Reply to reviewer 1

We would like to thank the reviewer for careful reading throughout our manuscript and for valuable suggestions and comments. In this document, we reply to each of these. **L** refers to the line number. For example, **L65-70**, refers to lines 65-70.

Reviewer 1		
No	**Comment**	**Reply**
1	This study presents an approach for considering related risks for wildfires and floods which is applied to produce baseline and future predictions for a single case study (Ebro river basin). This risk assessment method utilises the Fire Weather Index (FWI) and a number of indicators which were weighted according to expert feedback via an Analytical Hierarchy Process approach. The importance of considering the cascading, interlinked risks of fires and floods are clearly outlined and the chosen case study provides a useful demonstration and context.	We would like to thank reviewer for the acknowledgement of our manuscript that it provides a valuable demonstration and context of cascading floods and fires.
2	However, further information about the expert panel decision-making (in addition to the information provided in the supplementary info) would be helpful given the important role it plays in the final risk assessment method and the chosen weightings. In particular, I would welcome more information regarding the variability in opinions offered by the experts (ideally quantified to show the variability around the final, chosen weightings at each stage).	The referee has a valid point regarding more detailed AHP results. We will include a summary of the AHP results on exposure, hazard, and vulnerability prioritization in the revised Supplementary Information. Furthermore, we have incorporated expert opinions concerning the selected weights in the main text, specifically in the result section e.g., opinions about runoff and fire weights in **P11L225-P12L231**. In the revised version, we will provide further elaboration and reference these statements to the AHP results.
3	Additionally, it may be useful to provide further context in the results/discussion by explicitly comparing the expert panel opinions to the existing literature where possible.	We thank the feedback from the reviewer. However, it is important to note that detailed weights for all indicators used in this study are not available from the references. Hence, we conducted the AHP analysis (**P11L204-205**). In the literature, only a few articles were found discussing the increase of runoff due to wildfire in percentages (e.g., Folador et al., 2021; Leopardi and Scorzini, 2015) (**P18L356-362**). However, they did not discuss the weighting factors for analyzing flood risk. Our study is pioneering in flood risk analysis by considering the cascading effect of wildfires. We will add a summary on the expert opinions in the revised manuscript to provide further clarification.
4	Additionally, a large part of the fire activity is characterized by FWI predictions and it is important that the meaning of these predictions, the historical context of this index and it's role as a fire danger prediction tool, along with limitations if	We appreciate the reviewer suggestions regarding the FWI predictions and their limitations. This was discussed in **P18L377-P19L391**. In the revised manuscript, the discussion about FWI will be expanded and

	looking to extrapolate expected fire occurrence from FWI are clearly outlined. This is addressed in some of the references cited in the manuscript as highlighted in the specific comments below.	additional references will be added accordingly.
5	Line 21: Is there a more appropriate reference here than Wilby and Keenan which so far as I can tell does not address the link between fire and drought?	We appreciate the reviewer for spotting the mismatch. We will address this by adding references Mazdiyasni and AghaKouchak (2015) and He et al. (2022) in the revised version, which discuss the increase of drought, dry spell, and heatwaves.
6	Lines 30-31: Double check this statistic in the provided reference. Is this based on the info given at the start of the introduction in this reference? If so this is actually only over the last 20 years which may be worth highlighting. Also the % of the population affected seems a bit higher for flooding with droughts having affected 25% of the population.	In this sentence, we described the global population affected by floods, which was estimated around 2.5 billion people (2.5/8.1*100=30%) over the last 20 years, according to Tabari et al. (2021). We will revise the sentence.
7	Lines 44-46: Perhaps rephrase this section since one of the conclusions of Versini et al 2013 study is that 'our assumptions can appear as a low hypothesis that should underestimate the impact of forest fire on the hydrological response'. This seems to contradict the claim here that this study in an exception in not underestimating the amplification effects. Perhaps this is more about being understudied or receiving little consideration in which case this could be clarified in-text.	The referee has a valid point regarding the impact of wildfires in flood risk assessment. We will rewrite the sentence into: "Concerning the third source of complexity, despite amplifying the risk of floods, the impacts induced by wildfire are often given little consideration in conventional flood risk assessments".
8	Lines 73-74: Could clarify that Balasch et al. state that this was the mean figure for the period of 1920-2000.	Indeed, the mean precipitation of 622 mm is averaged from the period of 1920-2000. We will add this information in the revised manuscript.
9	Lines 82-83: Can you clarify/ rephrase for clarity here? I think from what's written in Terrado et al, that 38 people/km^2 is the average population density of the basin, rather than the average density for these 2 largest cities.	We agreed with reviewer that the population density of the whole basin is 38 people/km^2. We will clarify this statement in the revised version.
10	Lines 91-93: There may be specific motivations for dealing with wildfire management at various spatial scales. Is there other evidence that can also be provided here to support the statement that 'flood management appears to have a higher priority than fire management' e.g. a comparison of spending/funding?	At least in Europe, we have flood directive on the assessment and management of flood risks (2007/60/EC of the European Parliament). However, we could not find any information regarding fires directive although there are policies to protect the EU's forests against fire. We will add this information in the revised version.
11	Line 100: Are these previous literature reviews published and available to cite here?	In this sentence, when referring to the literature review, we meant the process of data collection to obtain all the indicators employed in this study. The sources of these data are presented in Supplementary Table S1 and S2. We will revise the text accordingly.
12	Lines 104-105: Can you clarify that Fire Weather Index provides a prediction of fire	We thank the reviewer for the suggestions. We will revise the statement from "future fire

	danger? And perhaps accompanied by clarification of the distinction from 'probability' which will also be affected by other factors e.g. the limitations highlighted in Abatzoglou et al, 2019. In this context, is 'probability of future fire events' a suitable term? As the probability (including likelihood of ignition) will vary with other factors e.g. location relative to population centers, public access, social dimensions which are not considered in a meteorological index which predicts the fire weather and danger were a fire to occur. See also the discussion in Di Giuseppe et al 2018 which you have cited. e.g. pg 5360 'The FWI is already widely employed in fire management and control (Lee et al., 2002). However, it does not explicitly model fire evolution, but it is a measure of fire danger (Van Wagner, 1987). Even for extreme FWI values there is a need for a stochastic component, i.e. ignition, to start a fire. For this reason, situations in which FWI is high but no fire is recorded are not uncommon'	events" to "prediction of fire danger". Additionally, the paragraph will be expanded to incorporate a detailed description of FWI. Regarding the suggestion about the likelihood of ignition, we have discussed this in **P18L378-P19L391.** We will include the suggested limitation factors of FWI in the revised manuscript. Furthermore, we will incorporate the limitations of FWI as described in Di Giuseppe et al. (2018) into the new version of the paper.
13	Line 116: As discussed later, were only highways considered? If so can you clarify this here when introducing the distance from roads parameter.	In this study, we only considered the distance from the highways as one of the exposure components since they play a major role in transportation (**P6L123-124**). We will describe this information here.
14	Lines 117-120: Is there any way to further assess the validity of this weighting approach? e.g. by further exploring the heterogeneity of economic activity in some of these regions e.g. by using population as a proxy for this or incorporating a distance from major town/city element?	Indeed, the reviewer has a point here. However, assessing the total GDP per province based on factors such as the types of economic activities in the province, distance from major towns/cities, or population can complicate the analysis. A more straight forward approach would be to calculate the weighting of GDP for each province based on the area in m^2 that lies inside the basin.
15	Lines 122-123: Was there a particular reason for the choice of this cut-off length or is this choice arbitrary?	We used 50 km as a proxy for the length to exclude small streams and only obtain the main channels that contribute more to flood vulnerability. It is arbitrary.
16	Lines 123-124: In relation to an earlier comment, were these the only roads considered? If so can this be clarified earlier when distance from roads is first mentioned (line 116). Perhaps this parameter could even just be labelled 'distance from highways' throughout or 'distance to major roads' as in Roy et al 2021.	We agreed with the reviewer and thus, we will clearly indicate distance from highways, following Roy et al. (2021). We will also modify the label from distance from road to distance from highways.
17	Lines 141-143: Are the size/number of personnel at fire stations considered at all? Is number of fire stations a better indicator (and/or easier to analyse) than for example total spending on fire resources?	In this study, we focus solely on the number of fire stations as the institutional capacity indicator, and hence we do not consider the number of personnel and budget. These indicators are not freely available online and

	Indeed, McLennan and Birch outline some of the complexity involved in the prevention and management stages alone in their discussion of various factors including station staff size, average age of firefighting staff, degree of co-operation between staff, additional private firefighting resources. Could you provide some further discussion of the suitability and limitations of number of fire stations as an indicator?	difficult in quantification for future scenarios. The reviewer also acknowledges this complexity, as described in McLennan and Birch (2005). For our baseline scenario, we use the most recent number of fire stations available. However, for future scenario, we need to make assumptions on the number of future fire stations. For SSP1, we assume 10 fire stations will be established while only 7 stations will be established for SSP5 (**P7L168-174**).
18	Lines 165-175: Can you clarify if all assumptions are listed here? If not could you provide a full list of unavailable exposure/vulnerability indicators and corresponding assumptions made e.g. in the Supplementary data. Can you explain how these assumptions were chosen? Does this involve the previously mentioned expert interviews or is this an arbitrary choice?	We provide all indicator assumptions in Supplementary Table S2, including the links to obtain the datasets. For many indicators, we calculate the future scenarios using growth factors derived from IIASA SSP public database version 2 (**P7L166-167**). Thus, we do not arbitrarily choose the number of future indicators, rather, we base our projections on established growth factors.
19	Lines 191-192: Would danger be a better word here than effects? Or perhaps just refer only to fire weather index?	We thank the reviewer for spotting typo. Here we meant future wildfire effect, indicated by FWI.
	Line 205: Understand the potential need for anonymity around experts involved but is it possible to provide any further details about specific areas/extent of expertise?	We will indicate their fields of expertise in the revised version.
20	Lines 227-231: How do these expert comments relate to any existing approaches in the literature? Given these complex considerations, is the scenario well-defined enough for experts to pass judgment on relative importance? In the future, would more local scale analysis involving expert analysis be required? Or for example, could a further set of scenarios be designed for expert feedback in which additional factors could be incorporated e.g. different landscape types, distance from river. Understanding of course that these are considered in other parts of the model.	In general, all experts agreed that wildfires could increase runoff, and this was confirmed by previous studies (Seibert et al., 2010; Folador et al., 2021) (**P18L357-358**). However, to the authors' knowledge, no study has discussed the weighting of runoff and wildfires for analyzing the flood hazard index. This was the primary reason for conducting the AHP. The scenario for weighting all the indicators are well-defined and we guided the whole AHP processes. We also calculated the consistency index to check whether answers of experts are consistent and the consistency ratio to make sure the respondents' weighting is consistent and validated (Roy et al., 2021) (Supplementary Method). For future research including local scale analysis, more exposure and vulnerability indicators could be included in the analysis for baseline study. For future scenarios, however, one should take into consideration on the available datasets or other reasonable assumptions need to be made. We will elaborate this information in the discussion section.
21	Line 232: For comparison, could you also show burnt area and runoff maps in this	We will combine Supplementary Figure S1 with Figure 3 in the revised manuscript.

	figure? So that the influence of the chosen weighting can be understood.	
22	Lines 237-239: So is it an increase in burnt area as a result of increased FWI which results in the increased FHI?	Yes, a strong increase in the FWI in RCP8.5 leads to higher wildfire component and thus FHI. We do not state burnt area since it is a prediction of wildfires and not a real burnt area, unlike in the baseline scenario.
23	Lines 242-244: Could more information about the variability in weighting assigned by the expert panel be provided?	We will provide the results of AHP in the Supplementary Information.
24	Lines 266-267: Was this the area in which the greatest difference in expert opinion was observed?	The highest difference in expert opinion is found in exposure indicators, such as population density (7.8%) and distance from river (6%). The figures of weight percentages including their error bars will be provided in Supplementary Information.
25	Lines 272-273: How does this compare to findings in the existing literature as were outlined in the introduction to this study?	Although distance from fire station is deemed less important than slope steepness and economic capacity, it is ranked as the third highest above saturated hydraulic conductivity, soil texture, and elevation (**P13L265-266**).
26	Lines 273-274: Would greater consensus have been reached by asking experts only to consider a smaller number of more relevant indicators?	We believe if the number of indicators is smaller, the expert will still weight the indicators based on the importance and thus, we will obtain the same rank but with different weights.
27	Lines 283-286: Are there existing studies regarding the influence of hydraulic conductivity which can provide further context for the decisions of the expert panel?	Yes. Versini et al. (2013) show an increase in river discharge after forest fire occurred in the Llobregat river basin, Spain (**P6L127-128**). Moreover, Seibert et al. (2010) and Folador et al. (2021) also show an increase in runoff after wildfire occurred (**P18L357-358**).
28	Lines 296-297: Can you explain how decision fits within the context of understanding and mapping existing risk (prior to any other management interventions) and for predictions based upon assigned levels of societal intervention.	We agree with the experts that FVI should get more weight and then followed by the exposure and hazard. The flood risk could be better managed if the vulnerability is reduced by increasing societal interventions such as improving economic and institutional capacities and physical interventions such as slope, regreening, and soil improvement works. Hazard and exposure, on the other hand, are less manageable.
29	Lines 301-303: What was the break-down of expertise in the panel? How significant was this difference in perspective?	We will provide the expertise of the experts in the revised manuscript. The background of the experts shows a different perception on the flood risk. As it was explained, fire experts consider fuel management practices as a manageable component while flood experts consider wildfires are a wicked problem due to human influence (ignition). We will discuss this accordingly.
30	Lines 306-307: What was the break-down of expertise in the panel? How significant was this difference in perspective?	The expert who indicates that exposure and vulnerability should be equally weighted has a background in social science and works on some technical aspects. This shows that experts' perspective is influenced by their backgrounds and their working environment.

		We will incorporate this in the revised version.
31	Lines 324-325: Can you clarify how notable this finding is? Or whether in fact this is just entirely due to the weightings assigned by the expert panel?	The burnt area is weighted for 30% in the flood hazard index (**P11L222**). Moreover, flood hazard index is only counted 20% in the calculation of flood risk compared to flood exposure index and flood vulnerability index (Eq. 4, **P15L300**). Thus, the effect of wildfires is greatly reduced in the flood risk calculation. We will clarify this in the revised version.
32	Lines 342-343: Given the role of FHI, how much is the effect of wildfires controlled by the choice of weighting for burnt area: runoff?	For future flood risk analysis, the most influential factor is the FWI and not the weights assigned for wildfire (30%) and runoff (70%). Strong increase in FWI for RCP8.5 counteracts the decrease in runoff.
33	Lines 356-357: How much does it indicate this vs. indicating the perceived role cascading effect of wildfires given the role of the expert panel in determining the various weightings?	All the experts agreed that burnt area affects runoff and therefore most of them gave high weight to runoff.
34	Lines 360-362: How possible would it be in future studies to further incorporate these previous findings to augment or replace the need for expert weightings?	A simple method to replace expert weightings is by using a correction factor. For example, if the runoff increases by a factor of 1.2 after wildfire occurred as found in Leopardi and Scorzini (2015), then the FHI is equal to 1.2 x runoff and FHI is equal to 1 x runoff for evaluating FHI without wildfire. We will discuss this in the revised version.
35	Lines 364-366: As discussed in Bedia et al 2013, does fuel moisture (and/or linked meteorological conditions) also play a role in limiting these large fire events?	Yes, the occurrence of wildfires largely depends on forest (fuel) management, vegetation and land use practices, and fuel moisture (**P19L382-384**).
36	Lines 378-379: As per previous comments, can you explicitly address the limitations of using FWI as a proxy for fire probability?	We discussed this limitation in **P20L434-438**.
37	Line 432: How did the annual timeframe affect the chosen FWI? Was this an average value for a whole year? Or a maximum value?	The FWI employed in the study is the mean fire weather index value over the European fire season (seasonal FWI, June-September) for 2050 and 2100 averaged from multi models. See Supplementary Table S2 for detailed information.
38	Section 4.4: Can you also discuss any limitations involved with the expert panel and the Analytical Hierarchy Process and associated data?	The limitation of AHP and expert panel will be discussed in the revised version.
39	Technical Corrections Figure 2: Proofing comment - check figure quality/resolution as slightly blurred in places. Line 149: Typesetting issue '1971 -2000' Line 179: 'USDA' - Acronym needs to be defined on 1st use. Line 312: Typo: 'into intervals of 16,7% per class' Line 365: Typo: 'can be related to that the Mediterranean'	We thank for the feedback on Figure 2. We will check the quality of the figure. The space will be added. We will add the acronym of USDA. We will change comma with dot. We will rephrase the sentence accordingly.

Additional References:

Folador, L., Cislaghi, A., Vacchiano, G., and Masseroni, D.: Integrating Remote and In-Situ Data to Assess the Hydrological Response of a Post-Fire Watershed, Hydrology, 8(4), 169, https://doi.org/10.3390/hydrology8040169, 2021.

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Mazdiyasni, O., and AghaKouchak, A.: Substantial increase in concurrent droughts and heatwaves in the United States, PNAS, 112(37), 11484-11489, https://doi.org/10.1073/pnas.1422945112, 2015.

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Seibert, J., McDonnell, J. J., and Woodsmith, R. D.: Effects of wildfire on catchment runoff response: a modelling approach to detect changes in snow-dominated forested catchments, Hydrology Research, 41(5), 378–390, https://doi.org/10.2166/nh.2010.036, 2010.

Versini, P. A., Velasco, M., Cabello, A., and Sempere-Torres, D.: Hydrological impact of forest fires and climate change in a Mediterranean basin, Natural Hazards, 66(2), 609–628, https://doi.org/10.1007/s11069-012-0503-z, 2013.

Leopardi, M. and Scorzini, A.: Effects of wildfires on peak discharges in watersheds [Technical Reports], iForest - Biogeosciences and Forestry, 8(3), 302–307, https://doi.org/10.3832ifor1120-007, 2015.