

Response to Reviewer #2

The authors would like to thank Reviewer #2 for taking the time to read the manuscript and provide valuable comments and constructive suggestions. We address the comments (*our ACs in italics*) follow the comments.

While the concept itself seems to be innovative and warrant publications, the following reservations/concerns are made:

a. The CLAIM framework as introduced by Abebe et al., (2019a), did not consider the interaction between individual agents and their feedback loop or mechanism. It assumes that agents change interact with the environment and their behavior is greatly influenced by the institutions and their past exposure to flooding. While this could represent the key attributes that impact or influence individual agent's behavior, the role of micro-level agent interactions with each other seems to be ignored.

AC: Indeed, agents' interaction is a crucial element of the CLAIM framework. In Figure 1 of (Abebe et al., 2019a), the arrow at the top left corner of the Agents box, which goes out and enters to the same box, represents that interaction. We acknowledge that there can be numerous actor interactions that influence one another's behaviour although not all interactions are two-ways (with feedbacks). In model conceptualization, the focus is usually on the dominant interactions that affect the behaviour of most agents as it might be neither practical nor relevant to model all the interactions. In the current manuscript, the social network factor (Lines 160-162) is introduced to show household agents' interactions with their neighbours, and how that influence their protection motivation behaviour. In Lines 311-315, we describe that an agent's decision to develop a coping behaviour is influenced by the number of household agents who implemented a measure. This interaction shows an agent's behaviour can be affected by its neighbours, and its behaviour further affects another agent's behaviour. The state subsidy factor also reflects the interaction between the household agents and the authority agent. However, in our conceptualization, that interaction is one-way (from the authority agent to households).

b. The threat appraisal and coping appraisal as presented in the decision trees (Figures 4 & 5), seems to provide level of rationality and control in agent behavior that far from reality and customized around predict and control. There are no feedback loops in the decision trees on figures 4 & 5 and the processes are assumed causative and linear. I would argue human behaviour is far messier than following coupled of few trajectories in decision making. The role of social network cannot be considered as an external factor as the process of social learning is part of the complex dynamics of interaction between models.

AC: We fully agree with the Reviewer that the rule-based decision trees for agents' threat and coping appraisals are simplified and linear. Human behaviour is complex and challenging to model as many factors play a role for an individual to develop a particular behaviour. Hence, assumptions and abstractions are inevitable in modelling. We used previous empirical studies to define the important factors that affect the threat and coping appraisals of individuals (see Section 3). Some aspects regarding feedback loops can be explained based on the assumptions made. For example, we assumed that (Assumption 13): "If a house has already appraised coping and implemented a measure, they don't appraise coping again, unless they abandon the measure, assuming that they do not implement another primary measure." That means, if an agent already implemented a primary measure, there is no need to go back and update the factors that lead to that decision. Some of these factors (for example, household income and house ownership) are not even affected by the adaptation behaviour of the household.

In general, we acknowledge that there are limitations regarding the threat and coping appraisal method used in our modelling. We will address those limitations in the "Discussion and conclusion" section of the revised manuscript.

c. Having studied the threat appraisal and coping appraisal as shown on Figures 4 and 5, I would clearly be able predict the behaviour of the model without a need for a mathematical simulation. This is quite evident from the results as there are few key factors that drive the results. these are: (i) the design of scenarios and the sequencing of storm events; (ii) household past experience to flooding; and (iii) the role of subsidies in the decision making.

AC: We applied the protection motivation theory to investigate household-level decision making, but we simplified how we modelled the threat and coping appraisals. The linear and deterministic nature of the decision trees may contribute to the predictability of some of the findings, especially the general trend. However, there are several stochastic elements that could have led to unexpected results. Having said that, we believe it is worth building such models as they could be used to explore other influencing factors such as the role of media in agents protection motivation behaviour (as suggested by Reviewr #1). Future researches may also use intelligent decision-making models such as Bayesian Networks as in (Abdulkareem et al., 2018).

We will address this limitation in the “Discussion and conclusion” section in the revised manuscript.

d. The institutions as defined in Table 1 (shared strategies) seems to be oversimplification of the reality which make it hard to generalize the results and make it more specific to the case under consideration. In the US the role of formal institutions as example Floodplain regulations and penalties associated with nonconformance played significant role in the decision making at a household level. Also Flood Insurance and Flood Rating as part of risk hazard played significant role in how household appraise threats that could be fundamentally different from the threat appraisal action and Coping actions as discussed in this tree. Another assumption that the Source of information as provided by government agencies (levees and flood wall provide protection) is highly subjective and debatable. I would argue being part of the flood managers in one of the US localities, we are sending different message to our citizens on not relying on structural measures.

AC: The reason we formulated the institutions as shared strategies (not as rules, for example) is to give agents an option whether to develop a protection motivation behaviour or not. Unfortunately, there are no formal institutions in the study area that oblige households to implement any adaptation measure. Hence, we assumed, introducing institutions as shared strategies would be a reasonable starting point for the study area. As described in Lines 222-226, the five institutions we defined are purely hypothetical and are specific to the case as the Reviewer noted. Agent attributes, initial conditions and assumptions defined (conceptualized) in the model are also specific to the case. Hence, the results are not generalizable. However, the modelling approach can be applied to any case to test FRM policy levers and strategies considering heterogeneous individual behaviours (Lines 595-598). Flood insurance is also not available in Wilhelmsburg (Birkholz, 2014, p. 169). That is the reason insurance is not included in the conceptualization. In the “Discussion and conclusion” section of the revised manuscript, we will specifically mention that the institutions are hypothetical. We will also explain why we formulated the institutions as shared strategies.

Regarding the information promoted by the government agencies, unfortunately, they do not advise households to implement individual adaptation measures. Our knowledge of the case study area and informal discussions with authorities are the basis for our assumption. Restemeyer et al. (2015) also discussed the lack of political capital towards realizing individual adaptation measures and considering dikes as “the best way to protect the city and its people” (see p. 54-55).

e. It seems that the PhD thesis (Birkholz, 2014) and structured survey that was undertaken as part of this greatly inform the conceptualization of PMT (Threat and coping appraisals). Hence there should be more of elaboration to link this study with the work of Birkholz. This could be in a form of appendix if the authors believe it would crowd the paper.

AC: We will add an appendix to elaborate on how (Birkholz, 2014) and the current manuscript are linked.

Reference

Abdulkareem, S. A., Augustijn, E. W., Mustafa, Y. T. and Filatova, T.: Intelligent judgements over health risks in a spatial agent-based model, International Journal of Health Geographics, 17(1), 8, doi:10.1186/s12942-018-0128-x, 2018.