

Interactive comment on “Probabilistic Flood Extent Estimates from Social Media Flood Observations” by Tom Brouwer et al.”

The authors would like to thank the anonymous referee for his or her review of our article. It is clear the referee has read the article thoroughly, which has led to useful feedback. We are convinced that the changes resulting from this feedback will greatly improve the quality of the article. Each of the comments of the anonymous referee, along with our reaction, and the changes to the article we propose, is discussed in the paragraphs below.

The changes discussed below are also included in a ‘track-changes’ version of the original manuscript. This document is included as a supplement and also contains changes made to the article in response to the feedback of the second reviewer as well as some additional minor improvements.

RC: page 2; line 10-23. The authors said that social media content gained much attention in flood mapping. For this reason it could be useful to add a sentence on the use of Facebook and Flickr (with references) in this context since only Twitter based studies are addressed.

AC: In two of the studies that are included in this paragraph, Flickr data was used. We found no studies that used data from Facebook. This is likely a result of Facebook’s restrictive policies, due to which only a very limited amount of data can be accessed through its API. On Facebook, a user of the API can only retrieve data about himself or his friends, whereas the APIs of Twitter and Flickr allow users to retrieve all public data from the platform. To clarify this, we propose to make the following changes to the article:

- Adding information about the data sources used in each of the studies mentioned (see ‘track-changes’ supplement)
- Appending the following to the paragraph: *“To our knowledge, no flood-related studies have used data from Facebook until now, which is likely due to Facebook being a more closed network. Flickr and Twitter allow for all public data to be found and extracted using their ‘Application Programming Interfaces’ (APIs; Interfaces to extract data from online platforms). The Facebook API however, is much more restrictive and cannot be used to retrieve large amounts of public data.”*

RC: page 2; line 10-11: please rephrase.

AC: “User generated content” is a general term, often used in studies related to data from social media. In the remainder of the article, we have used the more specific term “social media content”, since it was unclear to some readers who was meant by the “user” in “user generated content”. In order to make the article clear to both readers who are familiar with ‘user generated content’ as well as more novice readers, both terms are included. The first two sentences of the paragraph are used to link both. In order to make the first sentence clearer, we propose the following change:

- Replacing ~~“Applying user generated content, which is content generated by users of online platforms such as blogs, wikis and social media, has recently gained momentum in flood mapping”~~ by *“Data created by users of online platforms such as blogs, wikis and social media, often referred to as ‘user generated content’, offers an additional source of information about natural disasters.”*

RC: page 2; line 11: “focus” at the past participle can take either double or single s, with the single option being highly preferred. Please consider changing it throughout the text.

AC: All three mentions of ~~“focussed”~~ in the article, will be changed to “focused”.

RC: page 2; line 14: The authors could be more precise when citing that “these data can be used to assess the extent of the disasters”? Can you provide some citation? In addition it would be useful to differentiate extent of the area, extent of damage and extent of human losses.

AC: This sentence is meant to build up to subsequent lines in which references are provided. By extent, we specifically mean the geographic extent of a disaster. To clarify this, we propose the following change:

- Changing ~~“On a more detailed level these data can also be used to assess the extent of the disaster.”~~ to *“On a more detailed level these data have also been used to assess the geographic extent of a disaster.”*

RC: page 2, line 15: I would delete the word “merely” since it seems give a negative connotation to the sentence.

AC: We will delete the word ~~“merely”~~.

RC: page 2; line 25: relay or rely? Please revise it carefully

AC: We propose the following change to clarify that the flood maps created until now, did not include information about uncertainty:

- Changing ~~“...did not relay information about uncertainty...”~~ to *“...did not contain information about uncertainty...”*

RC: page 3; line 17: can you be more precise on the amount of rainfall?

AC: We propose to add information from the Met Office, about the amount of rainfall that fell over the two days prior to the flood, to the article. This involves the following change:

- Replace ~~“...caused by large amounts of rainfall over the month December, led to the flooding of a considerable area within the City of York in the North of England”~~ by *“...caused by large amounts of rainfall, led to the flooding of a considerable area within the City of York in the North of England. Up to 120 mm of rain fell in Yorkshire over a 48 hr period between the 25th and 27th of December (Met Office, 2016)”*

RC: page 3; line 17: over the month “of” December. Please consider adding the preposition “of”.

AC: This part of the sentence is removed in light of the previous comment.

RC: page 3; line 18-19: “The 2015 floods” mentioned by Scott (2016) were registered all over UK or within the study area? Please consider rearranging this part by adding more information of the flood event considered (27th of December), adding some information about the damages and the area involved.

AC: Around the 27th of December, flooding occurred at multiple places in the North of England. The specifics about damages, other than that 453 homes and 174 businesses were flooded (Pidd, 2016) , are yet to be published. One year after the floods, the report by the York City Council is still being written (Pidd, 2016). We propose to change the following:

- Replacing ~~“The 2015 floods were widespread and inundated almost 600 homes and businesses (Stott, 2016).”~~ by *“These large rainfall amounts resulted in the flooding of York and other places in the north of England. Within York, 453 residences as well as 174 businesses were flooded (Pidd, 2016). Detailed information about damages within York is yet to be published, since one year after the floods a report by the York City Council is still being written.”* This makes the reference to Stott (2016) obsolete.

RC: page 3; line 25: “North of these ridges..”, please rephrase this sentence

AC: To improve readability we propose to change the order of the words in this sentence:

- From ~~“North of these ridges the inner-city of York is located.”~~ to *“The inner-city of York is located to the north of these ridges.”*

RC: According to the methodology some issues need to be fixed, but first of all a general rearranging of the information in the sub-chapters needs to be done. Some details of the data are not concentrated together but are distributed on several chapters that make the reading a difficult process.

AC: To provide readers with an overview of all datasets used in the research, and the processing applied to the elevation data, we propose to add the following table to the article:

Data	Source	Purpose
2 m LIDAR DTM	EA (2014)	To group observations (Sect. 3.3) To calculate water levels (Sect 3.3) To estimate flood depth & extent (Sect 3.3) To pinpoint Tweets referring to streets (Sect 3.2)
Twitter	Twitter streaming API	To extract flood observations (Sect. 3.2)
Google Maps	Used online	To find locations with Tweets (Sect. 3.2)
Google StreetView	Used online	To find exact locations of photographs (Sect. 3.2)
OpenStreetMap	Exported from osm.org	To simulate locational errors along streets (Sect 3.4)
Recorded historic flood outlines	EA (2015)	To evaluate flood extent in areas affected by non-fluvial flooding (Sect 3.5)
Recorded 2015 fluvial flood outline York (draft)	EA (Personal communication)	To evaluate flood extent in areas affected by fluvial flooding (Sect. 3.5)

Along with this we propose to add a separate paragraph about the data to the beginning of section 3, and removing some of the then duplicate information in the subsequent paragraphs. (See changes in 'track-changes' supplement).

RC: In addition, it is not clear how many tweets have been considered and/or point of interest have been derived.

AC: Since this is a result of the methods that are discussed in section 3.1 (Twitter data extraction), the number of Tweets that were found are reported in the results chapter (chapter four). However, the exact numbers of Tweets with each type of locational reference (POI/Street) is not reported. Therefore, we propose to add the following at the beginning of the fourth chapter:

- Replace ~~“Although 56 of these Tweets had photographs attached, we could only match 26 of them to a location on Google StreetView.”~~ by “17 Tweets mentioned a point location (an address, intersection or POI) and 70 Tweets mentioned a street name, for which the elevation data was used to derive a point location. Although 56 Tweets from which locations were derived, had photographs attached, we could only match 26 of them to a location on Google StreetView.”

RC: Secondly, it misses to mention the vertical accuracy of the DTM

AC: We propose to include information about the vertical accuracy of the DTM, originating from a report by the EA, in the new section about the data at the beginning of chapter 3 (Also see comment two comments above, change included in 'track-changes' supplement).

RC: I think that the resampling method from 2 m to 20 m resolution should be stated before (please explain why).

AC: We propose to include this information in the new section about the data at the beginning of chapter three. (Also see comment three comments above, change included in 'track-changes' supplement).

RC: Moreover, when the observations have been grouped based on the LDDs have been based on the DEM or have been calculated by flow directions or by POI (point of interest) connected with flow directions?

AC: The grouping was indeed done by combining the locations derived from the Tweets with the LDDs. Now this is not clearly stated at the moment. Therefore, we propose the following change:

- Replacing ~~“This was done by calculating the LDDs in the area using the DTM. These LDDs were used to determine which cells are downstream of an observation.”~~ by “We grouped observations by combining information about the LDDs in the area, which were derived from the DTM, with the locations of observations. The LDDs were used to determine which cells are downstream of an observation.”

RC: In addition the authors need to justify the use of the IDW technique to determine the flood extent at this stage.

AC: We decided to use the IDW technique, instead of for example, the bilinear spline used by Fohringer et al. (2015), since we can apply smoothing using this technique. There is uncertainty in the water levels that are derived from Tweets, and by applying smoothing, the water levels of different observations that are in close vicinity, can be averaged. To clarify this, and put it in context with other studies, we propose to replace the last paragraph of section 3.2 by:

- *“Previous studies applied both IDW (Werner, 2001) and bilinear spline interpolation (Fohringer et al., 2015) to calculate flood extents from irregularly spaced flood observations. We used IDW interpolation since it allows for smoothing, which is useful in averaging the water levels of clusters of uncertain flood observations from social media content. In case of certain flood observations, which should be followed exactly by the interpolated water surface, bilinear spline interpolation may be more appropriate. An additional advantage of IDW interpolation is that the nominator and denominator of Eq. (1) can be updated with new observations, meaning the additional computational time in real-time applications is limited. We slightly modified the method proposed by Werner (2001) to improve the realism of the interpolated water surface. Firstly, water levels were expressed relative to the elevation of the nearest drain instead of mean sea level. Secondly, observations were interpolated along their downstream flow paths and subsequently projected to the grid cells upstream of these flow paths, to create a grid of water levels. From this grid we subtracted the HAND map, to create an initial grid of water depths in the area. Since the water surface might be extrapolated to areas which were separated from the observations by small barriers, flooded areas that were not connected to any of the observations were removed, similar to the method suggested by Werner (2001). This procedure produced the deterministic flood maps.”*

RC: In addition try to explain the HAND map with few sentences for non-expert users. Some minor changes are listed as follows.

AC: To clarify what the HAND map is, we propose to add the following sentence after “... inundation extents for fluvial floods.”:

- *“In contrast to a DTM, which contains elevation values relative to one single reference level, such as mean sea level, elevation values in a HAND map are relative to the nearest drainage channel. This drainage-normalized representation of the topography has a clear advantage for riverine flood extent mapping, as water depths over land can easily be related to water levels in the river.”*

RC: page 3; line 29: Which “useful information” have been extracted to create a deterministic flood extent estimate?

AC: Since none of the Tweets about the floods in York gave an estimate of water depth, we only derived information about which locations were flooded from the Tweets. To clarify this, we propose to change the following:

- Replace ~~“First we extracted useful information from flood-related Tweets.”~~ by “First we extracted locations where flooding was observed from flood-related Tweets”.

RC: page 4; line 4: It is correct “to perform a step”? Please consider revising this sentence

AC: We propose the following change:

- Replace ~~“We performed several step to create a database of Twitter based flood observations”~~ by “The process used to create a database of Twitter based flood observations consisted of several steps”

RC: page 5; line 20-21: Please rephrase the sentence

AC: To clarify this sentence, we propose the following change:

- Replace ~~“In order to only interpolate observations belonging to the same continuously flooded area, we grouped observations prior to interpolating the water levels”~~ by “We assumed that the water levels of flooded areas that are separated, are independent of each other. Therefore, we grouped observations to identify to which flooded area each observation belonged. The water levels of each group of observations were then interpolated separately”

RC: The chapter 3.4 “Evaluation of results” needs to be better contextualized and explained. The information inside this part seems to include limitation, problems, methodologies and expected results. I suggest rearranging this chapter.

AC: At the moment this paragraph contains both a discussion of the data, the methods and guidance on how to interpret the results. We propose to change the following:

- Move the information about the validation data to a separate ‘Data’ paragraph at the beginning of the chapter: “Recorded flood extents were used to validate the flood maps (Sect 3.5). A draft version of the fluvial flood extents of the City of York was supplied by the EA. These flood extents only identified areas that were directly affected by flooding from the rivers. However, areas separated from the river around Knavemire Road, Water Lane and Shipton Road were also known to be flooded based on news articles. The flood extents around these locations were approximated by using the EA dataset of recorded flood extents (EA, 2015) from between the years 1991 – 2012. These were merged with the recorded fluvial flood extent from 2016 into one validation dataset.”
- Remove the sentences about the interpretation of the reliability diagram, since this becomes clear in the results chapter (for the revised paragraph: see ‘track-changes’ supplement).

RC: In addition try to better explain the F(2) statistic expressed at page 7; line 20.

AC: A long textual explanation of the F(2) statistic will impact the readability of the article. Therefore we propose to remove the sentence that textually explains the F(2) statistic, and instead introduce the equation for the F(2) statistic, with a short explanation of the terms in this equation (for the revised paragraph: see ‘track-changes’ supplement).

RC: The discussion, should provide some interpretation of the results emerged without wasting entire sentences restating the results (ex, page 12; line 11-12 among others). Please, try to verify it and do not repeat same concepts.

AC: Some concepts are indeed repeated in the current discussion section, making the section unnecessarily lengthy and reducing the readability. To improve the readability of the discussion and remove the duplications from the discussion paragraph, we propose to rewrite the discussion chapter (see ‘track-changes’ supplement)

RC: In addition, you might relate your work to the findings of other studies by finding crucial information in someone else’s study that helps you interpret your own data, or perhaps you will be able to reinterpret others’ findings in light of yours. In either case you should discuss reasons for similarities and differences between yours and others’ findings.

AC: We found only very little studies regarding probabilistic flood inundation maps that used a validation method similar to ours. We propose the following change:

- Adding to the discussion section: “A comparison to the work of Giustarini et al. (2016), who produced probabilistic flood maps from synthetic aperture radar (SAR) data and used the same validation technique, indicates that results are similar. It illustrates that probabilistic flood maps from SAR data provide a degree of accuracy comparable to the ones in our study, with probability-error values up 0.38. Although their reliability diagrams differed among case studies, none of them had a consistent overestimation of flood probability in all bins of the reliability diagram, like the ones from social media content. This indicates that the method presented in this paper still has some limitations.”

RC: In addition, please rephrase page 12; lines 2-4

AC: In light of a previous comment (two comments above), the discussion was rewritten (see ‘track-changes’ supplement).

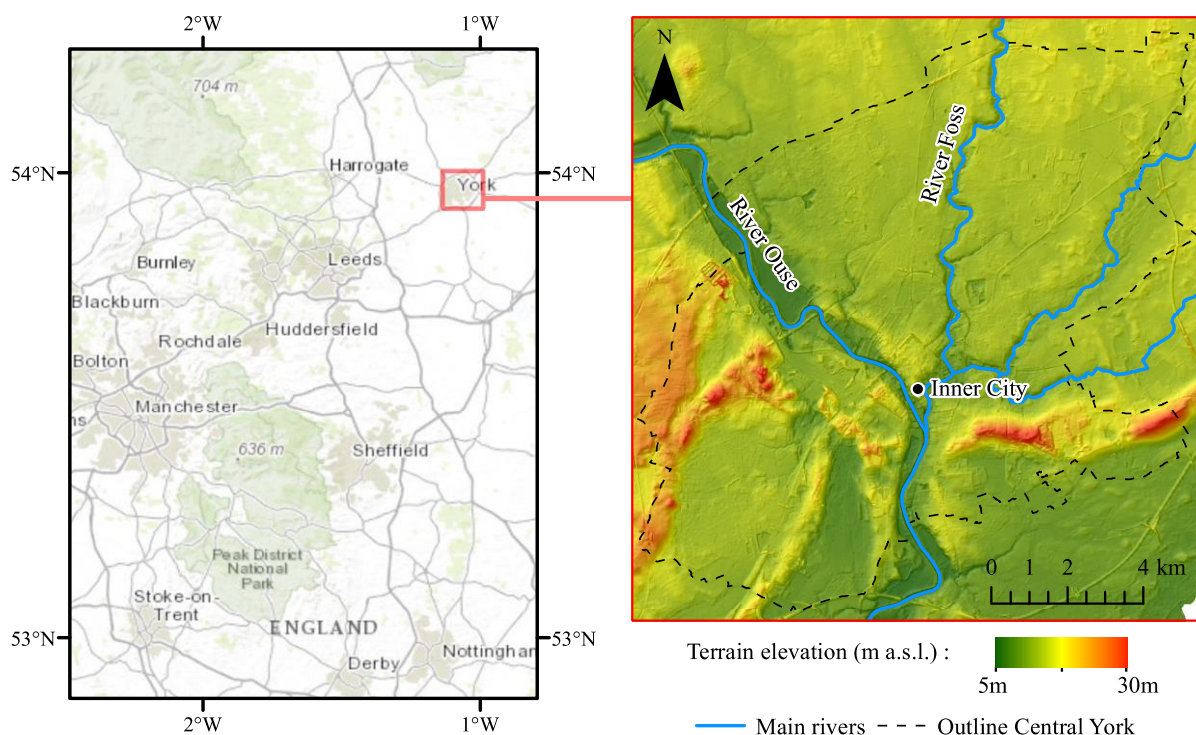
RC: Please, cite in the text the authors of the script just mentioned with a doi at page 13; line 15.

AC: We created the scripts we used for the analyses in this paper ourselves. To clarify this we propose the following change:

- Add a reference to the text (and in the list of references): replace “~~...code used for the different analyses is...~~” by “...code used for the different analyses (Brouwer, 2016) is...”

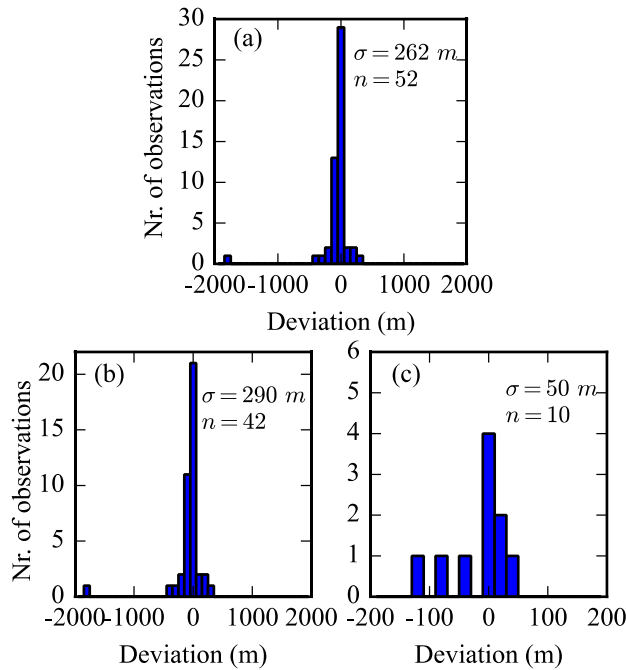
RC: Figure 1 needs more details of where the study area is located. A smaller map of UK where the study area is highlighted is highly suggested to help readers in locating the area. Terrain elevation needs “m (a. s. l.)”.

AC: This indeed makes the location of the study area more clear, for readers who are not familiar with the UK. We propose to replace Figure 1 with the following figure:



RC: Figure 5. Please add the unit of frequency

AC: Since this is not really a frequency (like s^{-1} for example), but a number of observations, we propose to replace Figure 5 with the following figure:



RC: Figure 6. What's the confusion matrix? Please add in the caption what represent the numbers in square brackets.

AC: It is indeed unclear what the confusion matrix is. The concept 'confusion matrix' is however not important for understanding figure 6, since the meaning of the colours in the map can be derived from the legend. Also, it is not completely clear that the numbers in brackets are used to indicate locations in the map. Therefore, we propose to change the following:

- Remove in section 4.2: "~~...data, by classifying all grid cells based on the four quadrants of a confusion matrix.~~"
- Changing the caption of Figure 6 to: "Comparison between the deterministic flood map (modelled) and validation data (observed). The locations denoted by the numbers [1] to [4] are referred to in text."

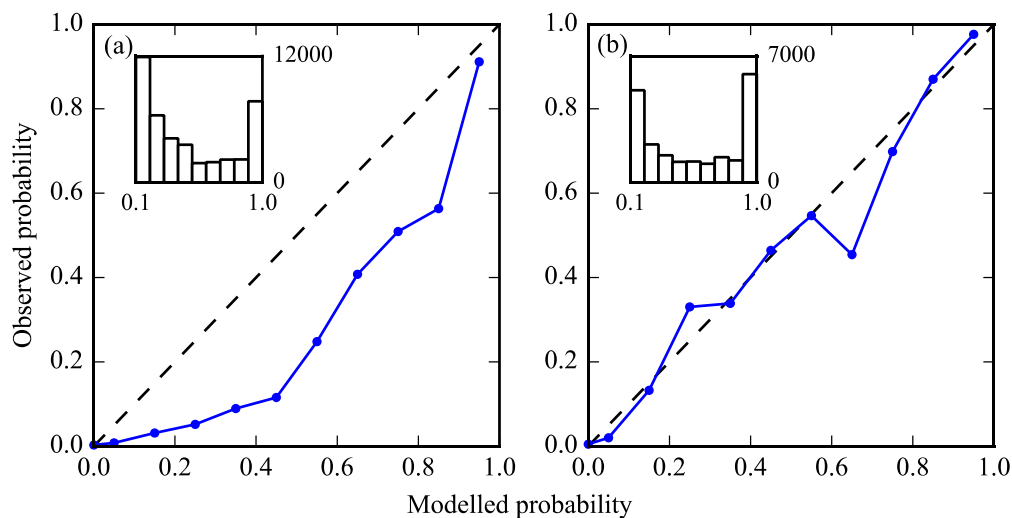
RC: Figure 7. Please add in the caption what represent the numbers in square brackets.

AS: We propose to append the following to the figure caption:

- "The locations denoted by the numbers [1] to [3] are referred to in text."

RC: Figure 8. I suggest enlarging this figure to be able to appreciate the details.

AS: Done. We propose to replace figure 8 with the following figure:



References

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