How do people behave during flash floods and why? Lessons for the prediction of the human vulnerability dynamics in short-fuse weather events

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Abstract

Social scientists have a long history of documenting disasters and natural extreme events' behavioural response through the collection of perishable post-event data (Gruntfest 1977; Quarantelli and Dynes, 1977; Stalling, 1987; Quarantelli, 1997, 2003; Drabeck, 1999). Such empirical and theoretical foundations constitute a strong background to understand crisis responses and advance our knowledge of the drivers of human behavioural responses to fast evolving weather-related events. Outputs from this field of research show that public warning and behavioural response is a social process that takes several phases before a protective action is put in place (Mileti, 1995; Trainor et al., 2008, Parker et al., 2009, Lindell et al., 2004). These authors identified factors related to the characteristics of the hazard, the warning information characteristics, the situational and personal characteristics of the receiver and the socio-cultural context as strong determinants of the public behavioural response. In fast-moving events like flash-floods, the amount of time available to detect the threat and respond to it is so limited that protective actions often consist in dealing with contingent situations triggered by the irruption of dangerous circumstances in the middle of daily life activities and routines (Ruin et al., 2008, 2009; Terti et al., 2015). Understanding how people actually detect potentially dangerous circumstances and manage to timely adapt their routine to cope with the speed of the hazard evolution remains a challenge. Based on insights from post-event interviews, online surveys were used to quantitatively document behavioural responses associated with 3 catastrophic flash flood events that happened in southern France in 2014 and 2015. The coupled analysis of responses to these surveys with hydrometeorological parameters allows to better understand the link between the event magnitude and self-protective behaviours in the context of short-fuse weather events as flash floods. Knowledge gained from such an integrated approach is necessary for drawing lessons for the development of coupled human-natural system modeling and the prediction of the human vulnerability dynamics in short-fuse weather events.

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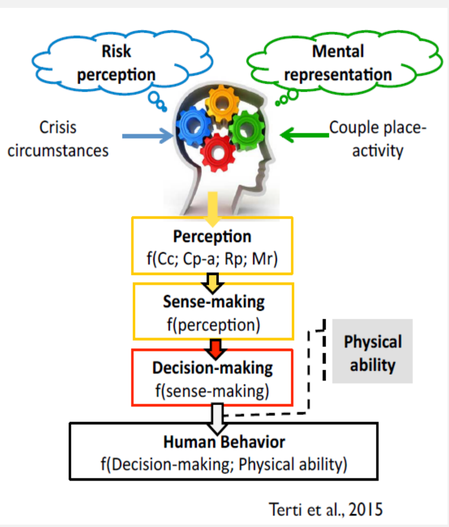
Introduction



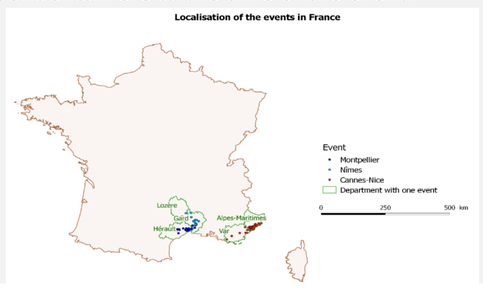
- The characteristics of the hazard, the warning information characteristics, the situational and personal characteristics of the receiver and the socio-cultural context are strong determinants of the public behavioural response.
- In fast-moving events like flash-floods, the amount of time available to detect the threat and respond to it is so limited that protective actions often consist in dealing with contingent situations triggered by the irruption of dangerous circumstances in the middle of daily life activities and routines (Ruin et al., 2008, 2009; Terti et al., 2015).

- Understanding how people actually detect potentially dangerous circumstances and manage to timely adapt their routine to cope with the speed of the hazard evolution remains a challenge.
- Based on insights from post event interviews, online surveys were used to quantitatively document behavioural responses associated with 3 catastrophic flash flood events that happened in southern France in 2014 and 2015.
- A multivariate statistical analysis among different variables that define the social structure, and different subcategories that characterize people's behavior was carried out in order to investigate the linkage between these two concepts.

Methodology

1. Data Collection

Victims of two flash floods in 2014 and 2015 were selected in this study: one near Montpellier (Hérault department) on 30th September 2014 and another one near Nîmes (Gard department) on 10th October 2015. Online questionnaire surveys were used to collect the data about flash floods and social behaviors. 250 people answered the online questionnaire. The rainfall data associated to questionnaire responses were obtained from reanalysis data that combine radar and rain gauges observations data. The rainfall data was calculated at the location where the respondents were at the time of the event.



	Event	**Montpellier-Nice-2014**		**Cannes-Nice-2015**
CONTEXT	**Place**	Hérault department (Montpellier)	Gard department (Nîmes)	Var + Alpes-Maritimes departments (between Cannes and Nice)
	Date	Monday 29/9 15-18h Weekday, afternoon and evening	Friday 10/10 1h-10h Weekday, night and morning	Saturday 3 October, 19-22h Weekend, evening
	Max cumulated rain1h (mm)	129	92	146
	Max cumulated rain 24h (mm)	352	426	215
	Météo-France warning	Red	Red	Orange
	Impact	No death	No death	20 deaths
SURVEY	**Number of valid answers**	100		180
	Link broadcast	Meteorological websites		Professional networks + Meteorological websites
	Main characteristics of the sample	Age 20-30 years (average: 33) Mostly men		Age 30-45 years (average: 40), Couple, children high socio-professional groups, public sector

2. Social Variables

Estimation of detected damage levels for each respondent by adding all the declared types which have been weighted according to their seriousness:

$$Score\ of\ damages\ type = River\ flood + Road\ flood \times 2 + Electricity\ cuts \times 3 + Building\ flood \times 4 + School\ closures \times 5 + rescues \times 6 + Corporal\ damages \times 7$$

Estimation of general seriousness by taking the weighted most serious type.

$$Max\ of\ damages\ types = max(River\ flood, Road\ flood \times 2, Electricity\ cuts \times 3, Building\ flood \times 4, School\ closures \times 5, rescues \times 6, Corporal\ damages \times 7)$$

$$Score\ of\ trip\ changes = Extend + Adapt \times 2 + Cancel \times 6$$

$$Max\ of\ trip\ changes = max(Extend, Adapt \times 2, Cancel \times 6)$$

Estimation of activity change levels :

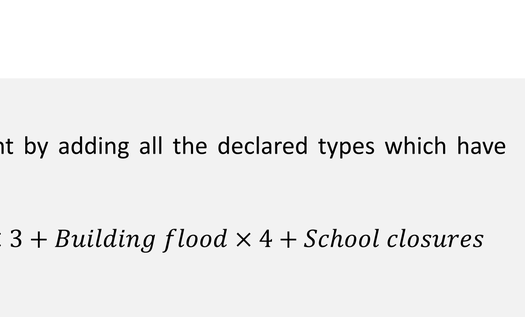
$$Score\ of\ activity\ changes = Inquiry + Organize \times 2 + Protect\ goods \times 6 + Protect\ myself \times 8 + Rescue\ others \times 8$$

$$Maximum\ of\ activity\ changes = max(Inquiry, Organize \times 2, Protect\ goods \times 6, SProtect\ myself \times 8, Rescue\ others \times 8)$$

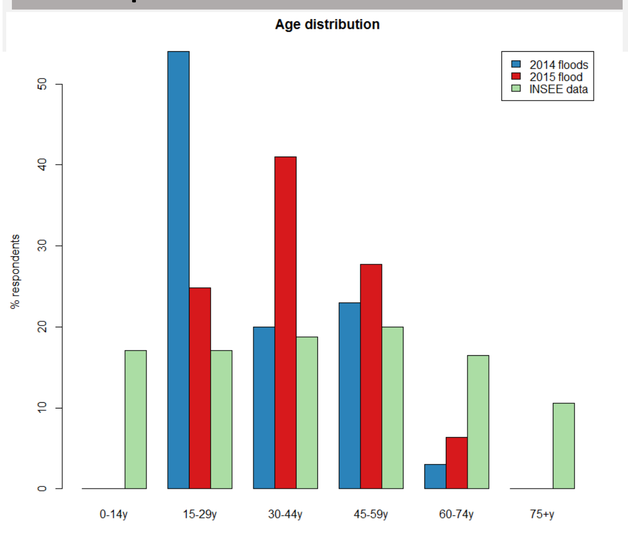
Results

1. Comparison between 2014 and 2015 events

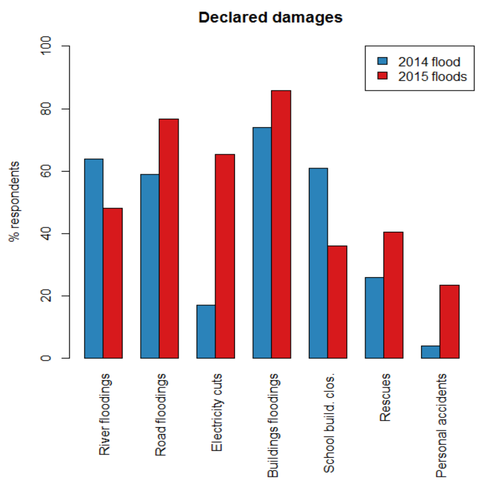
Ratio between individual (respondent) cumulated rainfall and maximum cumulated rainfall of the event was used to evaluate the difference of rainfall severity experienced by each respondent depending on their location at the time of the event. Respondents related to the Nice-Cannes event are the ones who were exposed to the most severe rainfall circumstances followed by the Montpellier respondents.



2. Social profile

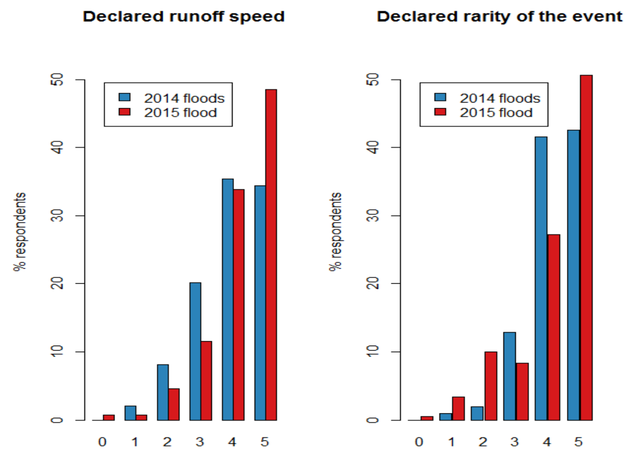


3. Damages

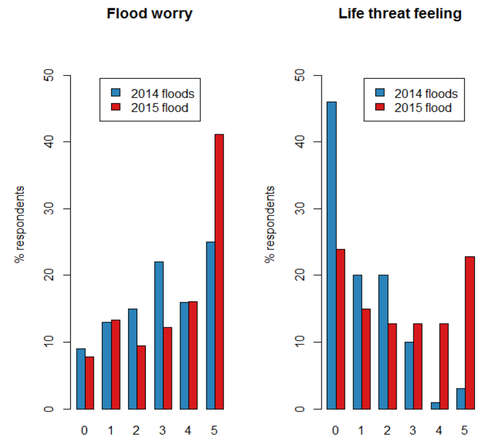


4. Perception of the hydro-meteorological events and their severity

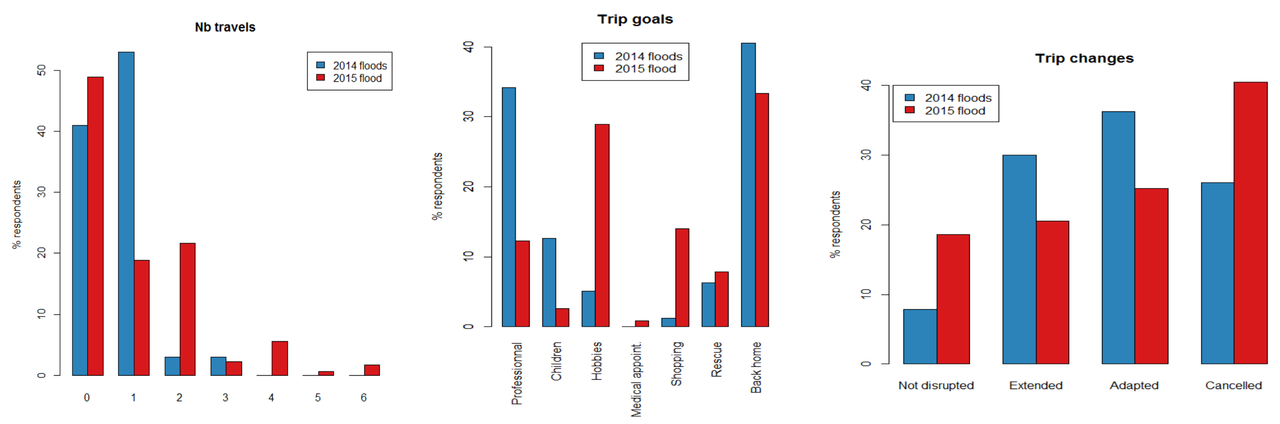
4.1 How do people perceive the floods?



4.2 Risk perception

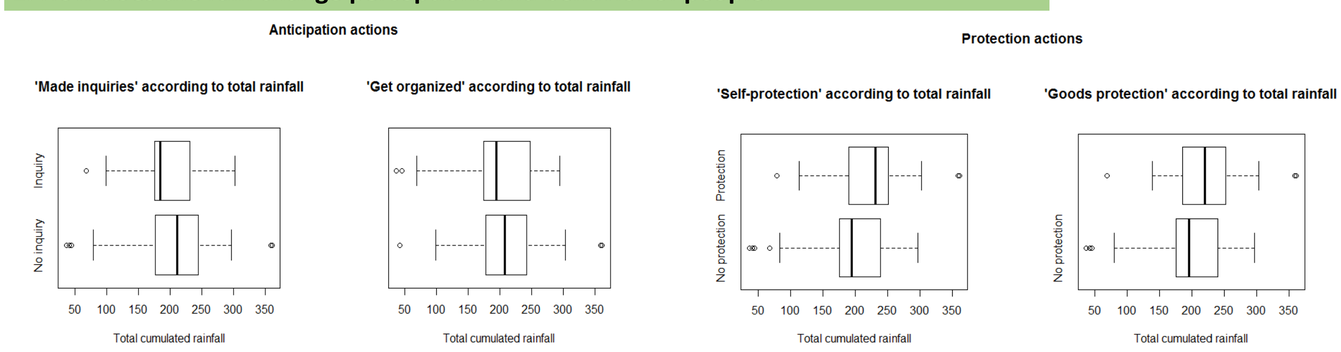


4.3 How do people change their travel plans and activities during flash floods?

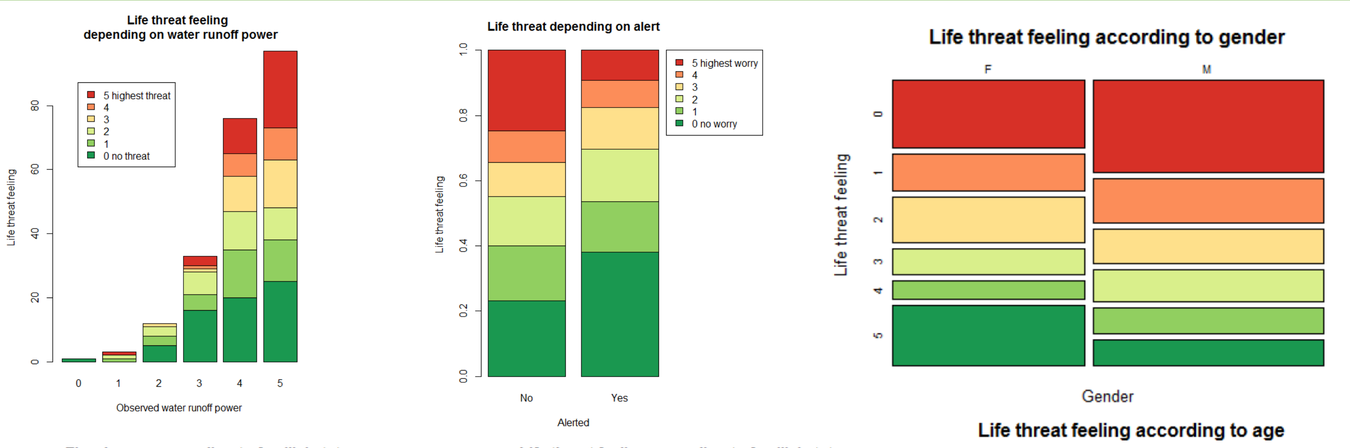


Bivariate analysis of the 2015 event

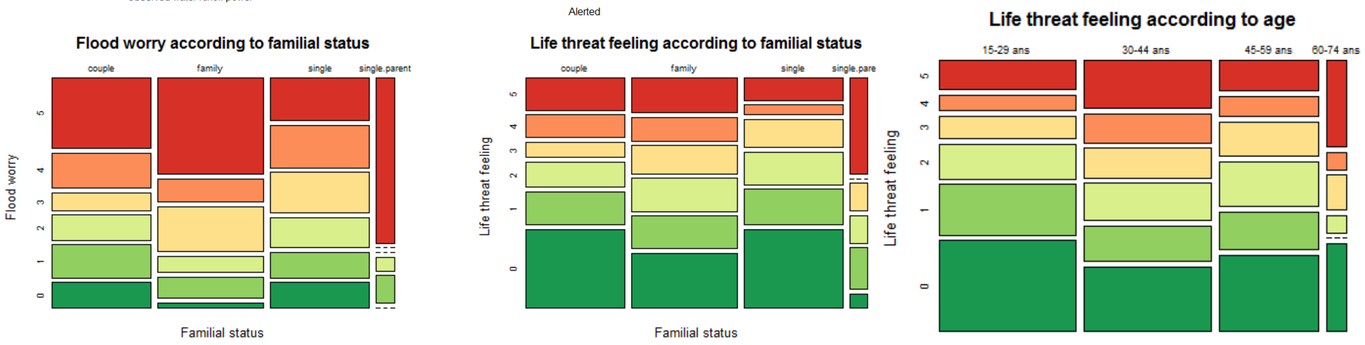
1. How does the rain change perceptions and behavior of people?



2. How do different parameters influence human emotions?



3. Protection actions and adaptation behaviors during flash flood



Conclusion

- The coupled analysis of responses to the surveys with hydro-meteorological parameters allows to better understand the link between the event magnitude and self-protective behaviours in the context of short-fuse weather events as flash floods. Knowledge gained from such an integrated approach is necessary for drawing lessons for the development of coupled human-natural system modeling and the prediction of the human vulnerability dynamics in short-fuse weather events.
- Flash floods affect every social system differently according to its characteristics. People behave and adapt differently in a dangerous situation depending how they perceive risk or what they are doing at that time. The time and space distribution of their daily routine influence the overall human behaviour during a flooding event.

References

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- Terti, G., Ruin, I., Anquetin, S. & Gourley, J. J., 2015. Dynamic vulnerability factors for impact-based flash flood prediction. Nat Hazards.

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