Forecasting of flash flood human impacts integrating the social vulnerability dynamics

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Résultats majeurs et illustrations

- **Development of a conceptual framework** that captures the dynamic interplay between the flash flood hazards and social vulnerability factors at relevant spatio-temporal scales [Terti et al., 2015].
- **Statistical and geospatial analysis** of historic fatality situations as determined by the victim's profile and fatality circumstance, and the spatio-temporal context of the causative flash flood event [Terti et al., 2016].
- **Machine-learning modeling and dynamic mapping** of human risk predictions, based on the circumstance of the anticipated incidents (here vehicle-related), and the time-variant exposure to a given flash flood forecast [Terti et al., 2017].
- **4 Journal publications** (*Natural Hazards Journal*, *BAMS*, *Risk Analysis Journal*)
- **8 Conference presentations** (*EGU 2015, ISEC 2015, HyMeX 2015, NWA 2015, AGU 2015, INQUIMUS 2016, HyMeX 2017, AMS 2018*)
- **Distinction : International Award -** Second Place Best Graduate Student Poster Presentation, NWA Meeting, 2015 (Award of 75.00$).

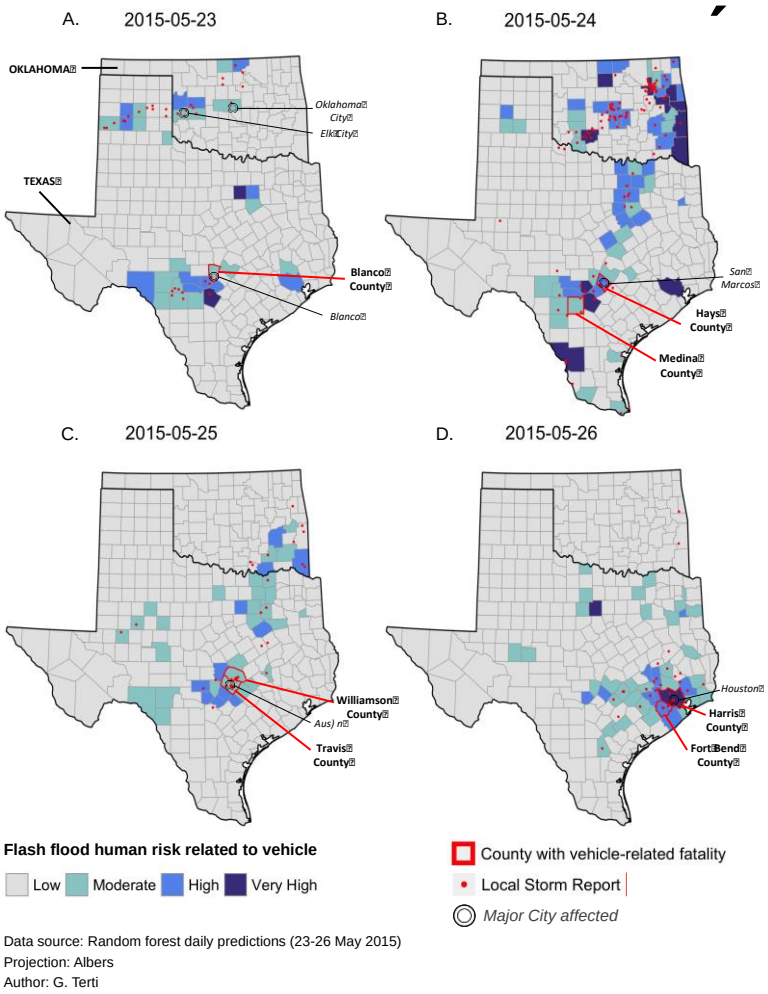

Fig. 1. County-level daily prediction of vehicle-related human risk for each day (from A to D) from May 23, 2015 to May 26, 2015 for Texas and Oklahoma States: the likelihood of flash flood vehicle-related casualty for individuals is predicted by the random forest model for each county and day (i.e., 1%-100%), and is assigned to four categories from low to very high. Counties with daily unit peak discharge < 2 ($m^3\ s^{-1}\ km^{-2}$) are also assigned to the low likelihood category. Counties with fatal flash flood events that according to the Storm Data led to one or more vehicle-related fatalities are highlighted with red line.

Résumé de la thèse

The comprehension and prediction of societal impacts due to sudden onset and localized hazards like flash flooding remain big challenges for forecasters, emergency managers and policyholders. This dissertation conducts a theoretical analysis as well as an analysis of flash flood-specific historic fatalities to explain complex and dynamic interactions between hydrometeorological, spatial and social processes responsible for the occurrence of human life-threatening situations during the “event” phase of flash floods in the United States (U.S.). The ultimate goal is to link human vulnerability conceptualizations with realistic forecasts of prominent human losses from flash flood hazards. Machine learning classification is adopted to assess the likelihood of fatality occurrence for a given circumstance as a function of representative indicators at the county-level. Starting from the most prevalent circumstance of fatalities flash flood events with lethal vehicle-related accidents are the subject to predict. The findings confirm the importance of situational examination of dynamic vulnerability over generic and static conceptualizations, and guide the development of flash flood-specific modeling of vehicle-related human risk in this thesis. Based on the case study of May 2015 flash floods in the U.S., the model shows promising results in terms of identifying high vulnerabilities in space and time. Though, critical thresholds for the prediction of vehicle-related incidents need to be further investigated integrating local sensitivities, not yet captured by the model. The developed model can be applied on a daily or hourly basis for every U.S. County. We vision this approach as a first effort to provide a prediction system to support emergency preparedness and response to flash flood disasters over the conterminous U.S.

Collaborations

Research Fellow in the **National Weather Center (U.S.)**. Grant from NOAA to the Cooperative Institute for Mesoscale Meteorological Studies at the University of Oklahoma. Collaborations in the frame of FLASH (Flooded Locations and Simulated Hydrographs) Project in the U.S. (https://blog.nssl.noaa.gov/flash/), HyMeX (HYdrological cycle in the Mediterranean EXperiment) Project in Europe (https://www.hymex.org).

Publications à comité de lecture

Terti, G., I. Ruin, S. Anquetin, J. J. Gourley, J. Blanchet, P.-E. Kirstetter, and Z. Flamig, 2017. Towards Probabilistic Prediction of Flash Flood Human Impacts, ***Risk Analysis****,* doi: 10.1111/risa.12921.

Terti, G., I. Ruin, S. Anquetin, and J. J. Gourley, 2016. A Situation-based Analysis of Flash Flood Fatalities in the United States. ***Bull. Amer. Meteor. Soc.***, **98(2),** 333-345.

Gourley, J., Z. Flamig, H. Vergara, P.-E. Kirstetter, R. Clark III, E. Argyle, A. Arthur, S. Martinaitis, G. **Terti**, J. Erlingis, Y. Hong, and K. Howard, 2016. The Flooded Locations And Simulated Hydrographs (FLASH) project: improving the tools for flash flood monitoring and prediction across the United States. ***Bull. Amer. Meteor. Soc.***, **98(2),** 361-372.

Terti, G., I. Ruin, S. Anquetin, and J. J. Gourley, 2015. Dynamic vulnerability factors for impact-based flash flood prediction. ***Nat. Hazards***, **79(3)**, 1481-1497. DOI 10.1007/s11069-015-1910-8.

Autres publications et présentations

Terti, G., I. Ruin, S. Anquetin, J. J. Gourley, J. Blanchet, P.-E. Kirstetter, and Z. Flamig. Impact based predictions of human risk to flash flood across the United States. 98th Annual Meeting of American Meteorology Society (***AMS, 2018***), 7-11 January 2018, Austin, TX, U.S.A (**oral presentation**).

Terti, G., I. Ruin, S. Anquetin, J. J. Gourley, J. Blanchet, P.-E. Kirstetter, and Z. Flamig. Building a prototype model for probabilistic prediction of flash flood human impacts. *10th HyMeX Workshop (**HyMeX 2017**)*, 2-8 July 2017, Barcelona, Spain (**oral presentation**).

Terti, G., Ruin, I., Anquetin, S., Gourley, J.J. Towards dynamic assessment of social vulnerability to flash flooding: A statistical classification approach for predicting casualties. (***INQUIMUS 2016***), 21-23 September 2016, Salzburg, Austria (**poster presentation**).

Terti, G., Ruin, I., Anquetin, S., Gourley, J.J. Vulnerability Situations Associated with Flash Flood Casualties in the United States. *American Geophysical Union Fall Meeting (**AGU 2015**)*, 12-18 December 2015, San Fransisco, CA, U.S.A (**poster presentation**).

Terti, G., Ruin, I., Anquetin, S., Gourley, J.J. Target the warnings: Probabilistic flash flood casualties prediction. *National Weather Association's 40th Annual Meeting (**NWA 2015**)*, 17-22 October 2015, Oklahoma City, OK, U.S.A (**poster presentation**).

Terti, G., Ruin, I., Anquetin, S., Gourley, J.J. Identifying the most relevant predictors of Flash Flood Human Impacts: An analysis of the U.S. Storm Database. *9th HyMeX Workshop (**HyMeX 2015**)*, 21-25 September 2015, Mykonos Island, Greece (**oral presentation**).

Terti, G., Ruin, I., Anquetin, S., Gourley, J.J. Multi-variate analysis for flash flood casualties prediction. *4th International Symposium on Earth-Science Challenges (**ISEC 2015**)*, 20-23 September 2015, Norman, OK, U.S.A (**poster presentation**).

Terti, G., Ruin, I., Anquetin, S., Gourley, J.J. Toward a coupled Hazard-Vulnerability Tool for Flash Flood Impacts Prediction. *European Geosciences Union General Assembly (**EGU 2015**)*, 12-17 April 2015, Vienna, Austria (**poster presentation**).

Valorisation

This thesis was partly conducted at the University of Oklahoma, and was partly funded by the FLASH project, with the aim to conduct basis research for a nationwide prediction effort for forecasters and emergency managers to target their warnings on anticipated human impacts during flash flood events in the U.S.. The study adopted a genuine interdisciplinary approach that combined knowledge and data from hydrology and human geography to integrate the physical and social dynamics leading to forecasts and understanding of circumstance-specific human losses from flash flooding. Insurance industry may also benefit from the conceptual and methodological developments proposed in this research to build innovative insurance strategies towards more resilient communities.