Innovative System for Collecting Flood-Related Observations

1. Objective

Worldwide, floods are the most frequent natural disasters and they cause over one third of overall economic losses due to natural hazards. Flood risk will further increase over the 21st century due to climate evolution and urbanization (Chen et al., 2015). Accurate modeling of *inundation flow* (inundation extents, water depths …) and of *damage* are necessary to guide flood risk management (Wright, 2014).

State-of-the-art *inundation models* benefit from widely available data obtained from remote-sensing technologies (e.g., as laser altimetry). However, the validation of these models remains incomplete because reference data from the field are scarce, uncertain and insufficient to reflect the whole complexity of inundation flow (Dottori et al., 2013). Even to a greater extent, additional data are needed to enhance the predictive capacity of *flood damage models*.

To address this lack of validation data, we aim at collecting two types of data:

1. direct field observations of inundation extents, water depths, flow velocity, as well as timing and duration of flooding;
2. surveyed data on the damage incurred following flood events.

This will result in a comprehensive database of field observations enabling improved calibration and validation of numerical models. It will also provide new insights into the processes governing floodplain inundation flow as well as flood damage pathways. Such data is of significant value for both scientists and policy-makers. Therefore, a representative of the water authorities in the Walloon region will be involved in the group of "clients" for the project.

> The overall objective of the project is to <u>further develop an innovative system for collecting field data related to inundation characteristics and flood damage</u>. A web-based crowd-sourcing approach was initiated last year. It has been developed up to a promising level; but substantial enhancements and new additional features are strongly needed.

These needs will shortly be discussed with the students. Meanwhile, a general description of the system is given in this document.

Type 1 data needs to be collected *during* a flood event, whereas Type 2 data is typically collected *after* a flood event (between 1 week and 6 months after the event).

We anticipate mainly two user groups, as described in Table 1:

- potential contributors, referred to hereafter as "User C",
- flood experts, referred to hereafter as "User E".

Table 1: User groups

	Contributors (User C)	Flood experts (User E)
Who?	Layman, citizens Student-workers hired for conducting field surveys (mainly for Type 1 data)	Researchers, flood risk modellers
Tasks	Contribute with observations into the system, such as observed water depth at a given location and time, delineation of the inundation extent, or estimates of damage incurred after a flood event	Retrieve collected data from the system to perform analysis outside the system

2. Functional requirements

We describe three use cases to present the expected functionalities of the system:

- User C contributes Type 1 data (Use case Ia),
- User C contributes Type 2 data (Use case Ib),
- User E retrieves data of Type 1 or 2 (Use case II).

These use cases differ in the associated time scales:

- Use case Ia corresponds to “on the fly” collection of data as a flood event is unfolding;
- Use case Ib corresponds to post-event collection of data from households which were affected by previous flood event(s);
- Use case II may correspond to long term analysis / research activities.

Note that Use case II may also be needed in interaction with Use case Ib to display online (a digest of) the collected contributions. In this case, data will not be retrieved by User E, but the system should retrieve and process these data automatically (through a processing / modeling component).

2.1. Use case Ia: User C contributes Type 1 data

During a flood event, a potential contributor (User C) is standing in the field, along the river / in floodplains. We are interested in the whole spectrum of flood events, from small-scale short-duration pluvial flooding (storm) up to large-scale river flooding.

When User C opens the system (e.g., an App or a web-based application), he/she has access to:

- a map (e.g., Google map, Open street map) as well as a limited number of geo-reference data layer (e.g., available from http://geoportail.wallonie.be/walonmap);
- all other contributions, or a **digest** of them (e.g., at the municipality of Paris-sector scale);
- flood warning information issued by water authorities and/or media (e.g., http://voies-hydrauliques.wallonie.be/opencms/opencms/fr/hydro/Actuelle/crue/index.html);
- (a **digest** of) information collected on social media (e.g., number of Tweets or Facebook posts geo-references in the area where User C is located and containing keywords such as “Inondation”) …

Also, User C will be able to make contributions in the following form:

- descriptive information (e.g., type of inundation, i.e. fluvial or pluvial),
- observed water depth, expressed either in metric format or in another system (ankle, knees …),
- estimates of flow velocity, expressed through ranges (e.g., below 1 m/s, in-between 1 and 2 m/s, above 2 m/s …) or in descriptive terms (quiescent, slow, fast …),

- pictures estimates of flow velocity, expressed through ranges (e.g., below 1 m/s, in-between 1 and 2 m/s, above 2 m/s …) or in descriptive terms (quiescent, slow, fast …),
- delineation of inundation extent, possibly supported by information from digital elevation model (DEM) …

Geo-referencing of all these contributions can be made either from the location of the user (location information from the device) or directly by the user (e.g., spotting on the map).

Additional information may also be collected on the profile of the contributor (layman / professional) and his/her willingness to contribute to Use case Ib (for people affected by flooding).

If digests of previous contributions and/or posts collected on social media are presented, this requires a processing / modeling component in the system.

In our view, a given User C may be registered or not in the system. In the former case, extended functionalities may be offered (access to all other contributions, history of his/her contributions …); but the latter case may be valuable also for harvesting data from people just ready to make a contribution on-the-spot without the burden of a registration.

2.2. Use case Ib: User C contributes Type 2 data

After a flood-event, the system will contact affected people (known from Use case Ia, or from a list provided separately). The system will submit a survey to User C, aiming at collecting data on the extent of damage induced by a particular flood event (e.g., monetary estimates) as well as all input data necessary for understanding the damage pathways and for damage modeling (characteristics of affected assets, such as type of house, precautionary measures, early-warning …, as well as inundation characteristics).

Flow data (e.g., maximum water depth over the whole flood event) are collected in Use case Ib for the sake of understanding damage pathways and validating flood damage models. In contrast, flow data (e.g., water depth observed at a specific location and time) are collected in Use case Ia for the sake of understanding flow processes and validating hydraulic models.

Typical data to be collected through the survey include:

- type of flood (river, pluvial …)
- location (address / geo-referencing …) and timing (start / end / time of peak) of flood
- observed water depths / flow velocity
- monetary estimate of damage (immobile vs. mobile …)
- number of affected people / casualties …

2.3. Use case II: User E retrieves data of Type 1 or 2

The system needs to provide data storage facility enabling easy access to researchers for retrieving data. It may also be needed to include a processing / modeling component in the system, so that the loop can be closed: a digest of contributions made in Use case I can be displayed online, hence enabling a win-win relationship with User C.

References

Chen, Y., Zhou, H., Zhang, H., Du, G. and Zhou, J. (2015). Urban flood risk warning under rapid urbanization. *Environmental Research*, 139, 3–10.

Dottori, F., Di Baldassarre, G. and Todini, E. (2013). Detailed data is welcome, but with a pinch of salt: Accuracy, precision, and uncertainty in flood inundation modelling. *Water Resources Research*, 49(9), 6079–6085.

Kreibich, H., Van Den Bergh, J. C. J. M., Bouwer, L. M., Bubeck, P., Ciavola, P., Green, C., Hallegatte, S., Logar, I., Meyer, V., Schwarze, R. and Thieken, A. H. (2014). Costing natural hazards. *Nature Climate Change*, 4(5), 303–306.

Wright, N. (2014). Advances in flood modelling helping to reduce flood risk. *Proceedings of the Institution of Civil Engineers: Civil Engineering*, 167(2), 52.