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Reply on RC2

Antonio Francipane et al.

Author comment on "A paradigm of extreme rainfall pluvial floods in complex urban areas: the flood event of 15 July 2020 in Palermo (Italy)" by Antonio Francipane et al., Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2021-61-AC2>, 2021

Responses to Referee #2

Referee: This research investigates on flood risk management of complex coastal urban areas. The case study of the city of Palermo is presented. Severe flooding events impacted the city in recent years. The meteo-climatic forcing and the dense urbanization are the major causes of flood risk for the city where natural channels were substituted by artificial sewer/drainage systems, urban growth increased the nuisance effects of flash floods linked to climate change with related increase of the frequency and severity of rainfall events.

The flood monitoring systems of the city seems also to be inadequate, and not being able to provide accurate, timely and distributed information of inundation events especially in the pre-event and during the event phases. The rainfall-induced fast flooding phenomena were the subject of citizen-driven observations that may present an important source of information to understand and mitigate the adverse impacts of floods.

As a result, this paper explores methods for developing useful and validated flood models in support of flood risk management and mitigation. Authors demonstrate to have solid knowledge, and scientific hydro-modelling tools (integrating geospatial, hydrologic and hydraulic modelling) and to provide interesting insights for how to develop accurate flood models and validate findings by means of available information. This is a relevant topic for this journal, matching NHESS topics of interest. Nevertheless, I see there are some major issues with this work that I do hope authors will address to improve this submission that – to my view and knowledge – is of interest for a potential publication on the NHESS journal. The general remarks and specific comments are provided here below.

Authors: We thank the Referee for the efforts in doing a so in-depth analysis of this work, which has surely improved the quality of our manuscript, and the positive feedback. Please find below our responses to the comments.

Referee: 1 - The introduction is missing to specify the scientific question or specific science advancement(s) proposed in this work. In the introduction you extensively introduced the issues of coastal Mediterranean areas affected by intense rainfall storms and flooding, with focus on the Palermo case study. Then, while mentioning uncertainties associated to urban growth and climate change, you referenced the flood adaptation and mitigation measures and more specifically the floodability concept. The use of integrated

hydro-modelling is also cited (but not properly references with citations of authors' works or related works to the methods used). As a result, it is not clear – reading the introduction – where this work is specifically pointing to. The manuscript of course include these information afterwards (methods, results later inserted), but I'd suggest authors to insert a paragraph in the introduction to properly guide the reader, citing relevant works and share with the reader the general and specific scientific aims of this work. See also next comment in this regard.

Referee: 2- The use of crowdsourcing is spread out from the methods to the results, but not cited in the introduction. I see this part as relevant for this work. You are validating your flood model using crowdsourced data. While waiting the revised work to understand the major focus (see general comment n.1) and you show how satellite images (supplementary) as well as standard flood observations from the regional agencies are not supporting with actionable information for post-event reconstruction. So, as also shared in specific comments, I see the material section as the one needing to be expanded to include the crowdsourcing and also other EO material citing pros and cons, inaccuracies and opportunities. As also suggested in the specific comments, this work needs some restructuring (some material information inserted in the results etc., see specific comments).

Referee: 3 - The manuscript title and the discussion. I am missing to see the link of the title and introduction to the discussion points. To what I read I think the "paradigm" in the title is not motivated and adequately linked to the final outcomes and critical discussion point of this work. To date, I'd think that post-event reconstruction would be a keyword and focus of this work. But, I see also a lot of potential in the information on meteo-climatic forcings and the way authors design the hydro-modelling of the complex system where natural channels and related hydrologic forcings are linked to the modelling within the city. The complex hydrologic domain is also a key factor of the challenges of similar cases.

Response: We really thank the Referee for the constructive comments and for pointing out some aspects to be clarified. Since the first three comments are somehow connected to each other, we decided to provide a unique answer to those.

Reading the paper in the light of the Referee's comment, we admit that the Referee is completely right in saying that *"it is not clear – reading the introduction – where this work is specifically pointing to" and he/she is "missing to see the link of the title and introduction to the discussion points"*. For this reason, following the precious indications of both the Referees, in the new version of our manuscript we have modified the Introduction to stress in a better way the aims of our work. We essentially tried to stress three main aspects that are: 1) the importance to develop a modelling framework to simulate and analyze pluvial flooding events in a complex urban area that can be used as a paradigm for many other cities that may experience similar phenomena as the city of Palermo; 2) the importance of crowdsourced data in the urban environment that is characterized by the lack of observed data (i.e., water levels) to be used as a reference for the calibration and validation of the models; 3) the importance to develop a new way to deal with the flood risk in urban settlements in all those cases in which the economic, social, and cultural conditions do not allow either to renew the old urban drainage systems, no longer suitable to drain the rain coming from some extreme events that are likely to always become more frequent and heavier, or to build new ones. In this perspective, the modelling framework developed on occasion of the flooding event that affected the city of Palermo on 15 July 2020 can be assumed as a "paradigm" for other cities. We also inserted a paragraph to guide the reader through the aims of this work. On this regard, the Referee can read an extract of the new Introduction in the following:

In this perspective, this study aims at capitalizing on this experience to create a

hydrological and hydraulic modelling framework that can be assumed as a “paradigm” for those cases in which i) complex hydrologic domains are linked to complex systems of natural channels integrated within an urban settlement, ii) the domain is forced with extreme precipitation, iii) there is a lack of observed data but a plenty of crowdsourced data that can be used qualitatively to verify the reliability of results returned by the modelling chain. In addition, the study attempts to address questions regarding the way to deal with the flood risk in urban settlements where the economic, social, and cultural conditions do not allow either to renew the old urban drainage systems, no longer suitable to drain the rain coming from some extreme events that are likely to always become more frequent and heavier, or to build new ones.

We also understand the Referee’s concern about the need to add some material about the use of crowdsourcing and satellite data, citing pros and cons, in pluvial flood risk studies to the Introduction and Material and Methods sections. With this regard, the Referee can read the new part added in the Introduction in the following:

Modelling such a type of floods is never easy, especially when these affect very complex urban areas. Bulti and Abebe (2020) provided a review of the main flood modelling methods adopted for the study of pluvial floods highlighting the benefits and drawbacks of each approach. Some approaches, such as the rapid flood spreading (Lhomme et al, 2009; Wallingford, 2006), are easy to apply but return only the final state of inundation. Other approaches, such as the 1D, are recommended for studies that do not require high precision in describing the surface runoff routing, while still others, such as the 2D approach, seem to be more suitable for applications in urban areas where there is no stormwater drainage or the influence of stormwater drainage is considered insignificant on the flood phenomenon under the study. Coupled models (i.e., 1D-2D) can provide accurate information but being computationally expensive both in terms of run-time and data requirements. In all cases, however, reliable modelling of the phenomenon always requires many kinds of information and level of accuracy, which are not always available or easy to obtain.

In this perspective, one of the main issues to deal with is the lack of observed data to be used as a reference for the calibration and validation of models (See, 2019). Indeed, differently than the case of fluvial (or river) floods in gauged systems, where the monitoring of the rivers makes available measures (i.e., water level, discharge, etc.) in different points of the domain, in urban areas there are no gauged sites that provide water level observations. Nowadays, one of the possibilities to deal with such a problem is represented by remote sensing data, which can provide the opportunity to overview flooded areas quickly and precisely (Di Baldassarre et al., 2009; Bates, 2012; Grimaldi et al., 2016). However, remote sensing data may not be always adequate to describe the evolution and the effects of a pluvial flood either because they are often not timely available for the satellite orbit revisit time (Annis and Nardi, 2019), especially when floods have rapid temporal evolution and limited flood area extent (Notti et al., 2018), or because the substantial areas of urban ground surface may not be visible due to the shadow caused by buildings (Dengsheng et al., 2010; Mason et al., 2014; Notti et al., 2018; Mason et al., 2021). In addition to remote sensing data, in recent times, data gathered by citizens (i.e., crowdsourced data) are becoming increasingly important, even because of the spreading of smartphones and social media users (Hilbert, 2016). The growing availability of crowdsourced data, especially in urban areas, such as pictures and videos acquired by mobile devices (e.g., smartphones, tablets, digital cameras, etc.) and content sharing on social media platforms (e.g., YouTube, Facebook, Instagram, etc.), offers the possibility to gather precious information about the temporal and spatial evolution of flooding events to be used for the calibration of hydraulic models. Many studies have used crowdsourced data to investigate flood events in the last years (Annis and Nardi, 2019; Mazzoleni et al., 2015; Mazzoleni et al., 2018; Smith et al., 2017; Yu et al., 2016).

In addition, following the specific comments of the Referee, we have added a new subsection in the Material and Methods section in which we have moved some parts of the original manuscript and added a brief description of the type of crowdsourced data used in the study. The Referee is referred to the new version of the manuscript to read this new subsection.

Referee: 4 - Writing and structure. I think the language needs some polishing and improvements. See specific comments. The structure editing may help in making the flux of information easier to read (as already requested in previous general comment n.3).

Response: We deeply checked and revised the text by trying to improve the grammar and the sentences structures throughout the entire manuscript.

Referee: Specific comments. See attached commented PDF.

Response: We really thank the Referee for his/her effort in such a deep analysis and for his/her useful indications that have surely improved the quality of our manuscript. The Referee can find our corrections in the attached file entitled *Replies to specific comments*.

Please also note the supplement to this comment:

<https://nhess.copernicus.org/preprints/nhess-2021-61/nhess-2021-61-AC2-supplement.pdf>