Response to Referee #1

We wish to thank the Referee for his/her time and effort reviewing the manuscript. We greatly appreciate the constructive comments and suggestions, which we have carefully addressed in this response. Where applicable, changes are proposed to the manuscript accordingly (and marked up for clarity). Following the guidelines of the NHESS Editorial Board, the revised manuscript was not prepared at this point.

Natural hazard risk of Complex Systems Part II offers a pilot case study of how graph theory can be used to assess the holistic risks of a system. Focusing on Mexico city, the authors build a model of the interconnections between 6 typologies representative of emergency management phase and long term impacts of emergencies at blocks, fuel stations, schools, fire stations, hospitals, and crossroads. The authors are able to extrapolate DRR interventions from the findings presented in the model. In doing so they seek to present the feasibility of their new risk assessment approach, show the benefits of how it can be used for DRR, and suggest future research. As with the first article, this article is based on the premise that graph theory is a new and unexplored mechanism for assessing risk in complex systems.

- As I described in the review of the theory paper, there is a significant literature on the topic. It should be discussed, as should the gap that this research fills.

In order to avoid a repetition of contents in the two companion papers, these two topics (literature review and discussion of the gap that this work aims to address) are mainly discussed in part I. As the issues raised by the Referee in this comment are also present in the review of part I, we have opted to not duplicate the response here for the sake of organization.

- The authors also need to clarify how representative their case is to the reality of flooding in Mexico city.

We agree that this was not sufficiently clear in the original manuscript. In order to address this, we propose adding the following explanation to the text:

> L89: "Given the very large scale of the city, certain simplifications and hypotheses had to be assumed for conceptualizing the network. Furthermore, the choice of element typologies, the connections between them and the definition of rules are also done considering the availability of data, which were provided by the Engineer Institute UNAM México D.F. While this data is only partially representative of the entire exposed assets present in MCFD, we consider it suitable for the specific purpose of this work, which is to illustrate the proposed approach and show the benefits of using it."

- What is the role of other schools, hospitals, police stations, etc. outside the research area? Can they pick up the slack or offer alternative services if the components inside the boundaries of the modeled system fail? Are there ways to bypass the road network if it is compromised, such as going by foot or, if flooded, by boat? The cascades described in the article may be less severe than the model shows given these connections and human adaptability/ingenuity.

This comment is related to the issues of open-ended systems that have also been mentioned by the Referee in the comments to part I of the article. Furthermore, it points out relevant questions regarding the redundancy of the system in response to a failure. We agree that these two aspects were not clear enough or sufficiently developed in the original manuscript, and propose the following modifications:

> L90: "The selection of typologies, connections and the studied geographical area define the boundaries of the system. These simplifications and hypotheses of the real open-ended systems, while necessary to enable the computational analysis, should be recognized and taken into account when evaluating the results of the analysis (Clark-Ginsberg et al., 2018)."

> L104: "The link between two elements of two different typologies was set up based on the geographical proximity rule: each specific service is received by the nearest provider (e.g., a Block receives the Education service from the closest School, and the School receives the Recovery service from the closest Fire Station). This simple assumption is due to the lack of data available at this stage; in case of more data, it would be possible to define relation more accurately (e.g. School offers education service to its zoning), but without changing the general validity of the method. Note that this hypothesis does not consider the redundancy that might exist between some services, which would necessarily influence the propagation of cascade effects."

> L290: "The strong correlation between hubs and authority explain the results described above. However, it is necessary to underline that these outputs also reflect the assumption of the rules of proximity adopted in this model, where the network has no redundancy by construction. The redundancy can change the values of hub and authority of the nodes, and therefore influence the magnitude of cascade impacts that are presented in the next section."

L327: "We acknowledge that these results can be affected by two important assumptions adopted in this research: 1) the redundancy within the network is not considered, and 2) the services are provided only by the elements inside the MCFD (as elements outside this area are not considered). Changing these assumptions could result in different cascading impacts. Regardless, ~~The~~ the framework illustrated here ~~can be then used~~shows the potential to quantitatively assess indirect impacts, which can subsequently be integrated into collective risk assessments."

L335: "In this application, the complexity of Mexico City is depicted by modelling certain selected typologies of elements of the urban system and assuming simplified rules of connection between them. Furthermore, the system complexity acknowledged in this study is restricted to the elements inside the MCFD and neglects any potential contributions from outside elements. The definition of a geographical boundary condition, which is a straightforward assumption in the traditional reduction approaches, can be controversial in the holistic approaches that aims to model the emergent characteristics of open-ended systems."

L342: "Adopting different rules (e.g. a provider could deliver its service to as many elements as inside a defined distance) would allow a degree of redundancy of the network, which could significantly change the impact of a hazardous event."

- *This is challenge to all risk assessment techniques that purport a holistic, systems level overview of risk– assumptions and limitations should be made explicit. Answering these questions and tying the article to the literature could improve this paper, which has the potential to be a useful contribution to the research on network analysis and risk.*

We agree that such challenges and limitations, typical of the systemic perspective, should be made more explicit. We believe that the modifications proposed above, based on the Referee's previous comments, will considerably improve the manuscript in this regard.

References

Clark-Ginsberg, Aaron, Leili Abolhassani, and Elahe Azam Rahmati. 2018. "Comparing Networked and Linear Risk Assessments: From Theory to Evidence." *International Journal of Disaster Risk Reduction* 30(April):216–24. Retrieved (https://doi.org/10.1016/j.ijdrr.2018.04.031).