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Reply on RC1

Pauline Brémond et al.

Author comment on "Process-based flood damage modelling relying on expert knowledge: a methodological contribution applied to the agricultural sector" by Pauline Brémond et al., Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2021-398-AC1>, 2022

We thank referee 1 for his review of our paper. We particularly appreciate the critical and detailed analysis he made and we think that taking these remarks into account will bring real added value to the paper. In particular, this will allow us to provide more illustrations of the modelling steps and better highlight the work we have done. In the following, we have taken up all the remarks, questions and suggestions made by referee 1 and numbered them from 1 to 10 for general comments. Sometimes comments have been subdivided into sub-sections in order to respond specifically to each suggestion. This is the case for general comments 7 and 9. Referee 1's comment is given in bold and our response follows the comment in plain text

General comment 1 : The manuscript deals with the modelling of flood damage to agriculture, one of the (relatively) less investigated sector among the exposed assets. Although this makes the paper a potentially interesting contribution for NHES, it actually suffers from several criticalities that, in my opinion, prevent its publication in its current version.

- We would like to thank referee 1 for his interest in the problematic of the article. We hope that the answers to the comments will improve the quality of the article so that it can be published.

General comment 2 : I would suggest the Authors to reconsider the way they presented their work, by better emphasizing the modelling aspects related to the proposed tool (floodam.agri), rather than presenting a 'philosophical' paper, with limited usefulness.

- We do not share referee 1's assertion that this is a philosophical article. On the contrary, with this article we want to propose a reflection on the methodology of process-based model development which is based on strong field experience and is articulated with strong operational needs. It seems to us that referee 1 has not perceived the operational scope in our description of the methodological approach and its application. We will try to make this aspect more explicit, particularly in the description of the case study.

General Comment 3 : the actual structure of the manuscript makes it very confusing, with repetitions

- We agree with referee 1 and we will carefully consider this comment and ensure that redundancies are removed.

General Comment 4 : the article does not give the right emphasis on the model itself and on its innovation, which should be the main core of the paper. I would therefore re-arrange the structure of the manuscript by first presenting the model (with more details on it) and then explaining why it should be considered a "good" model and what are its current limitations.

- floodam.agri model is currently described in details in a French report (Agenais et al, 2013¹). For this reason, we do not wish to make the floodam.agri model the core of the article but rather an illustration of the fact that applying a rigorous methodology makes it possible to consider a reuse and/or an adaptation of the generic parts of the process-based model with a feeding of specific data (at different scales and on different contexts).

General comment 5 : On the contrary, the Authors just presented a description of the "archetype of a model" and then they try to explain (with limited success) why their proposed model should be considered as "the" model.

- Our ambition in the article was not to present floodam.agri as "the right model". We will carefully review the article to avoid this being implied. We are well aware that very efficient models have been developed before, in particular the models developed by the FHRC and the AGDAM model developed by the USACE. We wanted to share our experience here because these process-based models are difficult to reuse because they are too context specific. We developed floodam.agri between 2010 and 2013 to be able to produce damage functions on a national scale because it was impossible for us to directly reuse existing process-based models in the French context. We really think that the modelling effort we have made could be reused and capitalised at the international level. But for this to happen, it seems to us that a rigorous methodological framework is needed.

General comment 6: In particular, the first part of the manuscript is very general, since the definition of the methodological framework for the development of a process-based flood damage model (Table 1) is not "new", given that the listed questions are typically taken into account in the development phase of any process-based model.

- Based on our experience and the review of existing literature, we believe that this methodological contribution is necessary. From our point of view, although many initiatives to develop process-based models have been carried out, we are not aware of a methodology to capitalise on the development of process-based models. We will take this remark into account by insisting on this point in the literature review associated with the presentation of the framework. We will be very careful to include in the literature review any additional element concerning this point that referee 1 may communicate to us.

General comment 7 : More importantly, the way the Authors presented their model is also not very convincing. Indeed, unfortunately, when presenting floodam.agri, they failed in properly addressing some of the questions raised by themselves. I especially refer to the ones labelled as "Axis 1: explicit assumptions", i.e. model and data transparency, which (I agree with them) should be regarded as one of the most important features of a model. I just

mention hereafter some examples related to the lack of details on modelling assumptions within the model.

- We agree with referee 1 that the description of floodam.agri lacks in its current state a concrete example that would better highlight how assumptions are taken into account in a more pedagogical way. The main difficulty we have encountered is to account for the extent of all the phenomena dealt with in a systematic way over all the families of crops present in France. However, we agree that, as things stand, the explanation of the assumptions is not sufficiently illustrated in our article. In response to this remark, we propose to take the example of a rather complex crop, the apple in arboriculture, since several biophysical processes and behaviours are involved. This will allow us to illustrate the various points listed by referee 1 in the form of a box. For other crops, we propose to refer to the report Agenais et al (2013).
- **GC 7.1: biophysical process taken into account to develop crop susceptibility functions: if you heavily claim for explicitness, the only Table 4 cannot be considered enough, but I would expect a thorough description on how the crop susceptibility functions were developed from a methodological point of view (e.g. by also considering a few crops as example and explaining how the different processes impact on the produced functions: i.e. how the plots reported in Figure 1 have been derived? (why I observe abrupt changes in damage at certain water depths and duration thresholds? Which are the driving mechanisms for these specific patterns?). I think this would be very interesting to know from a modeler's perspective and this could be a real added value to the manuscript.**
 - Using the example of apples in arboriculture, we will show how the data collected during the interviews and focus groups was implemented in terms of yield and quality variation. For example, we will show the graphs of yield variation for this crop (p227 to 228 of our report) and describe the biophysical processes mentioned by the experts (e.g. at the flowering stage, yield decreases are mainly due to root asphyxia...). We will also indicate the processes taken into account for the variation in quality by specifying the uncertainties expressed by the experts and the way we have dealt with them.
- **GC 7.2: interviews with experts: no detailed information is provided within the manuscript on how the Authors actually took advantage of experts' knowledge for developing floodam.agri. Again, I would suggest you to better describe the following aspects: how the questionnaires were structured (templates may also be included as supplementary material), how the collected data were analyzed and, in particular, whether you found uncertainty in the collected data and you handled this uncertainty in developing the model. Moreover, (if I understood correctly) the same experts were involved both in the development as well as in the "validation" (I would suggest not using this word) stage of the model: doesn't this introduce a bias in the results of model "validation"?**
 - We propose to put the interview grid developed for arboriculture and the materials discussed during the interviews (vegetative cycles) with the experts and translated into English in an appendix. We could also annex the presentation materials proposed to the experts during the arboriculture focus group.
 - Referee 1 is right to point out that there may have been divergent versions of the damage or variations in intermediate consumption collected in interviews with the experts. This is why we used the focus group method for the validation phase of our model. During the focus groups, the experts were able to discuss the assumptions and reach a consensus. Sometimes, processes had not been sufficiently explained in individual interviews. In this sense, we propose to give elements of the report of the focus group that was conducted on arboriculture. In particular, we will list, as an example, the elements that were modified following this focus group for the parameters of the model for apple crop.

- Although referee 1 suggests not to use the word validation, we think it is important to keep this term as it seems to us an essential step which is missing most of the time in process-based modelling approaches due to lack of time or methodology. However, we found that when we reformulated and modelled the hypotheses formulated by the experts, modifications could be made. We propose to introduce the term partial validation to take into account referee 1's remark.
- **GC 7.3: farmers' decisions: I would find interesting to know if you could report more (quantitative) details on the driving factors for farmers' behaviors.**
 - We will respond to this comment of referee 1 in conjunction with comment GC2.1 of referee 2. We propose to create a synthetic table that lists all the possible behaviours of farmers according to the crops considered. In addition, we propose to illustrate these behaviours with the case of apple crop.
- **GC 7.4: the description of damage to soil should be better explained: it is not clear how tilling and cleaning are assessed, as I would expect these to be highly influenced (minimum) by the hazard parameters, soil and crop type. The modelling of damage to the equipment needs to be better clarified as well.**
 - We propose to put in the biophysical processes section an illustrative table of how soil damage has been taken into account for arboriculture according to flooding parameters. Then in the decisions related to soil section we give the working times and values assigned for each level of damage (translation of table C.11 p238 of the Agenais 2013 report).
- **GC 7.5: could you provide details on how the flood impact to the quality of the crops is modelled in floodam.agri?**
 - The answer to the question concerning the quality of the crops will be dealt with under remark 6.1.

General comment 8 : The Authors may reply to my comments raised above that it would be impossible to provide full details of a (complex) model within a Journal paper, with limited available space. This is true, but, at the same time, you cannot claim a full lack of transparency (as you are experiencing also with your paper) of other models in the literature, by also mentioning this as the reason from writing the present article. So, the Authors' comment on this point (P8-L186-189) appears to me a bit subjective (and not fair), given that the cited Agride-c is a well documented, explicit model, which seems to be originated by the same need for model transparency claimed by the Authors.

- We agree with referee 1 that it is impossible to give all the modelling assumptions for all the crops treated. We believe that the proposal to treat the apple crop in an exemplary way and to refer to the Agenais report (2013) and to the online damage functions² for the other crops makes it possible to answer this remark.
- Concerning Agride-c and its presentation in Molinari et al. (2019) and Scorzini et al. (2020), we did not write that there was a full lack of transparency in presenting this model, this assertion seems to us excessive. It turns out that this model can be seen as a transfer from floodam.agri to the Italian context as it is largely based on the work presented in Agenais et al (2013). Indeed, the crop damage coefficients that largely determine the damage are directly adapted from Agenais et al, 2013. Similarly, the crop pursuit strategies and soil damage are very similar to what was proposed in Agenais et al, 2013. We have expressed the idea, without elaborating on it, that this transfer was not carried out in a way that allows for capitalisation. For example, the "validation" part by the local experts consulted is not documented in a sufficient way to understand what are the limits of the assumptions retained in floodam.agri for the Italian context. One possibility is that the description of floodam.agri was not explicit enough to discuss these assumptions, which is one of the reasons for writing our article. We propose to make this point more explicit.

General comment 9 : Another aspect that would deserve more attention is the actual applicability of the model. The Authors mentioned that floodam.agri has been already applied in France in several projects. It would be then very valuable if you could give more details on these experiences, e.g. which were the main difficulties for application, necessary adaptations and/or assumptions in the input data (for both hydraulic and vulnerability / exposure data). Indeed, floodam.agri, as any micro-scale process-based model, requires very detailed input data, with some of them usually not know/difficult to know or with high local variability, then necessarily requesting some kind of averaging or simplification process in order to make the model actually applicable at the river basin/ reach scale.

- Referee 1's remark GC9 suggests that it is not completely clear that floodam.agri is a model for producing damage functions at different scales. In the paper, we show how we used floodam.agri to produce national damage functions in France. These damage functions were parameterised for use in cost-benefit analyses of flood management projects in France. We used national databases to estimate yields, prices, intermediate consumptions... (Table 9 and 10). The important steps for the production of ready-to-use FDFs were steps 3 and 4 in Figure 4 as they were necessary to make the FDFs compatible with the database for spatial location of crops (RPG). We propose to explicitly answer questions GC9.1 and GC 9.2 as follows.
- **GC 9.1: how the problem of crop rotations was handled for identifying crop type in each plot?**
- For the national application, we proposed to create a mixed function to manage rotations if necessary on the application territory. If the 3-year rotation is wheat, wheat, rape, the weight assigned to the wheat function is 2/3 and the weight assigned to rape 1/3. This explanation will be added in the section case study/ready to use flood damage functions.
- **GC 9.2: In which month of the year the flood was supposed to occur in the damage calculations (did they consider the month with the highest probability of flood occurrence / or did they calculate a weighted average damage, with the weights represented by the probabilities of flood occurrence in each specific month ?)**
- For the national application, it was proposed to simplify the season parameter and we defined 4 seasons whose periods are specified in table 12. The consultancy firms that carry out cost-benefit analyses have the possibility, if their hydrological model allows them, to produce the agricultural damages for these 4 seasons within the framework of the CBA. However, in the model, the time step is the week, which leaves the possibility of adjusting to the local context. This explanation will be added in the section case study/ready to use flood damage functions.

General comment 10: I finally do not agree with the statement at P27.L615-616 (as well as the one in the abstract, P1.L5-8), or I may did not interpret well the Authors' point, which I then ask to be better clarified. According to me, the model framework must be certainly general, but, especially when modelling damage to agriculture, it is strictly necessary to be context- specific, in order to capture the typical features of the region where the model is applied, otherwise we are oversimplifying reality, which can be an acceptable solution (a "full adaptation" may be a huge effort, since while some components can be easily adapted (e.g. yields and price values), there are others that highly change from a context to another (e.g. the cultivation practices and operations)), but that we must be aware of it

- Referee 1's comment GC 10 suggests that it is not yet clear enough in the article at this stage which parts are generic and which are inputs, intermediate inputs and outputs. We propose to address this by improving Figure 4 and 5 by merging them and making

the above explicit. In particular, our major contribution is to model damage processes and behaviours that are thought to be generic because they are based on the vegetative cycle of the crops that can be calibrated for each study case on the weeks of the year. We will explain this point around figure 4. Concerning the adaptation to another context, we propose to add a reflection on the perspectives in terms of applicability on a micro scale and the reflections that arise in terms of variability of behaviours (adaptation to floods, variability of technical itineraries).

Minor comment: although the sense is always clear and English usage is almost correct, the paper needs to be proofread as there many typos (e.g. "litterature", "diven", "developped", just to cite some) and few weird sentences (e.g. P2.L24, P2.L41).

- We are aware that English still needs to be improved. We have tried to make our words as clear as possible in this non-native language. We thank referee 1 for pointing out the typos, which will be corrected. Knowing the publication process of NHES, we have full confidence that the final review process of English, in which we will be fully involved, will achieve the necessary language standards.

¹<https://hal.inrae.fr/hal-02600061/document>

²[https://www.ecologie.gouv.fr/levaluation-economique-des-projets-gestion-des-risques-naturels#:~:text=Fonctions%20de%20dommages%20fluvial%20agriculture%20\(XLS%20%2D%20411.5%20Ko](https://www.ecologie.gouv.fr/levaluation-economique-des-projets-gestion-des-risques-naturels#:~:text=Fonctions%20de%20dommages%20fluvial%20agriculture%20(XLS%20%2D%20411.5%20Ko)