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

Javed Ali and Isabelle Ruin

Université Grenoble Alpes, CNRS, IRD, Grenoble INP, IGE, 38000 Grenoble, France

Introduction

Risk perception — Mental representation

Crisis circumstances → Couple place-activity

Perception f(Cc; Cp-a; Rp; Mr)

Sense-making f(perception)

Decision-making f(sense-making) — Physical ability

Human Behavior f(Decision-making; Physical ability)

Terti et al., 2015

Hear/receive warning → Understand → Believe → Personalize → Decide to act → Take appropriate action

- 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).
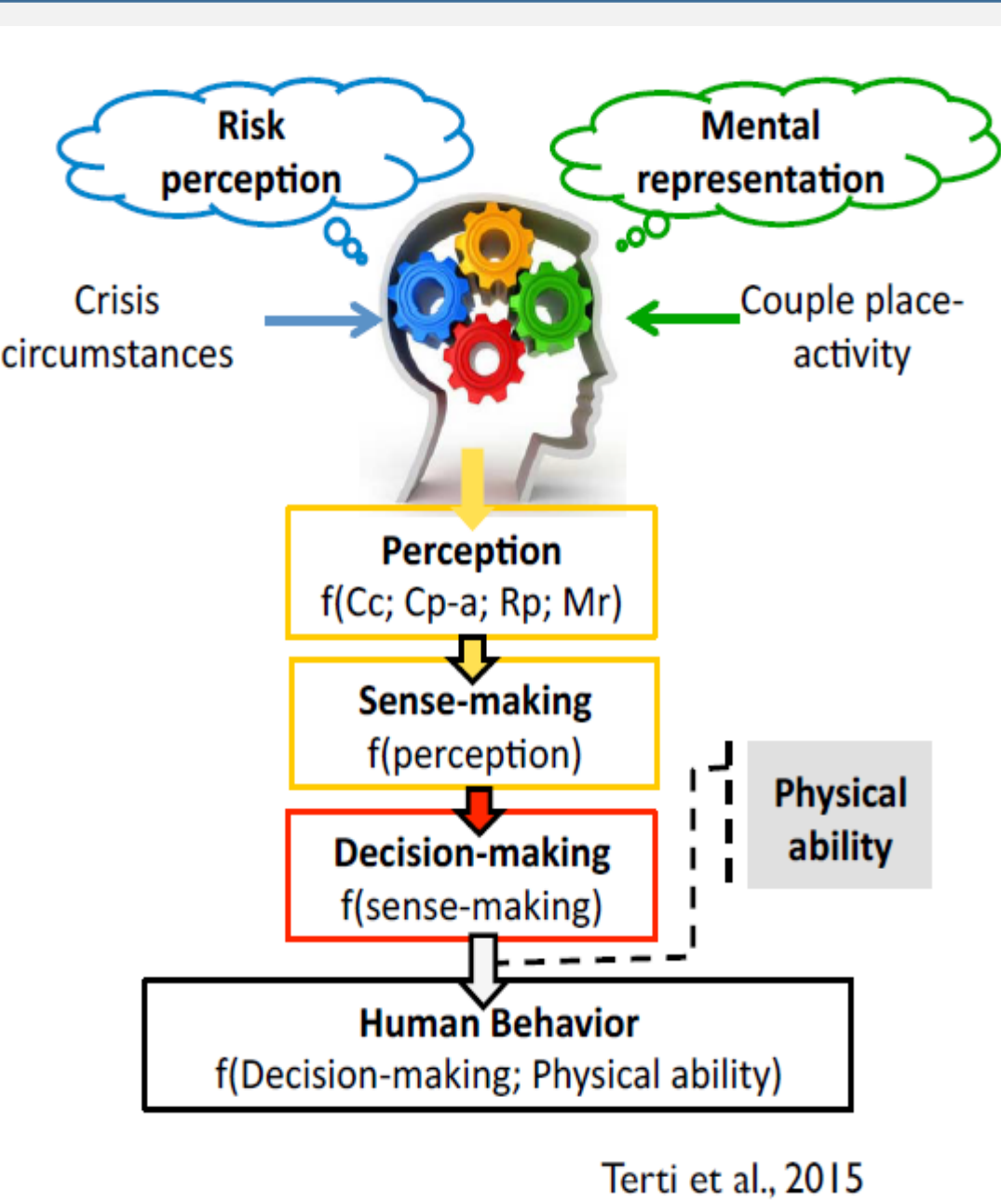
- Understanding how people actually detect potentially dangerous circumstances and manage to timely adapt their routine to cope with the speed of the hazard evolution remains a challenge.

- 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.

Localisation of the events in France

Event
- Montpellier
- Nîmes
- Cannes Nice
- Department with one event

Event	Montpellier-Nice-2014		Cannes-Nice-2015
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-13h 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
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

(CONTEXT / SURVEY)
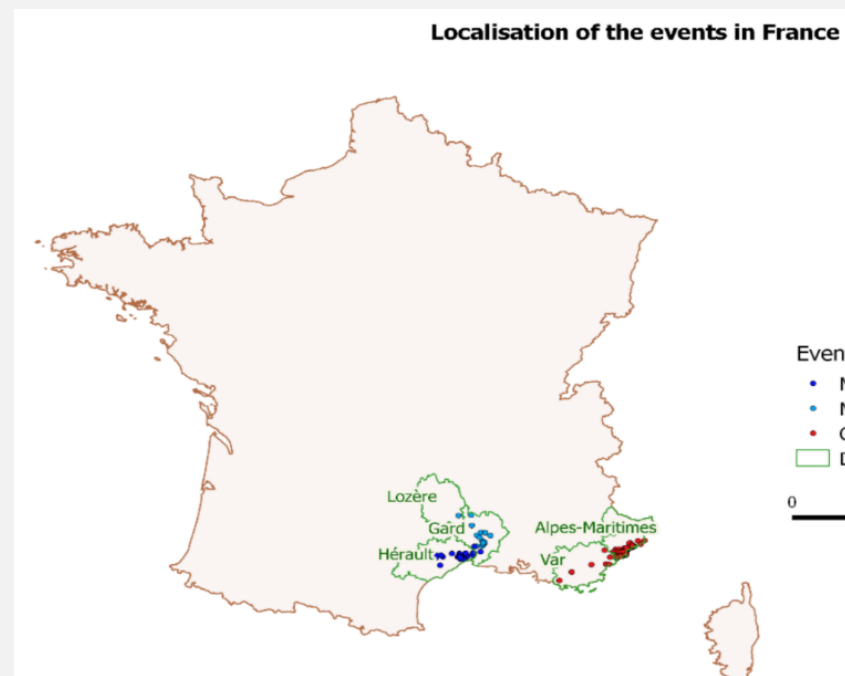
2. Social Variables

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

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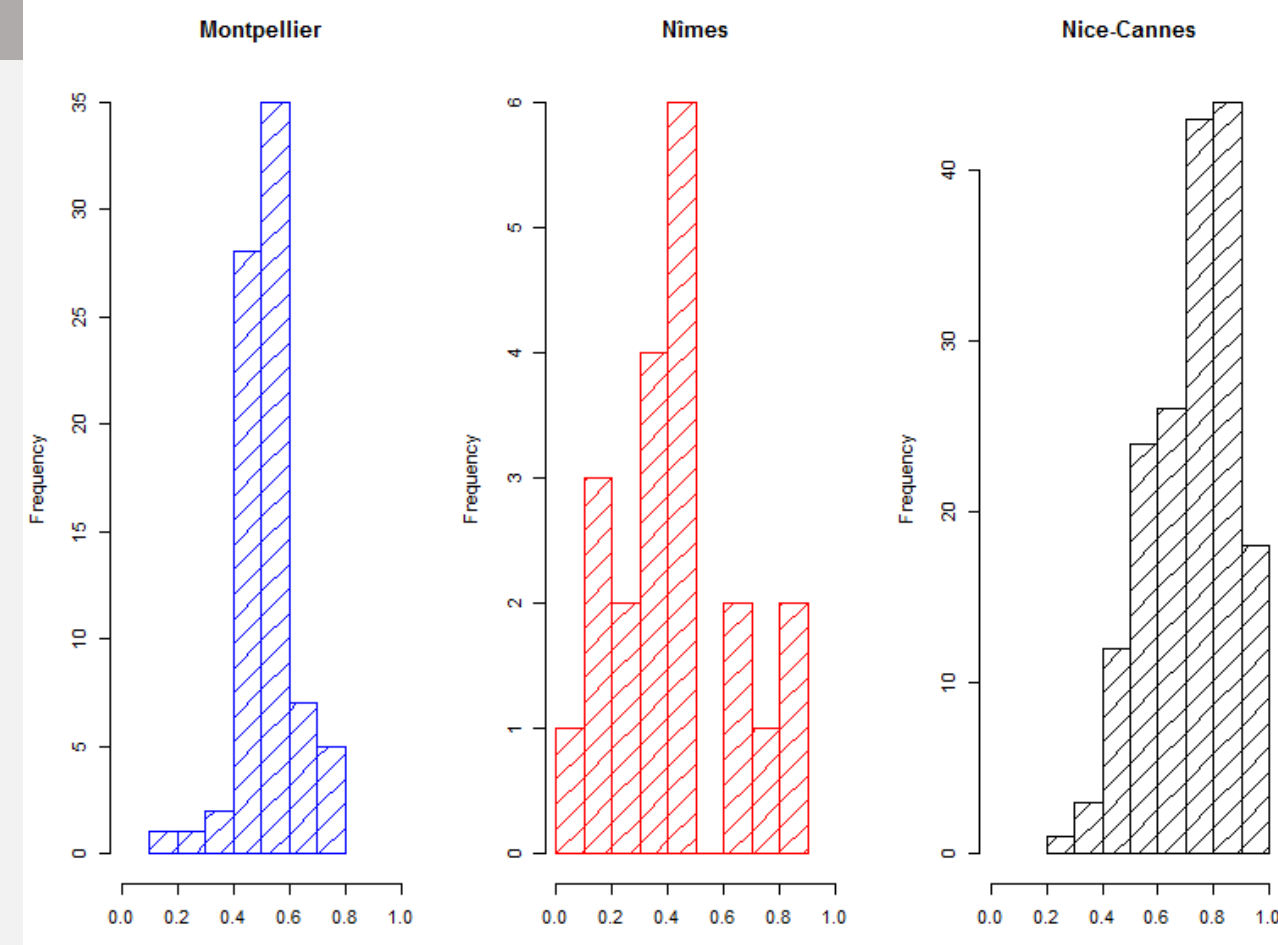
Results

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.
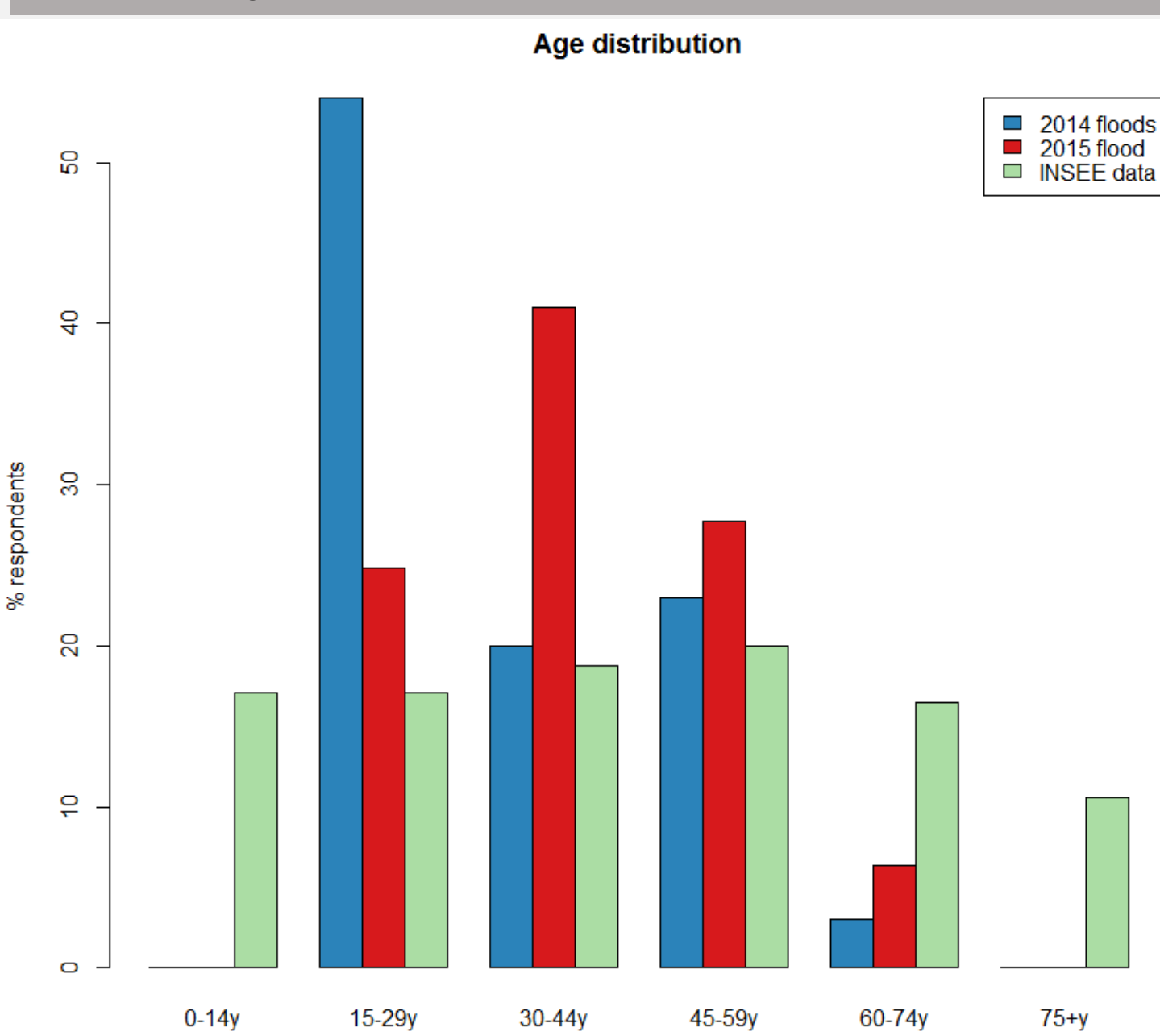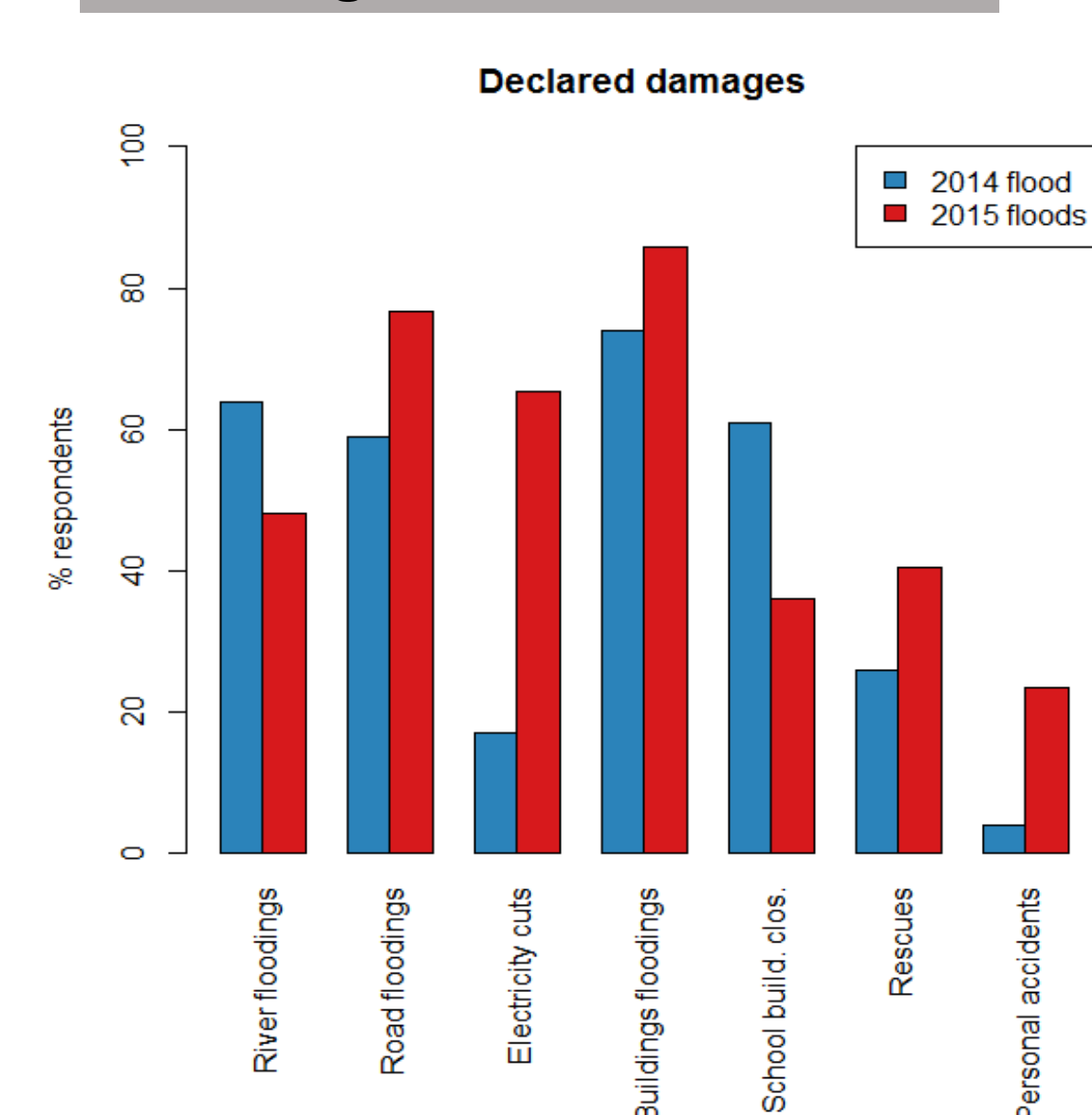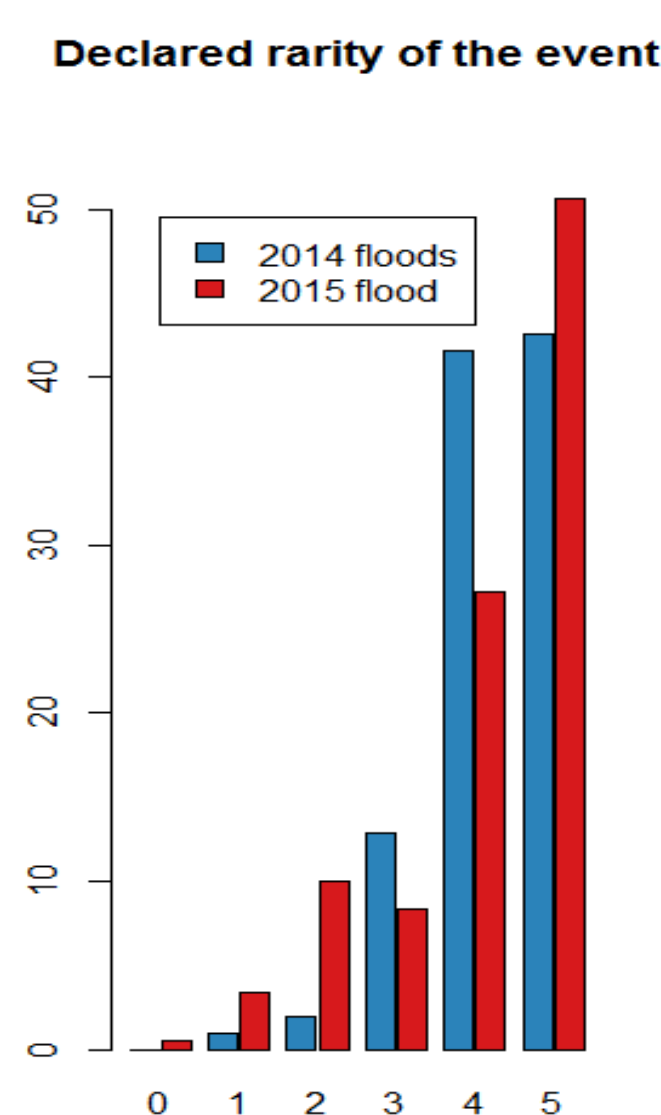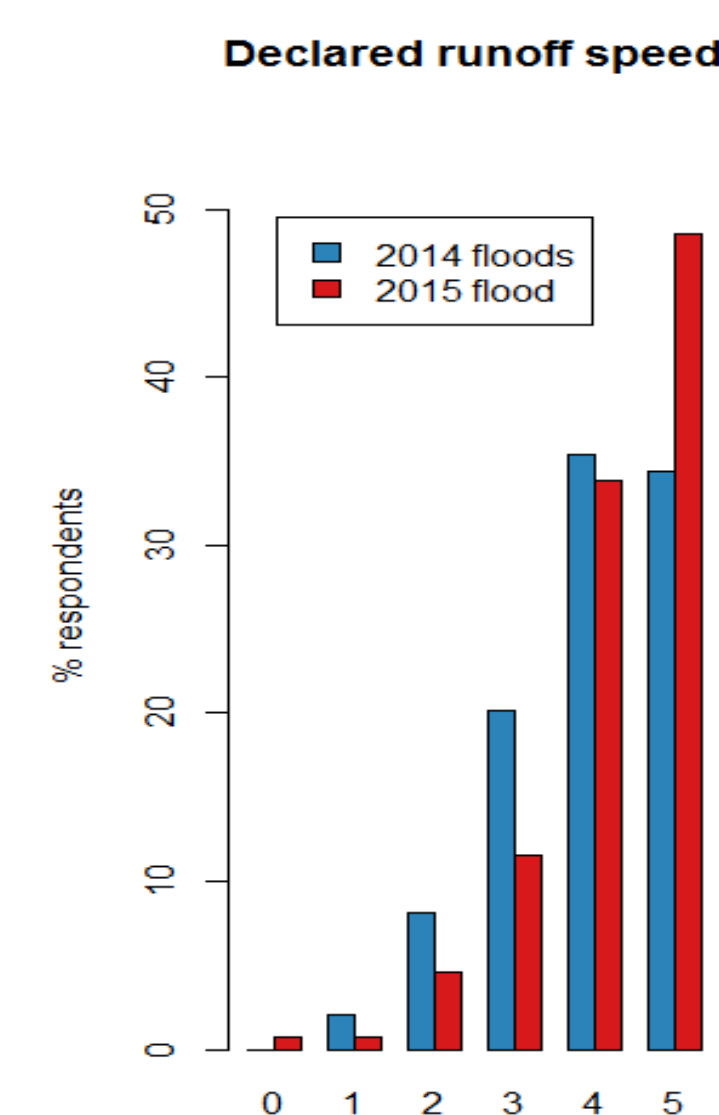
Ratio individual/event for cumulated rainfall
(Montpellier, Nîmes, Nice Cannes)

2. Social profile

Age distribution
(2014 floods, 2015 flood, INSEE data)

3. Damages

Declared damages
(2014 flood, 2015 floods)
River floodings, Road floodings, Electricity cuts, Buildings floodings, School build clos, Rescues, Personal accidents
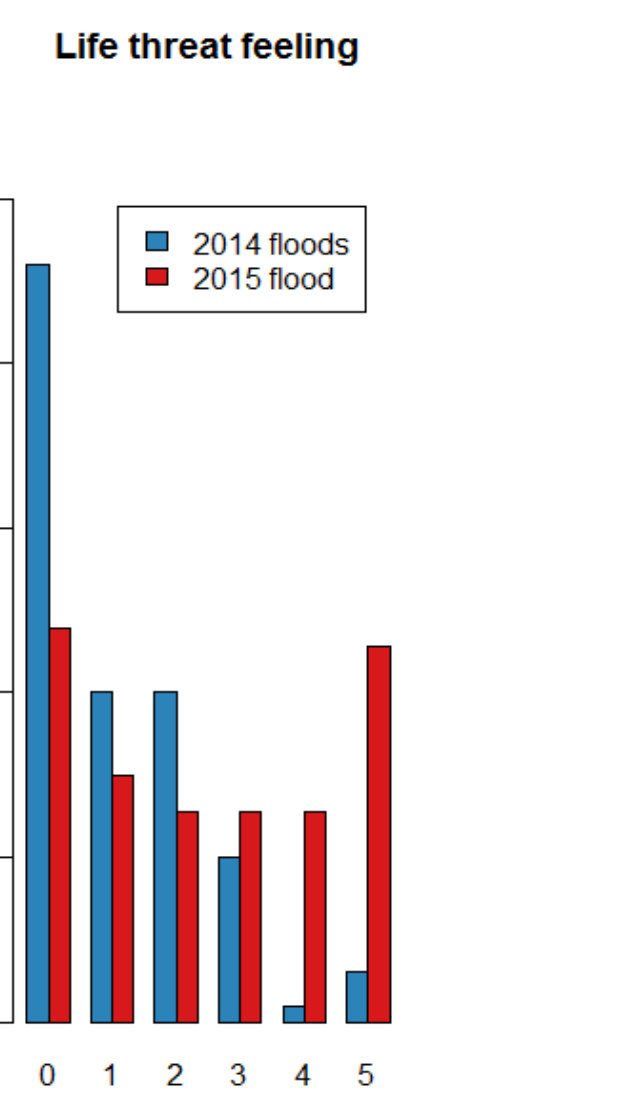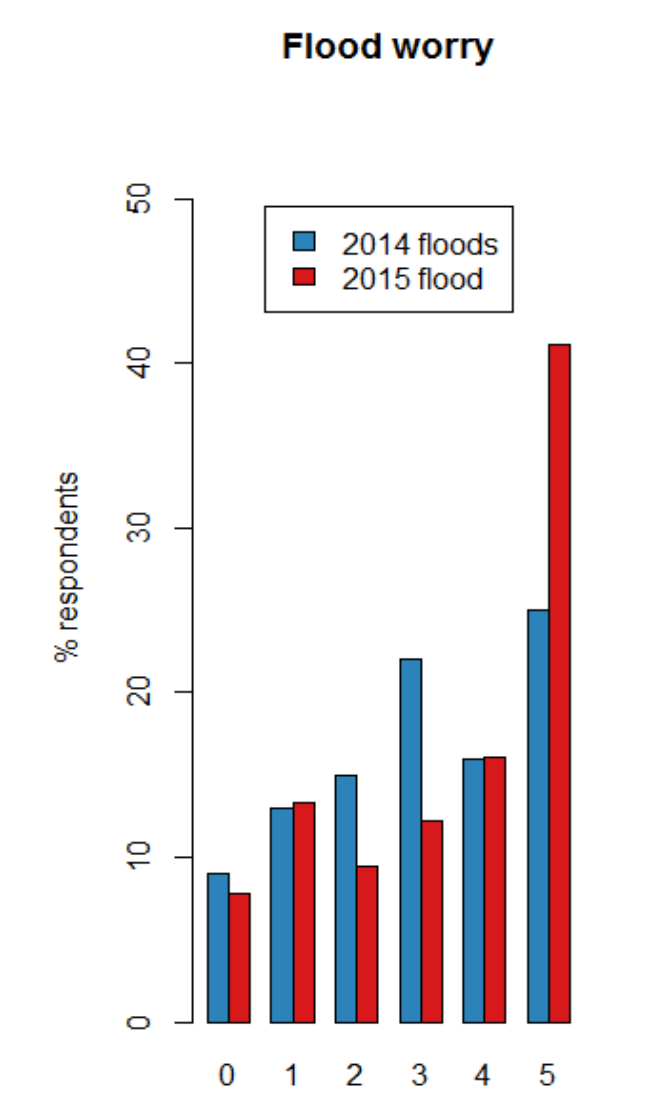
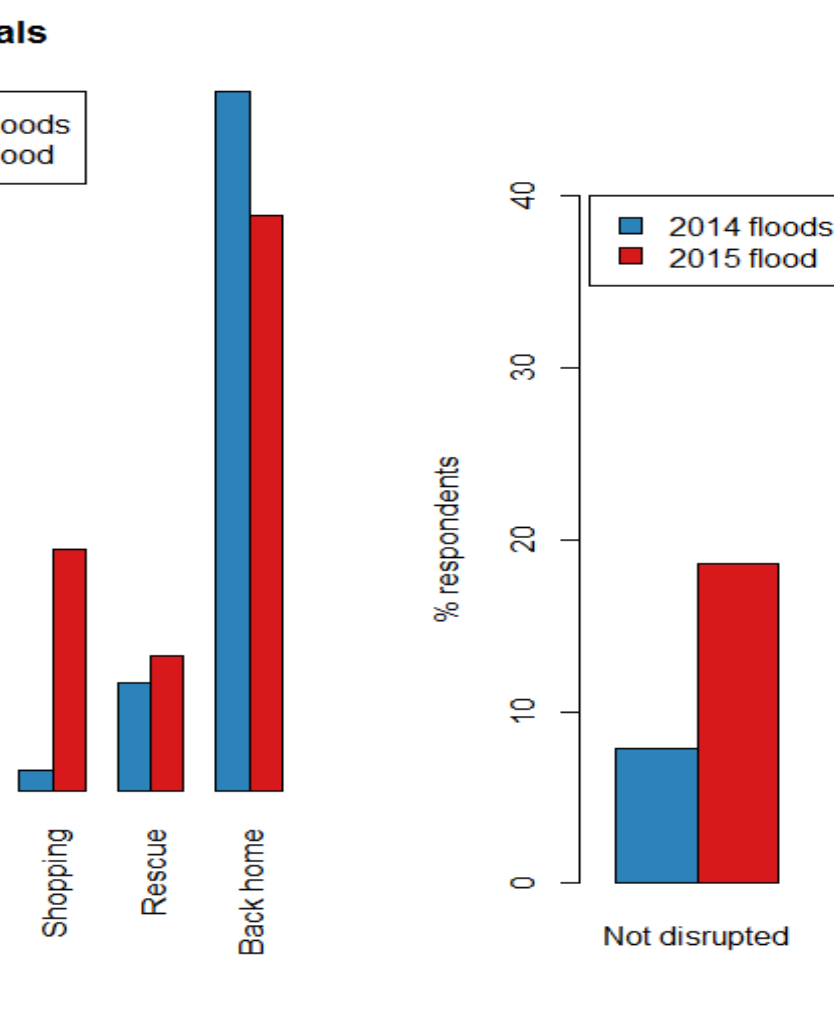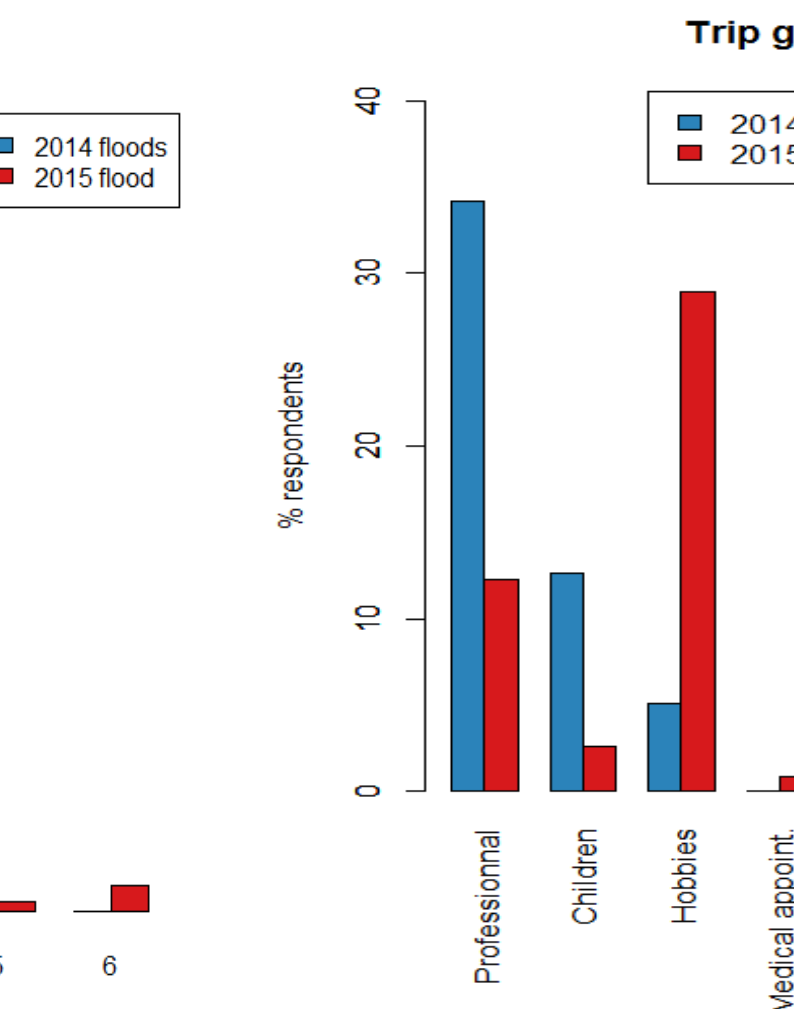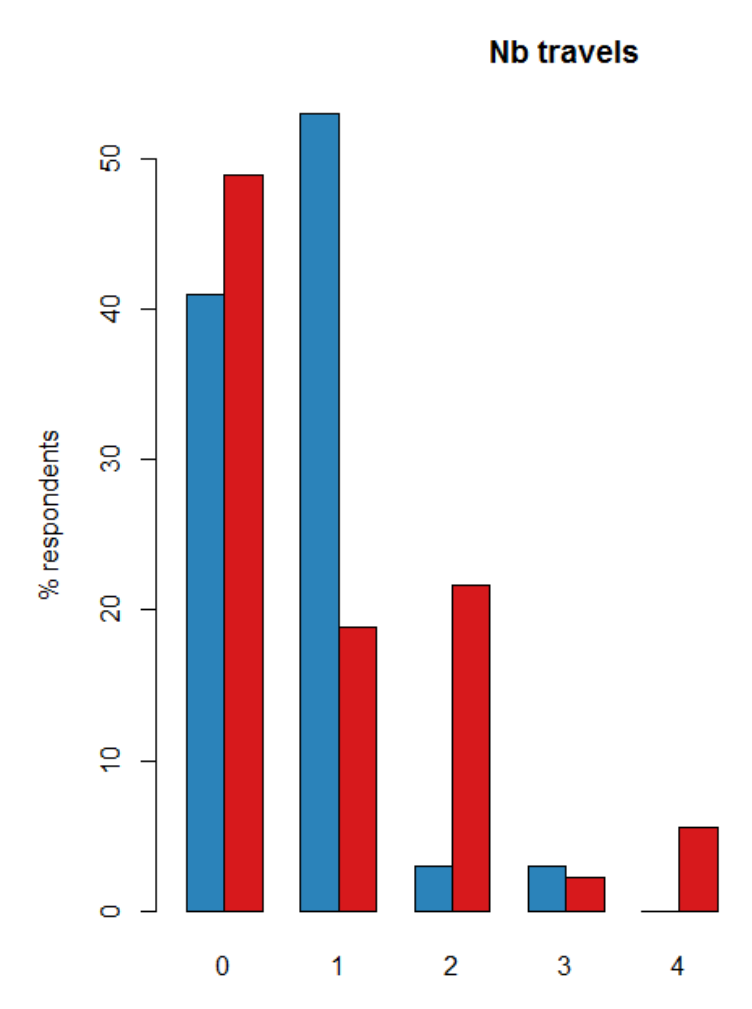## 4. Perception of the hydro-meteorological events and their severity
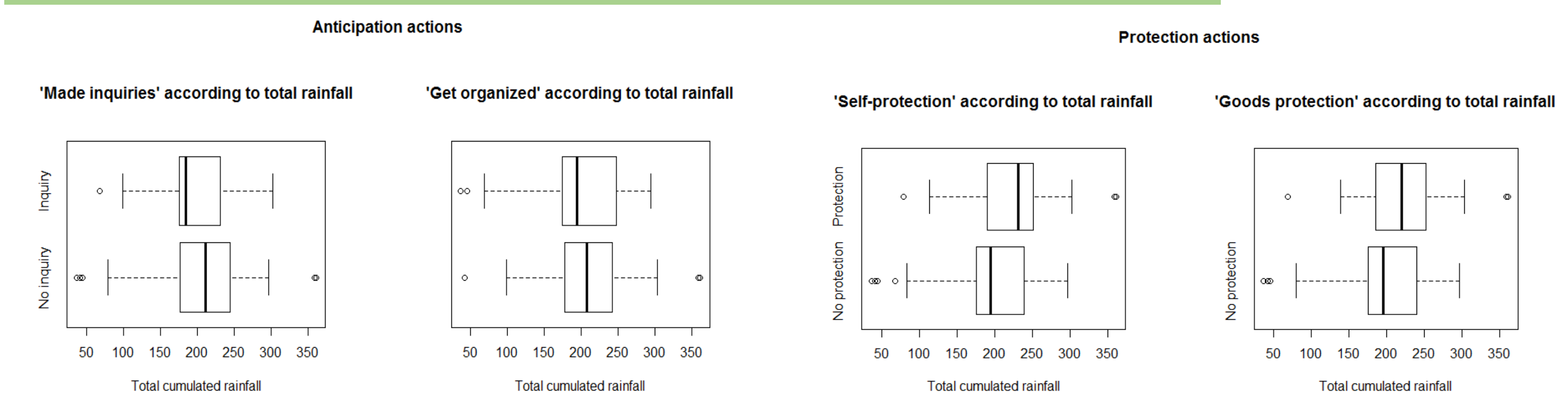
4.1 How do people perceive the floods?

Declared runoff speed (2014 floods, 2015 flood)

Declared rarity of the event (2014 floods, 2015 flood)

4.2 Risk perception

Flood worry (2014 floods, 2015 flood)

Life threat feeling (2014 floods, 2015 flood)

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

Nb travels (2014 floods, 2015 flood)

Trip goals (2014 floods, 2015 flood): Professional, Children, Hobbies, Medical appoint, Shopping, Rescue, Back home

Trip changes (2014 floods, 2015 flood): Not disrupted, Extended, Adapted, Cancelled

Bivariate analysis of the 2015 event

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

Anticipation actions

'Made inquiries' according to total rainfall (Inquiry, No inquiry) — Total cumulated rainfall

'Get organized' according to total rainfall — Total cumulated rainfall

Protection actions

'Self-protection' according to total rainfall (Protection, No protection) — Total cumulated rainfall

'Goods protection' according to total rainfall (No protection) — Total cumulated rainfall

2. How do different parameters influence human emotions?

Life threat feeling depending on water runoff power — Observed water runoff power (5 highest threat, 4, 3, 2, 1, 0 no threat)

Life threat depending on alert — Alerted (No, Yes) (5 highest worry, 4, 3, 2, 1, 0 no worry)

Life threat feeling according to gender (F, M) — Gender

Flood worry according to familial status — Familial status (couple, family, single, single parent)

Life threat feeling according to familial status — Familial status (couple, family, single, single pare)

Life threat feeling according to age (15-29 ans, 30-44 ans, 45-59 ans, 60-74 ans) — Age

Flood worry according to age (15-29 ans, 30-44 ans, 45-59 ans, 60-74 ans) — Age

Proportion of respondents having cancelled trips according to life threat feeling — Level of threat (Cancellation, No cancellation)

3. Protection actions and adaptation behaviors during flash flood

Proportion of respondents having to protect themselves according to life threat feeling — Level of threat (Protection not needed, Self-protection)

Self protection depending on water runoff power — Observed water runoff power (Self protection, No protection)

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

- Ruin, I. et al., 2009. Human vulnerability to flash floods: Addressing physical exposure and behavioural questions. Flood Risk Management: Research and Practice, pp. 1005-1012.
- Ruin, I., Creutin, J.-D., Anquetin, S. & Lutoff, C., 2008. Human exposure to flash floods – Relation between flood parameters and human vulnerability during a storm of September 2002 in Southern France. Journal of Hydrology, Volume 361, pp. 199 - 213.
- Terti, G., Ruin, I., Anquetin, S. & Gourley, J. J., 2015. Dynamic vulnerability factors for impact-based flash flood prediction. Nat Hazards.

Contact: javed.ali@univ-grenoble-alpes.fr