Memo

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Subject
Operationalization of Tier III Flood Mapping Using Social Media

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1 Introduction

Although both remote sensing techniques and hydraulic models can be used to generate flood maps at high resolution, the main limitation of these techniques is that they are often only able to give a highly detailed picture of flood extent sometime after a flood has occurred. Social media on the other hand are a real time source of data, meaning maps can be generated as soon as floods are reported. The availability of high resolution flood maps in real time can help governments and first responders in assessing the situation, setting up response plans, and helping the people that are most in need of assistance. This will lead to a more effective flood response, which helps in reducing the impacts of floods. We developed a multi-tier framework to map flood extent based on social media at different scales depending on the detail of the available observations. Where tier I and tier II flood maps give an indication of flood risk on catchment and flood plain scales respectively, tier III flood maps aims to produce flood extent maps at resolutions of 25m or higher. Such an approach is especially important in urban areas, which require more detailed estimates of flood extent. In this memo we summarize the work that has been done and discuss steps to bring this forward.

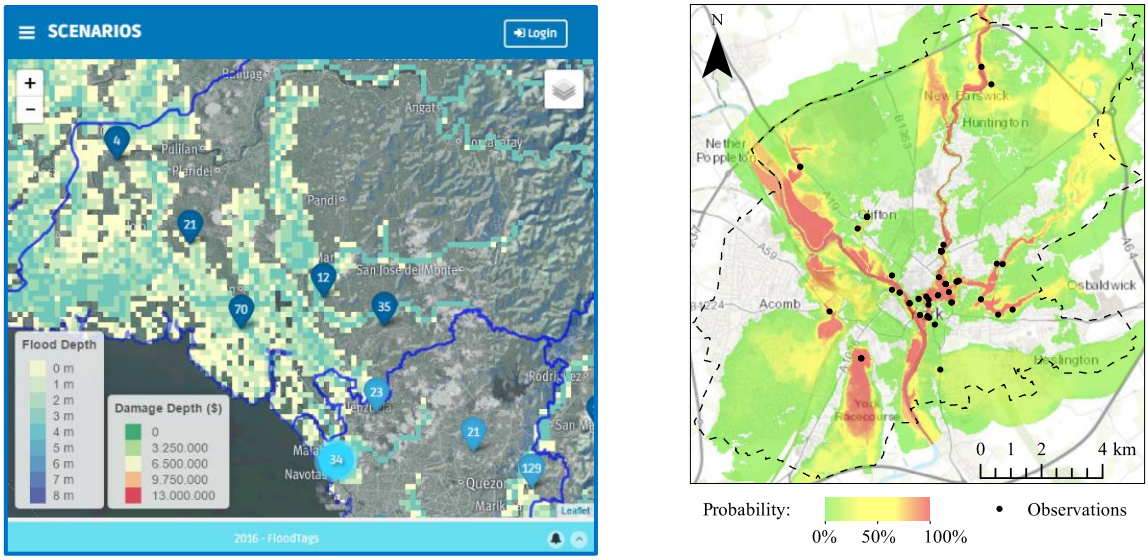

Figure 1.1 Left: Web service combining Twitter information and flood scenarios; right:example of a tier III flood map for the city of York (December 2015)

2 Previous work

In the TKI project, the use of social media data for Tier I flood mapping was explored. This involved geo-locating tweets by matching locations mentioned in the tweets, to a database of villages, cities and provinces. Also flood extent maps for a variety of flood scenarios were produced, and both the flood scenarios as well as the locations of tweets were disseminated through a web service (Figure 1.1; left). This provided users with an indication of flood extent, by choosing the flood scenario that matches best with the information derived from Tweets.

Research has also been conducted to investigate the possibility of creating more detailed flood maps from social media data. For example, Smith et al. (2015) explored the possibility of linking the information derived from Tweets, to the outcomes of hydraulic models. Brouwer et al. (2017) used the locations of Tweets directly to derive high-resolution urban flood maps of historic flood events (Figure 1.1; right). In addition they created probabilistic flood maps from Tweets based on uncertainty in elevation data, geo-location of tweets and model parameters. The study showed that the resulting flood maps are most sensitive to uncertainty in geo-location. The exact water depth at one location is less important for deriving flood extent maps.

3 Operationalization

Though Brouwer et al. (2017) showed that social media data can be used to generate high resolution flood maps, some further steps are required to apply this Tier III flood mapping approach in real time. The main limitations are the availability of accurate high resolution DTMs, volume of flood observations on twitter and accurate location information from Tweets:

- A high resolution DTM is required in order to derive detailed water level and water depth information. The required resolution is depended on the complexity of the terrain; the more complex the terrain the higher the resolution that is required. In order to maintain reasonable model performance a lower 2D resolution can be combined with critical 1D elements. However the availability of high resolution DTMs is limited. Some examples of <5m resolution datasets derived from LiDAR surveys are available in (parts of) the Netherlands (AHN)[1]; UK[2]; USA (NED)[3] and Australia[4]. Also Deltares is working on generating high resolution DTM maps globally by combining SRTM data with OpenStreetMap (OSM) data, possibly reducing the dependency on local elevation data sources. This, however, requires a good coverage of OSM data. The method is available online[5]. Finally, NASA is working on an improved global elevation dataset which might be more suitable for local applications called NASADEM[6].
- Deriving more accurate locations from Tweets (e.g. streets / addresses / points of interest) is crucial for creating high-resolution flood maps. This is preferably done using an automated method, that can keep up with the Twitter streaming API in real time. Currently, Jens de Bruijn at VU (IVM) is working on a method to derive high resolution

[1] http://www.ahn.nl/index.html
[2] https://data.gov.uk/publisher/environment-agency
[3] https://lta.cr.usgs.gov/NED
[4] http://dx.doi.org/10.4225/25/5652419862E23
[5] https://osm-terrain.appspot.com/
[6] https://earthdata.nasa.gov/community/community-data-system-programs/measures-projects/nasadem

locations from Tweets using OSM. Another, yet unexplored, method is to harvest locations from imagery (see e.g. Zamir & Shah, 2014).

- An automated method for geo-location can possibly be complemented by the (crowd sourced) manual geo-referencing of Tweets. This would require an interface where users can quickly browse through the most relevant tweets and be able to validate the observation and modify its location and water depth properties.
- An area has to be selected with a high adoption of Twitter, meaning a large volume of Tweets is available. Also, a study area is preferred with moderate to high terrain slopes, since this improves the accuracy of the flood maps.

In addition, the tier III method of Brouwer et al. (2017) can be further improved by:

- Improving the search method to find more relevant Tweets. Currently, Jens de Bruijn at VU (IVM) is working on a method to find more relevant Tweets for specific flood events using OSM.
- Incorporating normalized density of observations into the uncertainty estimates made using the data
- Post processing the probabilistic maps or improving the simulation of the errors, since the method discussed by Brouwer et al. (2017) resulted in an overestimation of flood probability. If this overestimation is found to be systematic, post-processing can be applied to the maps to scale the probability values. In case flood probabilities are not systematically overestimated, the methods used for simulating the sources of error should be further improved (See Brouwer et al., 2017)
- Incorporating important barriers in the study area into the high resolution DTM or as 1D elements
- More test cases in different terrains in order to have a better understanding of the variation in the IDW parameter settings
- Incorporating other sources of social media (other than Twitter), such as Instagram and Flickr which potentially have better coverage of detailed location information.

4 References

Brouwer, T., Eilander, D., van Loenen, A., Booij, M. J., Wijnberg, K. M., Verkade, J. S., & Wagemaker, J. (2017). Probabilistic flood extent estimates from social media flood observations. *Nat. Hazards Earth Syst. Sci., 17*, 735-747. doi:10.5194/nhess-17-735-2017

Smith, L., Liang, Q., James, P., & Lin, W. (2015). Assessing the utility of social media as a data source for flood risk management using a real-time modelling framework. *Journal of Flood Risk Management*. doi:10.1111/jfr3.12154

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