PhD proposal at Institute for Geosciences and Environmental Research (IGE) Grenoble

Title : Toward integrated forecasting of flash flood human impacts

PhD abstract

Recently, significant advances have been proposed in the field of modelling population exposure related to its daily mobility (Terti et al., 2015, 2017; Shabou et al., 2017). In a previous project, a Road Inundation Warning System (RIWS) was developed to estimate the risks of fast submersion of the road network during flash-floods (Naulin et al., 2013). This approach was based on a preliminary analysis of the road network sensitivity to flooding, based on a morphological analysis of its intersections with rivers. Based on the RIWS outputs, two consecutive ANR projects, allowed to develop a complementary modelling approach (MobRISK) to assess the exposure and vulnerability of road users to the submersions of the road network (Debionne et al., 2016; Shabou, 2016; Shabou et al., 2017). This model connects road-user characteristics with activity-based mobility patterns to evaluate in space and time the number and characteristics of the people that are most exposed to road flooding. An additional decision-making module incorporates behavioural rules to simulate the adaptation of traveler's behaviour according to the evolution of the environmental context (hydro-meteorological circumstances, reception of warning message, visibility issues, etc). Both models were applied and tested on the Gard territory, which offers an interesting framework for models calibration and validation. The objective of this PhD is to further improve these approaches by i) identifying potential end-users needs to ensure the usefulness of the tool and its outputs, ii) incorporating the outputs of the improved forecasting chain of rainfall-runoff predictions (WP2 of the PICS project), iii) consolidating and refining the mobility and decision-making processes modeled in MobRISK based on a complementarity of survey tools and crowd sourcing data, iv) co-construct, validate and evaluate the model outputs and its usefulness for emergency management together with a dedicated user group.

Context and Motivation

The comprehension and prediction of societal impacts due to sudden onset and localized hazards like flash flooding remain big a challenge for forecasters, emergency managers and policyholders. Modern advances in hydrological forecasting-warning systems alone do not guarantee reduction of losses during short-fuse flash flood events. Additional factors, related to social and behavioral vulnerability processes, are to be integrated in operational forecasting efforts in France and worldwide to better capture and prevent human risk during flash floods. In the Institute for Geosciences and Environmental Research (IGE) we have been developing a genuine interdisciplinary approach that combines knowledge and data from hydrology and human geography to integrate physical and social dynamics. This work builds upon i) qualitative analysis leading to a conceptual framework defining dynamic vulnerability and flash flood risk factors for individuals and societies (Terti et al., 2015), ii) analysis of human losses learning from past events in France and U.S.A. (Ruin et al, 2007, 2008, 2009, 2014; Terti et al., 2016), and iii) machine-learning predictions at the U.S. scale (Terti et al., 2017) and the MobRISK microsimulations in southern France (Debionne, 2016; Shabou et al., 2017), assessing the risk of vehicle-related incidents and road-users' exposure at coarser and higher spatial resolutions, respectively. The proposed PhD will benefit from these developments to propose a decision-making support tool allowing forecasters and emergency managers to better take into account the expected human impacts related to short-fuse weather events as flash-floods. The PhD proposal is embedded in the PICS project funded by the French National Research Agency, including 7 academic and operational partners together with actors of the French weather warning system, involved in the co-construction of an improved emergency decision-support tool.

Scientific objectives

Within the ANR PreDiFlood project, a Road Inundation Warning System (RIWS) was developed to estimate the risks of fast submersion of the road network during flash-floods based on the morphological road network sensitivity to flooding (Naulin et al., 2013). Based on the RIWS outputs, two complementary ANR projects, developed a human-natural modelling approach called MobRISK to assess the exposure and vulnerability of road users to the submersions of road-river intersections (Debionne et al., 2016; Shabou, 2016; Shabou et al., 2017). This model connects road-user characteristics with activity-based mobility patterns to evaluate in space and time the number and characteristics of the people that are most exposed to road flooding. An additional decision-making module incorporates behavioral rules to simulate the adaptation of traveler's behavior according to the evolution of the environmental context (hydro-meteorological circumstances, reception of warning message, visibility issues, etc). These models were applied and tested on the Gard territory, as impact and behavioral data collected for nearly 20 years offer an interesting calibration framework.

The objective of the proposed PhD is to integrate dynamic flood inundation map and water level elevation model outputs issued from the rainfall-runoff integrated chain developed in the PICS project to propose, through the improvement of the MobRISK model, a global evaluation of the population dynamic exposure and coping capability. For now exposure and risk assessments are only taking into account the static component of the population exposure, focusing on the location of buildings and critical infrastructures. This work proposes to integrate the circadian and/or seasonal fluctuations of the population distribution and the context-dependant nature of human vulnerability and coping capacity to weather hazards that are not yet integrated in warning systems.

Methodology and planning

After conducting a literature review related to social impact forecasting and companion modeling methods, a first step will be to identify key actors interested in using the model and to elicit knowledge gaps and operational needs through the constitution of a user group and the set-up of co-construction techniques. This phase will last from month 1 to 8.

A second step will be to inventory scientific, lay or expert knowledge, available through survey data, diagnostic studies and analysis of the existing literature to propose improvements in the parameterization of the social processes related to daily mobility and behavioral emergency response. At this stage, the use of crowd sourcing social media data will be investigated in order to evaluate how such data could be used for hypotheses testing and/or model validation. This phase will last from month 6 to 12 and should lead to the publication of a first literature review paper.

A third step will be to implement the proposed improvements with the support of a software engineer. In addition, the hazard exposure component of the model will be refined in order to integrate the dynamic flood inundation map and water level elevation model outputs developed in the Work Package 2 of the PICS project. This step will be followed by calibrating, verifying and validating the model with the user group on well document past events. This phase will last from month 12 to 24 and should lead to the publication of a second paper.

Finally, scenarios, for instance on the implementation of emergency measures or awareness campaigns, will also be build together with local stakeholders of the study area, to implement new simulations and discuss the effect of such measures on the overall exposure and risk for people. The user group and local stakeholders will also be invited to evaluate the usefulness of the model outputs through the use of serious game techniques, based on the ANYCaRE table-top game that the IGE have been developing in the context of the EU H2020 ANYWHERE project (Terti et al, 2018). This last phase will last from month 24 to 32 and should lead to the publication of a third paper. The last 4 months will be dedicated to the writing and defense of the PhD thesis.

Keywords
- human impacts prediction,
- dynamic exposure,
- flood risk,
- coupled natural-human system modeling
- warning system

Candidate desired profile
- An Engineering or Master degree in Environmental sciences, quantitative geography, geoinformatics, or geostatistics is preferred.
- Pluridisciplinary curriculum and interest in both social and physical sciences would be welcome.
- Knowledge and experience in using R, GIS softwares and SQL is required.
- Excellent command of written and spoken English. Working knowledge of French would be highly appreciated. It is expected that the candidate would master the French language by its 2nd year of PhD.
- Ability to work in an interdisciplinary team

Eligibility criteria (related to the "Make our Planet Great Again" doctoral funding)
- French citizens are not eligible
- Candidate should not have resided in France since the 1st of April 2016 or should have spent less than 90 days in France since that date.

International Context

This PhD is part of the HYMEX international research program (https://www.hymex.org) and will provide a major contribution to two science teams respectively called « flash-floods and social vulnerabilities », and « Toward integrated prediction of heavy precipitation, flash flood and impacts ». The proposed work also aims at advancing the new area of research called « socio-hydrology », an interdisciplinary field interested in i) the dynamic cross-scale interactions and feedbacks between hydrological and human processes, ii) comparative analysis of the co-evolution and self-organization of human and water systems in different cultures, iii) process-based modelling of coupled human-water systems (Sivapalan et al., 2012).

Partnership

This research is part of the PICS project that aims at building and evaluating an integrated forecasting chains of impacts associated with flash floods, by associating the various scientific actors involved (meteorologists, hydrologists, hydraulic engineers, economists, geographers), alongside the operational actors (crisis supervisors, insurers, infrastructure managers, citizens). 8 academic institutions and operational actors are involved: Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR), Caisse Centrale de Réassurance (CCR), Centre d'Expertise pour les Risques, l'Environnement, la Mobilité et l'Aménagement (CEREMA), Institut national de Recherche en Sciences et Technologie pour l'Environnement et l'Agriculture (IRSTEA), Géosciences Rennes (UMR 6118), Météo France, Institut des Géosciences de l'Environnement (IGE- UMR 5001), Service Central d'Hydrométéorologie et d'Appui à la prevision des inondations (SCHAPI).

Application

Please send a CV + motivation letter **before April 22, 2018** to Isabelle Ruin, IGE – isabelle.ruin@univ-grenoble-alpes.fr