clarify more specifically what was happened (existing knowledge) in the introduction and discuss it with our findings in the discussion mentioning more essential aspects.

> *They did not pay too much attention to the description of the occurred events*

We understand that. We will improve that in the above-mentioned way.

Additional references (for AC1 and AC2):

Fujita, K., Inoue, H., Izumi, T., Yamaguchi, S., Sadakane, A., Sunako, S., Nishimura, K., Immerzeel, W. W., Shea, J. M., Kayashta, R. B., Sawagaki, T., Breashears, D. F., Yagi, H., and Sakai, A.: Anomalous winter snow amplified earthquake induced disaster of the 2015 Langtang avalanche in Nepal, Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-317, in review, 2016.

López-Martínez, C., & Pottier, E. (2007). Coherence estimation in synthetic aperture radar data based on speckle noise modeling. Applied optics, 46(4), 544-558.

Plank, S. (2014). Rapid damage assessment by means of multi-temporal SAR—A comprehensive review and outlook to Sentinel-1. Remote Sensing, 6(6), 4870-4906.

Touzi, R., Lopes, A., Bruniquel, J., & Vachon, P. W. (1999). Coherence estimation for SAR imagery. IEEE Transactions on Geoscience and Remote Sensing, 37(1), 135-149.

Shiraiwa, T., & Watanabe, T. (1991). Late Quaternary glacial fluctuations in the Langtang valley, Nepal Himalaya, reconstructed by relative dating methods. Arctic and Alpine Research, 404-416.

Shiraiwa, T. (1994). Glacial fluctuations and cryogenic environments in the Langtang Valley, Nepal Himalaya. Contributions from the Institute of Low Temperature Science. Series A, 38, 1-98.

Watanabe, M., Thapa, R. B., Ohsumi, T., Fujiwara, H., Yonezawa, C., Tomii, N., & Suzuki, S. (2016). Detection of damaged urban areas using interferometric SAR coherence change with PALSAR-2. Earth, Planets and Space, 68(1), 131.