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Research papers

Crowdsourced data for flood hydrology: Feedback from recent citizen science projects in Argentina, France and New Zealand

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ABSTRACT

New communication and digital image technologies have enabled the public to produce large quantities of flood observations and share them through social media. In addition to flood incident reports, valuable hydraulic data such as the extent and depths of inundated areas and flow rate estimates can be computed using messages, photos and videos produced by citizens. Such crowdsourced data help improve the understanding and modelling of flood hazard. Since little feedback on similar initiatives is available, we introduce three recent citizen science projects which have been launched independently by research organisations to quantitatively document flood flows in catchments and urban areas of Argentina, France, and New Zealand. Key drivers for success appear to be: a clear and simple procedure, suitable tools for data collecting and processing, an efficient communication plan, the support of local stakeholders, and the public awareness of natural hazards.

1. Introduction

New communication and digital image technologies have enabled the public to produce and share large quantities of flood observations. Such observations are often authored, time-stamped, georeferenced and eventually shared through social media (Fohringer et al., 2015). Social media actually convey flood information of diverse nature including flood hazard and damage reports, but also rational discussion (understanding), public debate, appeal and remark to the government and local authorities, and emotional messages and expression of feelings (Al-Saggaf and Simmons, 2015).

As for other fields, initiatives for crowdsourcing flood data have emerged in the recent years, with a main focus on rapid, near real-time mapping of the reports of flood damages and emergencies, generally to support disaster management (Fohringer et al., 2015; Koswatte et al., 2015). Efficient tools for collecting, filtering, reviewing and analysing massive amounts of data in social media have to be developed. Typically, Fohringer et al. (2015) implemented the PostDistiller tool for the data mining of Twitter posts and applied it to map the inundation extent and depths of the June 2013 flood in Dresden, Germany. As done for other types of volunteered geographical information, interactive maps have also been developed for crowdsourcing flood data and reports, for instance:

- PetaJakarta,[1] an open source flood map of Jakarta, Indonesia, to share real-time flood information using social media (Twitter);
- The QLD Flood Crisis Map, an interactive map based on the open-source Ushahidi[2] platform and operated by Australian Broadcasting Corporation (ABC) to allow citizens report information during the 2011 Queensland floods (Koswatte et al., 2015);
- Flooding Points,[3] a collaborative flood map for São Paulo, Brazil, also based on the open-source Ushahidi platform and the concept and prototype elaborated by Hirata et al. (2015).

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[1] https://www.petajakarta.org/banjir/en/.
[2] https://www.ushahidi.com/.
[3] http://g1.globo.com/sao-paulo/mapa-do-alagamento/platb.

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0022-1694/

Another way to enhance flood data crowdsourcing is through dedicated mobile phone applications such as, for instance:

- Flood Patrol (Philippines), an Android mobile phone application developed for allowing people send flood reports to NOAH[4] (Nationwide Operational Assessment of Hazards) for mapping;
- SIGNALERT[5] (France), a smartphone application to report various situations of natural hazards including floods;
- mPING[6] (Meteorological Phenomena Identification Near the Ground, NOAA, USA), a free mobile phone application used to collect public weather reports, including flooding across the USA as contributions to the Flood Observations – Citizens As Scientists using Technology Project (FLOCAST[7]) launched in 2013.

Most of these projects and the related research focussed on volunteered geographic information, usually flood damages rather than quantitative hydraulic data. Despite of quality and credibility issues related to crowdsourced data, their filtering and mapping allows for unprecedented spatio-temporal analyses of the flood hazard and flood damages. Combining crowdsourced data and authoritative data, Schnebele et al. (2014) were able to assess the spatio-temporal dynamics of the damages to the transportation infrastructure in New York City flooded by Hurricane Sandy (29–30 October 2012). Using telephonic reports of flood incidents in Rotterdam from 2004 to 2011, Gaitan et al. (2015) analysed the spatial distribution of flood damages and their (lack of) relation with the subcatchments and flow paths derived from a DEM of the urban area.

Quantitative hydraulic data such as the extent and depths of inundated areas (Fohringer et al., 2015) or flow rate estimates (Fujita et al., 2013; Le Boursicaud et al., 2016) can be computed using messages, photos and videos from eyewitnesses and help improve the understanding and modelling of flood hazard. This way, ordinary citizens or some enthusiastic flood chasers can contribute to hydrological science in the same way the so-called storm chasers have historically contributed to meteorological science since the Tornado Intercept Project (1975) of the National Severe Storm Laboratory (USA).

Projects encouraging the public to act as citizen scientists in flood hydrology still appear to be scarce. The main well-established initiative of that kind is the CrowdHydrology[8] project (Lowry and Fienen, 2013), which encourage citizens to read and text the station number and the water level to the phone number listed on the gauge of gauging stations in the USA. The water level is then added to a publicly available database. To our best knowledge, besides the CrowdHydrology project there is no available feedback on such specific projects, and more generally there is a lack of feedback and guidance on the failure and success factors of data crowdsourcing and citizen science projects for flood hydrology.

We introduce three recent citizen science initiatives which have been launched independently by research organisations to document floods in some catchments and urban areas of Argentina, France and New Zealand. These projects were specifically designed to derive quantitative hydraulic data from digital photos and videos from the public for further retrospective analysis and modelling of the flood processes. While the three projects differ in their objectives, methods and hydrological situations, they provide convergent feedback on the potential and limitations of such initiatives for flood hydrology.

[4] http://noah.dost.gov.ph/.
[5] http://www.signalert.eu/.
[6] http://www.nssl.noaa.gov/projects/ping/.
[7] http://flash.ou.edu/flocast/.
[8] http://crowdhydrology.geology.buffalo.edu/.

2. The three projects

2.1. Flood Chasers (Argentina)

2.1.1. Objectives

The mountainous rivers of the Córdoba province, Argentina, are characterised by the occurrence of flash floods with very high volumes of fast flows during the rainy season (October to April). Due to the sudden nature of flash floods, it is very unlikely to be able to survey several river sections of interest using instruments and techniques suitable for recording the peak flow and its temporal evolution during the flood. Even when it is possible to visit the study sites in time, flow velocities and floating river debris endanger both the instruments and operators. Considering this issue, the researchers of the National University of Córdoba have developed and implemented the Flood Chasers Project ("Cazadores de crecidas" in Spanish, Patalano et al., 2015) to populate a database of videos and photos of flash floods in rivers of the province of Córdoba recorded and shared by citizens using advanced digital technology (cell phones, digital cameras, tablets, etc.) on the basis of the willingness of people filming these extreme hydrological events to share their footage in social networks, websites, forums, etc.

Flood videos recorded by citizens are then processed to estimate river flow velocity and discharge using image velocimetry techniques such as Large Scale Particle Image Velocimetry (LSPIV, Patalano et al., 2014). The implementation of LSPIV using non-professional videos appears as a valuable alternative or supplemental technique to traditional post-flood discharge estimation methods such as the slope-area method, and proves great potential in the Córdoba province, Argentina (Patalano et al., 2015). During the last rainy season (2014–2015), extreme hydrological events occurred in the Córdoba province and in some cases the data obtained with such technique are the only available information to characterise the observed hydrological events.

2.1.2. Implementation

The first step of the Flood Chasers Project was to create a website with domain of the University, then perform an intensive dissemination of the existence of this webpage in major newspapers and some television channels. On the Project website (Fig. 1) people can upload their flood videos along with metadata (recording date and time, location of the river section, etc.). In case the recording conditions are favourable, the videos are manually screened, analysed and processed using the Large Scale Particle Image Velocimetry technique (LSPIV, Fujita et al., 1998). This technique allows quantifying the surface velocity field of the rivers remotely. The website provides guidelines for users without prior knowledge of hydraulics about the best way to make contributions that are useful for quantifying flood discharges. Users who are interested in participating in the Flood Chasers Project can send or upload their videos using different platforms (i.e. Dropbox, Mega and WeTransfer) following basic tutorials generated by the scientists. There is also a webpage listing all the recorded floods and including the flow results if the video has been suitable for analysis. In turn, there is a YouTube channel called "Cazadores de Crecidas" in which the Project leaders upload their own collection of videos, which are also published on the website.

The images are analysed following the methodology described by Patalano and García (2016) that uses state-of-the-art tools (i.e. that apply classical PIV/PTV analysis) and brings them to Large Scale surface flow characterisation, using the first operational version of the RIVeR (Rectification of Image Velocity Results) software. RIVeR has been developed in the Center for Water Research and Technology (CETA) at the National University of Córdoba, Argen-