Nat. Hazards Earth Syst. Sci. Discuss.,
doi:10.5194/nhess-2017-42-AC1, 2017

Natural Hazards and Earth System Sciences
Discussions
Open Access
EGU

Interactive comment on "Application of UAV-SfM photogrammetry and aerial LiDAR to a disastrous flood: multitemporal topographic measurement of a newly formed crevasse splay of the Kinu River, central Japan" *by* Atsuto Izumida et al.

Atsuto Izumida et al.

aizumida@s.nenv.k.u-tokyo.ac.jp

Received and published: 23 March 2017

Authors: Thank you for your interests about our paper and valuable comments to improve it. We would like to respond your comments in point-per-point manner. We are afraid that the page/line numbers the referee indicated are different from those of our discussion paper. We have inferred the corresponding texts from the referee's comments, but we're sorry if there were any mismatch.

GENERAL COMMENTS This study gives a nice insight in the topographic changes that occurred during a levee breach / crevasse splay and its aftermath. Taking the

Printer-friendly version

Discussion paper

analysis of this data set slightly further, notably through determining volume changes, would improve the paper significantly and give more insight in the events.

Authors: Thank you for commenting and suggesting for volume calculation. We are also sure that volume calculation will effectively describe this event and would like to do that. Volume calculations are intended to represent the volume of sediments that were transported from the river and that of materials that were eroded and removed from the research area. and will be based on the difference between the first two DSMs (Jan 2007 and Sep 2015). However, September 2015 DSM has inundated areas, which can lead to underestimate of the eroded volume, so the December 2015 DSM will be used to estimate the correct erosion depths.

SPECIFIC COMMENTS Title - You mention 'disastrous flood' and 'disaster' in the paper. It would be good to give some indication of the magnitude of this event in terms of return time, wounded / casualties and costs.

Authors: Thank you for suggesting additional information that is needed for our paper. The "disastrous" aspect of the flood and rainfall will be mentioned in the revised form (see our reply below).

2-2/3 Unclear what you mean here: 'land use' and 'human-built structures'. Do you want to indicate that breaches differ when there is agriculture/roads as opposed to natural floodplain vegetation? Or do you want to indicate that lobes of sediment accumulate behind human objects such as buildings? Or otherwise?

Authors: Thank you for commenting. We believe that the artificial modification of the floodplain causes both of what the referee suggested. Both are considered to be complexities added to crevasse splays by human works. In the revised manuscript, more explanation will be added.

2-23 I think you should make the nuance here that the topography before a flood may be available but not of sufficient detail to investigate the topographic change.

Authors: Thank you for suggestion. Actually, in many cases it is difficult to quantify the topographic changes in much detain even if the data before a event exists because of its low resolution. However, high-resolution LiDAR data that covers almost the nation is available in JapanâĂŤwhich makes researches like ours possible. The rarity of using a rich data will be mentioned in the revised manuscript.

3-27/28 Can you also indicate peak (and average) discharge and flood return time?

Authors: Kinugawa-Mitsukaido gauge station, which is at 10 km downstream of the breached point of the Kinu River marked a peak discharge of c.a. 4000 m3s-1, which is the maximum observed in history of 90 years, and a similar discharge (c.a. 3900 m3s-1) occurred only once at 1949 there (KRDB, 2015). Unfortunately, average discharge during the flood was unclear for the authors. Statistical analysis by Yoshimura et al. (2016) suggests that the return time of the cumulative rainfall for a single day, two days and three days over the drainage area of the Kinu River during the 2015 flood is 95, 138 and 237 years, respectively. These information will be added in the revised paper.

(referee) In general the text concerning the STUDY AREA and THE 2015 FLOOD OF THE KINU RIVER can be shortened and more to the point. On the other hand, relevant information on settlements, land-use and the flood impact (wounded/casualties and costs) should be mentioned here.

Authors: Thank you for suggestion. Actually, some information about the river and region is not directly related to the scope of the manuscript. It will be omitted in the revised version. Human suffering in Joso City, where most of damages by the levee breach of the Kinu River occurred, was 2 deaths and 44 injured (Joso City, 2016). The economic loss by the flood and rainfall have been provisionally estimated to be 155.5 billion yens in Ibaraki Prefecture and 289.6 billion yens for the entire disaster of September 2015 (MLIT, 2016). These information will be added to the revised manuscript. See the report of Nagumo et al. (2016) for more detailed damages by the 2015 flood of the Kinu River.

5-13 Indicate the locations / distribution of GCPs in a figure.

Authors: A new figure that shows locations of GCPs and comparing points for DSM subtraction will be added to the revised manuscript as they are distributed inside and outside of the Fig. 2.

5-12 What were the results for the automatic camera calibration, did it return the known values?

Authors: Thank you for commenting. We have not conducted a camera calibration manually for the GR used in this study before, so it might be nonsense to show the results of automatic camera calibration. However, we believe that the obtained DSM successfully show the trend of topographic changes at least in 10-1 order, as explained in the discussion paper.

5-24 If you mention this, give an indication for how many locations and how they are distributed. Did you also include houses on the top-right (figures 2a-c)?

Authors: All the three DSMs used in this study were georeferenced with accurate GNSS systems, so we believe that the two locations shown in Fig. 4 are sufficient to check the horizontal accuracy. The sentence "The same $\sim$ (5-14)" will be omitted in the revised version.

6-2/4 How are these points distributed, with respect to each other and the GCPs. Include these in a figure.

Authors: See the reply above.

6-9/19 You can calculate a limit of detection using these numbers and apply this in the figures.

Authors: Thank you for suggestion. We have set a limit of detection of elevation changes for each comparison pair as the twice of the standard deviation of the systematic error between the DSMs, namely, 9.0 cm for the first two periods and 4.0 cm for

the last two periods (newly calculated value; see the reply below). These values will be applied to the Fig. 5 to indicate the location where significant topographic changes occurred. Volumetric calculations will be conducted only where the topographic changes were larger than this limits.

6-13/14 Why didn't you use the lower of the two resolutions? Using the higher resolution can lead to local scale effects.

Authors: Thank you for comment. We tried to downsample the SfM-DSM to 1 m resolution which is equal to that of LiDAR data in September 2015, and as a result, we have decided to use the lower resolution for raster calculation in our revised manuscript. Although the figures look more elaborated with the original resolution, 1 m resolution is enough to represent the artificial and natural changes of crevasse splay to some extent, and trivial relief of the surface model derived from wheel tracks, plants, etc. have been significantly removed with that resolution. However, the higher resolution (1 m) have been used in the DoD for the first two periods (January 2007 and September 2015) because a significant effect has not been obtained with lower resolution. In the revised manuscript, relevant texts and figures will be modified.

(referee) For the applied systematic error correction you assume that the error is both linear and in the Z direction. Therefore it is important to: 1) show the distribution of the GCPs and control points (see earlier comments) and 2) show that there is no doming in the SfM DEM - this is a known problem see e.g. James and Robson (2014). James, M. R. and Robson, S. (2014), Mitigating systematic error in topographic models derived from UAV and ground-based image networks. Earth Surf. Process. Landforms, 39: 1413–1420. doi:10.1002/esp.3609

Authors: Thank you for comment. 1) See the reply above. 2) In this study, we have used the following technics to prevent the dooming effect. ïĄň Placed sufficient number of GCPs. ïĄň Not used an automated camera gimbal, thus controlled vertical photos were not taken. ïĄň The camera was flexibly held by a picavet (Inoue et al., 2014, Fig.

11), so off-nadir angles a little varied for each photo. ïĄň Off-nadir angle was between 10–15 degrees backward. These explanation will be added to the revised manuscript.

In addition, a GNSS survey point which was not used as a GCP for SfM processing confirmed there is no dooming in the DSM. The suggested reference will be cited in the revised version of the manuscript for short explanation of the dooming effect.

7-1 I think you should exclude inundated areas in the DEM of difference (either filter these areas out indicate them using a different color) - you could include them in a separate figure to indicate the water depth.

Authors: Thank you for suggestion and we agree with the referee. To indicate the topographic changes and inundation depths separately, a new figure will be added and inundated area (on 13 September 2015) in Fig. 5 will be masked by a different color. The inundated area have been determined mainly by interpretation of the aerial photographs used in this study (inundated water was muddy in the photograph in September 2015, resolution: 0.25 m). The orthophoto obtained by the UAV have been secondary used.

7-18 See earlier remark on limit of detection.

Authors: The limit was set to the twice of the standard deviation of the systematic error. The non-transparent cells in the Fig. 5 will be subjected to the description of the topographic changes and the volume calculation.

8-8/9 Please support these comments with volume calculations.

Authors: Thank you for commenting. When the discussion paper was written, we had considered the flood sediments in the canal to be non-negligible compared to the entire volume of sediments. However, the volume calculation have revealed that is not the case. In the revised manuscript, that text will be omitted, and instead, the entire mass transportation will be discussed.

8-21/23 Unclear what you mean with 'important environmental component of the flood-

plain' and the relation with human changes. Do you mean that without human impact there would have been more vegetation in the floodplain and the crevasse splay topography might have been different (but how)?

Authors: In floodplains of natural rivers, the type and distribution of vegetation can be affected by emergence of crevasse splays by providing new deposits and creating new topography. In the 2015 flood, however, new vegetation was lost through post-disaster restoration works, although that vegetation did exist around the sandy mound of crevasse splays in December 2015. They could potentially respond and record the nature of a crevasse splay and the adjacent floodplain if they were not removed by human. In the revised manuscript, relevant texts will be rewritten.

8-31 Is the wind velocity sufficient to pick up the (fine) sediment?

Authors: In Joso City, the maximum wind velocity in a day sometimes exceeds 10 m s-1 in winter, so it is possible to think the wind is responsible for the post-deposition deformation of the crevasse splay. However, the analysis of the wind process is not the scope of this study, and we believe that this topic should not be examined in detail. Thus, Table 3 and Figs. 6c and 6d will be omitted in the revised manuscript, and the possibility of the wind process will be shortly mentioned in the revised text.

9-7/9 What do you exactly mean with 'simpler topography'? Would it have been possible if the topography was more 'complex' at the later time?

Authors: Thank you for commenting. Within the research area, the land use was almost cultivated land before the flood, so the relief was so small that a resolution of 1 m was enough to represent the ground surface. In contrast, the topography had much relief due to local disturbance of the flood flow and transported deposits. However, we have decided to use a common resolution of 1 m for DSM calculations in the revised manuscript, so these mentions will make little sense. The entire paragraph will be omitted or rewritten.

9-21/22 Note that it may also be valuable to research historical events using archival photogrammetry, e.g. Bakker and Lane (2016). Bakker, M., and Lane, S. N. (2016), Archival photogrammetric analysis of river–floodplain systems using Structure from Motion (SfM) methods. Earth Surf. Process. Landforms, doi: 10.1002/esp.4085.

Authors: thank you for suggesting a valuable paper which have discussed the accuracy of SfM photogrammetry using historical aerial photographs with limited number and resolution. We would like to include it in our reference list as an example of recent studies about reconstructing floodplain topography with SfM photogrammetry. However, our dataset has much more number of photographs for SfM photogrammetry and accurate GCPs, and georeferenced LiDAR DSMs, so it might be difficult to directly compare the 2015 flood with historical events with archival photogrammetry. In the revised version, the possibility of reconstructing the historical events will be mentioned.

9-31/34 This is a very important point and I think you have a good data set to include these calculations!

Authors: Thank you for commenting. We think the sandy lobes deposited in the research area can be a good example because they are easy to detect and represent considerable portion of sediments brought to the research area by the flood. This calculation will be additionally conducted to make more specific insight into this event.

(referee) Most important remark concerning the RESULTS AND DISCUSSION is that a volumetric analysis would be very valuable (for the area as a whole and / or for certain regions), indicating the net amount of sediment that came from the river channel, the amount of erosion / sedimentation on the levee/floodplain, the amount of sediment that was redistributed / imported during post-flood works.

TECHNICAL CORRECTIONS

Authors: Thank you for the corrections. These comments will be reflected in the revised manuscript.

Title - You mention 'multitemporal', but in this case (3 measurements) 'repeated' is perhaps more appropriate.

Authors: 'multitemporal' have been replaced by 'repeated' in the title.

1-14 'by subtraction' can be removed.

Authors: 'by subtraction' have been removed.

1-16 'carried out by people' can be removed.

Authors: 'carried out by people' have been removed.

1-17 'with different resolutions and acquisition periods': I would say different spatial and temporal resolutions. (Acquisition period can be interpreted as the duration of acquisition, e.g. the flight time of the UAV).

Authors: The text have been rephrased: 'with different spatial and temporal resolutions'

1-18 'sudden' can be removed.

Authors: 'sudden' have been removed.

2-4 It is questionable if you should include a reference to this unpublished paper. Both here and further in the manuscript this reference is not required / of added value. I would advise not to include it.

Authors: That unpublished paper have been removed from the reference list.

2-4 'Thus' can be removed (there is no direct link with the previous sentence).

Authors: 'Thus' have been removed.

3-3 Refer to the figure here.

Authors: Figure 1 have been referred.

4-22 Brackets can be removed here and later on when mentioning points/m2.

Authors: They have been removed.

4-28 Include that this was converted to raster (similar to the pre-flood lidar data).

Authors: That have been included.

5-8/10 Only mention the usable photos.

Authors: The word ‘1433 photos’ have been removed.

6-17/27 This is a (specific) description of the study area - not results.

Authors: This part have been moved to the study area section.

7-1 This part of the method.

Authors: It have been moved to the method section.

Table 1: This table can be removed (little information and no additional information than in the text).

Authors: It have been removed.

Table 3: What is the (estimated) velocity required to transport sediment? Mean velocity is probably not a suitable measure, perhaps the 90th percentile(?).

Authors: This table have been removed because the wind process is not the point of our study (see the reply above).

Figure 1: Include ’Japan’ in the left top figure.

Authors: ‘Japan’ have been included.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-42, 2017.