Response to Reviewer #1's comments on the manuscript HESS-2022-362

General comments:

This paper develops an integrated socio-hydrological modeling framework that couples a hydrodynamic model, an agent-based model, and a transportation model to examine household evacuation outcomes under various shelter location plans and human behavior scenarios. The results demonstrate the unique functionality of the model to support flood risk assessment and to advance the understandings of evacuation performances. The manuscript is well organized and written. The logic flow is easy to follow. Tables and Figures are clear and well presented. I think this is a high-quality manuscript, which will contribute to the flood management practice. I have only few minor concerns as follows:

Response:

Thank you very much for the positive comments and excellent feedbacks that have led to significant improvements to this work. We have addressed your comments point-by-point as follows. Note that the text in grey are the reviewers' original comments. The text in blue are our responses to the comments. The text in red are the new additions included in the revised manuscript.

Comment 1:

Lines 184-187: May agents also consider the shelter with least travelling time? please check the assumption.

Response to comment 1:

Thank you for the comment, which helps us to clarify the assumptions of this study. Yes, the agents will seek to evacuate to the safe areas as soon as possible, aiming to minimize total traveling time during evacuation processes. However, during an emergency situation, it is unclear and/or quite challenging for the agents to assess which shelter can ensure the shortest traveling time due to, for example, uncertainties of real-time traffic condition and traffic load (e.g., the number of evacuating agents on the road). Therefore, we follow the classic approach in evacuation simulation and assume that an

agent focuses on choosing the shortest route from its original location to the safe area, thereby choosing a closer shelter in the system as its evacuation destination (Note that a shorter traveling distance is typically associated with a shorter traveling time). In the revised manuscript, we have followed the comment and added some text to elaborate the assumption, which read as follows.

"During flood evacuation processes, the agents seek to evacuate to safe areas as soon as possible, aiming to minimize their traveling times. However, during an emergency situation, it is unclear and/or quite challenging for the agents to assess which shelter can ensure the shortest traveling time due to, for example, uncertainties of real-time traffic condition and traffic load (e.g., the number of evacuating agents on the road). Therefore, we follow the classic approach in evacuation simulation and assume that an agent focuses on choosing the shortest route from its original location to the safe area, thereby choosing the geographically nearest shelter in the system as its evacuation destination." (Lines 194-202)

Comment 2:

Lines 209-212: Will family agents consider at system level? Why will agents want to contribute to system efficiency? Mode 2 should be re-interpreted based on rational assumption.

Response to comment 2:

Thank you for the question that helps us to explain and clarify the motivation of analyzing the two route search modes. Yes, the agents will typically focus on reducing their own traveling times, and do not necessarily consider system efficiency during evacuation processes. Thus, mode 1 represents the case in which every agent focuses on its own evacuation efficiency (i.e., chooses the shortest route for evacuation), while mode 2 represents the case of system-level evacuation efficiency (i.e., all the agents' route choices are optimized at the system level). In this regard, mode 1 is the baseline evacuation scenario and mode 2 is the benchmark scenario. The results of mode 2 can be used to assess the extent to which the evacuation outcomes of model 1 can be

improved by changing agents' route choices. Policy makers can compare the results of the two traveling modes and then improve flood evacuation outcomes by, for example, providing route recommendations for the agents who may encounter/cause severe traffic congestion during their evacuation processes. We have followed the comment and included the following text in the revised manuscript to elaborate the motivation of analyzing the two travel modes.

"It is worth noting that the agents will typically focus on reducing their own traveling times, and do not necessarily consider system efficiency during evacuation processes. Among the above two route search modes, mode 1 represents the case in which every agent focuses on its own evacuation efficiency (i.e., chooses the shortest route for evacuation), while mode 2 represents the case of system-level evacuation efficiency (i.e., all the agents' route choices are optimized at the system level). In this regard, mode 1 is the baseline evacuation scenario and mode 2 is the benchmark scenario. The results of mode 2 can be used to assess the extent to which the evacuation outcomes of model 1 can be improved by changing agents' route choices. Policy makers can compare the results of the two traveling modes to improve flood evacuation management by, for example, providing route recommendations for the agents who may encounter and/or cause severe traffic congestion during evacuation processes." (Lines 235-246)

Comment 3:

In the results section, I think it is better to discuss the specific policy implications and recommendations following each result, from the perspectives of both emergency responders and family agents. In this way, readers can easily link the new findings to management practice.

Response to comment 3:

Thank you for the excellent suggestion. In the original manuscript, modeling results and discussions on policy implications are separated and presented in two sections (Section 4 for results and Section 5 for discussions). We agree with the reviewer that readers may be confused about how the results and policy implications are connected.

In the revised manuscript, we have followed the suggestion and included additional text in the result section to explicitly discuss their policy implications. The new additions are as follows.

"These results can yield policy implications in terms of the number and geographical locations of evacuation shelters needed to meet a particular flood management goal. For example, if the management goal is to evacuate all the residents to a single site, shelter #1 would be the best choice, among the five optional locations, in terms of minimizing the evacuation clearance time. However, for the case of establishing two shelters in the region, shelter set {#2, #3} is a better choice as compared with the other shelter site combinations." (Lines 483-489)

"These modeling results highlight the importance for policy makers to pay explicit attention to households' behavioral heterogeneity during flood evacuation processes. For example, the modeling results show that the variation in agents' departure times can significantly affect traffic load in the road network and evacuation clearance time. Traffic congestion condition can be alleviated if the variation of agents' departure times is larger. Thus, to improve evacuation efficiency, emergency responders may need to divide all the households in the community into a number of groups and guide them to evacuate in batches, rather than let them start evacuation in a chaotic manner without appropriate coordination." (Lines 552-560)

"The comparisons of the two route search methods show that households' route choices play an important role in their evacuation processes. Evacuation clearance time and traffic congestion will be significantly alleviated and become more robust against the change in shelter location arrangement if evacuation routes are optimized. In this regard, policy makers may improve flood management by providing clear guidance to all the households in terms where (i.e., shelter choice), when (i.e., departure time) and through which route (i.e., route selection) to evacuate in emergency conditions. In order to improve evacuation efficiency, households need to follow the evacuation guidance and take the recommended routes to travel to safe areas." (Lines 628-636)