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Authors' Reply to Referee 1

Elena Mondino et al.

Author comment on "Longitudinal survey data for diversifying temporal dynamics in flood risk modelling" by Elena Mondino et al., Nat. Hazards Earth Syst. Sci. Discuss.,
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In our response below, we will use Rn.m to indicate the referee comment and An.m to indicate the authors' reply, where n is the referee number and m the comment number.

R1.1: Dear authors, the paper with the title „Longitudinal survey data for diversifying temporal dynamics in flood risk modelling” address a very interesting topic, not only in social science with the use of longitudinal methodological approaches to understand mid-term/long-term changes within a community in terms of flood risk management. The paper fits to the scope of the journal. I have some questions and remarks on the paper, which might need a larger more in-depth assessment of the current status of the paper. In overall, there are some major and minor remarks to the paper.

A1.1 We thank the Referee for taking the time to review our manuscript and for providing many constructive comments that will help us improve our work.

R1.2: A first overall remark reflects your conceptual framework, aim of the paper, discussion and literature review. The first point I would re-consider within the current version is the question about the use of theoretical framework. The paper needs to re-think to add theoretical-psychological framework (or frameworks) to assess and to explain your results, which theoretical concept (besides the socio-hydrology framework) are you using: Protective Action Decision Model (PADM), Risk Information Seeking and Processing model (RISP), Framework for Risk Information and Seeking (FRIS), Planned Risk Information Seeking Model (PRISM), Protection Motivation Theory (PMT), Transtheoretical model (TTM), Health Belief Model (HBM), Social amplification of risk framework (SARF), Model of Private Proactive Adaptation to Climate Change (MPPACC), Regulatory Focus Theory (RFT), Theory of Reasoned Action (TRA), or Community Engagement Theory (CET)? I would strongly suggest choosing one of these theoretical frameworks to re-consider your aim of the paper as well as your discussion.

A1.2: We agree: the use of a theoretical framework is often useful to define the aim of a study. We will clarify in the revised manuscript that our survey loosely refers to the Protection Motivation Theory (PMT) and will discuss this aspect more in depth in the

revised Section 5. We will also clarify that the main goal of our work is to conduct a methodological comparison between two longitudinal study approaches. To avoid any confusion in the aim of our paper or interpretation of results, we will remove the paragraphs about protective measures and flood insurance. These data, which were not collected longitudinally, will be employed in future studies exploring the relationship between risk awareness and preparedness.

R1.3: What I'm largely missing is: what's the innovation in your paper, what's the theoretical added-value of your paper; I see large potential within the paper, but at the moment this isn't addressed, such as aim of the paper reads more like providing some new case studies; I largely missing a theoretical debate within your paper, which needs to be addressed within your aim of the paper.

A1.3: We thank the Referee for highlighting that the aim of our paper was not stated clearly. We will specify the aim clearly in the revised version of the manuscript, focusing on the core aspect of how risk attitudes change over time. Indeed, the innovation of this paper largely lays in the methodological contribution to the understanding of risk perception evolution/changes. As discussed above, our aim is to compare how results change when using two different longitudinal study designs in terms of sampling, specifically repeated cross-sectional and panel. In addition to this, we provide longitudinal evidence in terms of flood risk awareness, trust, and perceived preparedness through an entirely new set of data.

R1.4: This goes also hand in hand with your literature review, which included a wide range of papers from socio-hydrology community (which is fine), but none of these papers are really talking about risk perception (in terms of theoretical contribution!). Please, provide a broader risk perception debate within your paper.

A1.4: We agree that we have provided limited background on flood risk perception. We will add a new section in the revised manuscript where we discuss previous literature on risk perception and its dynamics over time.

R1.5: Another point, what are the differences of this paper with your already published work in Journal of Hydrology and Hydrological Sciences Journal?

A1.5: This paper considerably differs from previously published work. This paper relies on an entirely new set of data based on two surveys carried out with alternative methods in a new case study (Negrar). Apart from being in the same country (Italy), this case study is different from the previous ones (Romagnano and Vermiglio) in terms of both type of hazard (debris flows vs. floods), temporality of the extreme event occurrences, as well as timing of the two surveys (1 year apart vs. 13 years apart). Moreover, the paper published in Journal of Hydrology adopts a probabilistic approach to the data analysis (using Latent Class Analysis), whereas the paper published in Hydrological Sciences Journal adopts a deterministic approach. While these first two papers aimed at exploring what influences the change of perceptions (or lack thereof), in this current paper, as discussed previously, we aim at comparing two different approaches for longitudinal studies (in terms of sampling methodology) to explore their effects on the dynamics of risk awareness.

R1.6: Some minor points: also reconsider some structural aspects, such as within the discussion: you are talking about risk perception paradox, but this isn't mentioned in your introduction, similar aspect is the 'white male' effect; you should mention and explain this concepts already in your introduction.

A1.6: We agree: these concepts will be introduced early on in the introduction of the revised manuscript.

R1.7: Important issue: what's your theoretical added value to the current psychological debates on risk perception and coping strategy and adaptive capacity?

A1.7: While our survey loosely refers to the Protection Motivation Theory, a theoretical contribution to the psychological debate is out of the focus of this paper. This comment makes us realize that mentioning adaptive behavior can create confusion. Thus, we will remove the short results sections dedicated to this aspect that may distract from our main contribution: the methodological comparison between two different longitudinal approaches.

R1.8: Second point goes directly to your data and used methodology: I would suggest providing much more detail information about the sampling: how you selected them, who drop out, why, how etc.

A1.8: In the revised manuscript, we will add more information on the respondents who dropped out (% females/males, age, damage suffered, etc.).

R1.9: Also, I would re-think about your used methodology in analysing your data: you are using a very descriptive approach with some Chi-Square assessments: I would suggest providing a more sophisticated statistical analysis, such as using a series of hierarchical regression models as there is much more potential within your dataset.

A1.9: The Chi-square tests were used only for testing differences in answers to certain specific questions between respondents who suffered no-low-high damage, to additionally explain the results from the ordinal logistic regressions (which were at the center of our data analysis). Using hierarchical regression models would definitely be appropriate when testing a theory, but in this paper the data analysis focuses on exploring how certain variables change over time, thus there is only one predictor/independent variable (time). We then additionally tested for interactions of time with gender and amount of damage suffered, to explore whether it changed differently for different groups of people. We will clarify this more in detail in the revised version of the paper.

R1.10: In addition, the paper only address the social part of the socio-hydrology modelling framework. I would suggest including at least some information about the hydrology issue and risk analysis from the events, including social and physical vulnerability assessment of your sampling and selected case study. In

particular, you mention a very interesting point, mainly low damage and preparedness. At the moment, it's largely unclear what does it mean low damage, low damage in terms of physical vulnerability, in terms of social vulnerability, in terms of a combination of both, see for example your statement on page 18, on the line 520? I would strongly suggest to include both vulnerability concepts in the revised version to understand your assumption about low damage/high damage; we need much more information about your sampling.

A1.10: This comment highlights that this part was not sufficiently clear. Thus, the revised manuscript will provide more information about the hydrology of the flood event and associated risks. Second, regarding the damage, in Table 2 we intend to report the specific questions upon which the variables are based. Damage suffered refers to damage suffered by the respondents and/or the respondent's home. This question was intentionally left vaguer to let the respondent interpret what they consider "damage", as it is their interpretation, not the researcher's, what eventually would influence their risk perception. Considering that there were no fatalities and no injured residents in the 2018 event, we consider this to be damage suffered mainly to the place of residence and belongings (e.g. car, motorcycle, etc.). Regarding the statement on page 18 line 520, in the revised manuscript we will specify that we are actually referring to "perceived preparedness", to avoid any further confusion around the concept.

R1.11: Third issue reflects your results section. First, the sections are too short; some of the sections only include 100-200 words, as NHESS has no upper word limit I would suggest to extend this part.

A1.11: We agree and in light of the discussion above we will remove these short sections referring to insurance and private protection measures in the revised manuscript, as they are not central to the aim of the paper.

R1.12: Second issue reflects two key results sections: mainly, the private protection measures and insurance. First to the private protection measures: this is too far unclear what you are asking them: did you asked them to use PLFRA? Did you asked them to implement emergency management activities? Which measures did you asked them? This section needs more detail information about the type of measures, how they implemented it, the role of self-efficacy etc.?

A1.12: The content of the questions and available answers are listed in Table 2. We did not investigate which type of measures they implemented, neither how, nor their self-efficacy. It was a yes/no question on whether they adopted any private structural protection measure. Thus, we will remove it from the paper.

R1.13: Second aspect reflects your insurance section: as far I remember, the Italian government didn't introduced the Monti law about natural hazards insurance or is there any private or mandatory natural hazard insurance system in Italy or is the government providing the disaster aid payments? If not, you probably will always get some wrong impression from your results on insurance like other surveys in other countries, such as Austria, Germany, Czech Republic etc. where people associate household insurance bill with a natural hazard insurance bill, which isn't correct as in Germany, for example, most insurance

companies are not providing any compensation; the disaster payments are provided (usually) from the public administration. I think this might cause some misunderstandings for many readers across the globe (especially Anglo-Saxony countries) where the private insurance market plays a central role in the recovery. I'm not sure about this sections, it might be worth to remove it.

A1.13: In light of potential confusion and due to the small amount of information on insurance collected through the questionnaire (here too, just a yes/no question), we will remove this section from the paper.

R1.14: Fourth issue goes to your statements about system dynamics and ABM. First of all, I don't think ABM might the solution to include individual risk perception or human behaviour aspect. As most (or almost most) ABM studies are using a stochastic approach to explain individual behaviour, main reason is that all humans are rarely acting within a swarm like in biology. Secondly, how you would integrate your results within current SD modelling frameworks, such as Vensim or Stella? It's more me a little bit vague how you argue; please provide a much more detail information about it.

A1.14: Indeed, more information on the way in which our results can inform the modeling of human behavior would enrich our paper. The revised manuscript will include a compelling paragraph on this aspect.

Minor points:

R1.15: Please provide more in-depth information on table 1, such as population composition to understand how your sample reflects the population.

A1.15: In the revised manuscript we will include as much information as possible about the sample, including summary statistics on the education level and income of respondents.

R1.16: Page 9, line 238 restriction to one person within the household: I see this as a very problematic issue as we know from previous studies the factor of gender in the rural-side play a crucial role in the data; I don't like this fact you exclude the others from the household. Therefore, I would suggest to add this aspect as a crucial limitations in your paper.

A1.16: While we agree with the Referee that gender differences are an important factor in the risk perception literature, we disagree that interviewing one person per household represents a crucial limitation. The area is not rural, and in lines 238-242 we reported why we initially decided to interview one person per household. Many similar studies in the literature report interviewing only one person per household (see, among others, Bubeck et al., 2020; Kreibich et al., 2011; Osberghaus & Hinrichs, 2020; Seebauer & Babicky, 2020), showing that it is a common practice. Moreover, we selected one person per household based on quotas including gender and age (in practice, the interviewers had a grid to fill in). As a result, our data is representative of the local population not only in terms of gender, but also of age. Unless each and every household member of each and every household in the study area were interviewed, the sample would have lost its representativeness. In addition, we extensively explore the role of gender and show the

differences between men and women when it comes to risk perception.

Osberghaus, D., & Hinrichs, H. (2020). The Effectiveness of a Large-Scale Flood Risk Awareness Campaign: Evidence from Two Panel Data Sets. Risk Analysis, https://doi.org/10.1111/risa.13601

Bubeck, P., Berghäuser, L., Hudson, P., & Thielen, A. H. (2020). Using Panel Data to Understand the Dynamics of Human Behavior in Response to Flooding. Risk Analysis, https://doi.org/10.1111/risa.13548

Seebauer, S., & Babczyk, P. (2020). (Almost) all Quiet Over One and a Half Years: A Longitudinal Study on Causality Between Key Determinants of Private Flood Mitigation. Risk Analysis, https://doi.org/10.1111/risa.13598

Kreibich, H., Seifert, I., Thielen, A. H., Lindquist, E., Wagner, K., & Merz, B. (2011). Recent changes in flood preparedness of private households and businesses in Germany. Regional Environmental Change, 11(1), 59–71. https://doi.org/10.1007/s10113-010-0119-3

R1.17: Page 13, line 376: you are using cluster analysis: how did you organise the cluster analysis within this very small sampling? It's somehow unclear for me.

A1.17: We will clarify this aspect in the revised paper. What we meant with clustering was simply grouping the individuals depending on the amount of damage suffered: those who suffered no damage (replied 1 on the 1-5 scale), those who suffered low damage (replied 2-3 on the 1-5 scale) and those who suffered high damage (replied 4-5 on the 1-5 scale), to see whether risk perception dynamics were different depending on the amount of damage suffered.

R1.18: Page 18, line 498: please provide some cross-references on the ABM section. Similar later on SD.

A1.18: We will add more references in the revised paper.

R1.19: What I'm somehow missing are the role about the Italian civil protection in the case study; does the civil protection system in Italy influencing your preparedness as well as understanding of risk perception?

A1.19: We will add a section in the revised manuscript regarding the role of civil protection in the area.

R1.20: Finally, please provide some further limitations within your study as well as next research steps within the longitudinal research in flood risk management.

A1.20: We will add a section about future research within the flood risk domain.