

## ***Interactive comment on “The relationship between precipitation and insurance data for flood damages in a region of the Mediterranean (Northeast Spain)” by Maria Cortès et al.***

**Maria Cortès et al.**

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Manuscript: nhess-2017-278 "The relationship between precipitation and insurance data for surface water floods in a Mediterranean region (Northeast Spain)".

Responses to reviewer #1:

Reviewer #1 (Highlight): The manuscript is analysing the link between the causes and impacts of floods by means of precipitation measurements and insurance claims. The main objective of this study is to identify the best indicators for describing this relationship. The topic is of great interest. However, the manuscript is weak due to a

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few but important points.

Response: We wish to thank the anonymous referee for his/her useful and constructive comments. Each specific point has been addressed in the manuscript as explained in the following document.

Referee's Comment: The use of the Spearman rank test on the data is to test the correlation between two indicators. However, this test is not providing any information for drawing conclusion. The correlation between precipitation and flood losses is to be expected and reported anywhere. Indeed, other literature goes far behind correlation only and analyses the form of the relationship resp. provides e.g. minimal rainfall intensity thresholds for losses. The added value of this study is therefore disputable.

Response: We would like to thank you for this very important comment. To address it, we applied a logistic regression model to gauge the probability of large damaging events given a certain precipitation amount, an approach that is frequently used for this kind of modelling study (Kim et al., 2012; Wobus et al., 2014).

Referee's Comment: A detailed definition of the terms "floods", "pluvial floods", "flash floods" and "urban floods" is missing. It is not clearly defined which processes are relevant for the respective insurance claims. This is important because of the chosen approach in defining the aggregation units. Depending on the size of the aggregation unit, the spatial distances between rainfall (in the catchment) and flood impacts (in the floodplain) may be very different for riverine floods and pluvial floods (in situ precipitation).

Response: The insurance company (CCS) offers insurance compensations for all the claims related to flood damages, regardless of the type of flood. Nevertheless, the floods that most frequently affect the region of study, the Mediterranean, are caused by in situ precipitation (pluvial floods or, in broader terms, "surface water floods") (Llasat et al., 2014). Surface water floods can be thought of as the most general form of rainfall-related (pluvial) floods (Bernet et al., 2017). For this reason, the hypothesis of

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the study is that precipitation is the main cause of damaging floods in Catalonia, and it is expected that flood insurance data will show a strong correlation (Cortès et al., 2017). Taking into account the limitations of the data, we decided to work on a basin scale. For each basin and event, the maximum 24 h precipitation and total flood compensation was estimated. In the case of the MAB, the availability of precipitation data for lower time intervals (30 minutes) allowed us to make a comparison for both results. Finally, we added this sentence in the manuscript: “Most floods that have affected the region of study, Northeast Spain, are surface water floods. This type of floods can be regarded as coming under the most general definition of rainfall-related floods (Bernet et al., 2017), including pluvial floods but also flooding from sewer systems, small open channels, diverted watercourses or flooding from groundwater springs (Falconer et al., 2009). River floods that affect great distances are very rare in the region, and are only related to catastrophic and extended floods (for the analysed period only the October 2000 floods were of this type). Nevertheless, these are usually absorbed by reservoirs. It is therefore expected that flood insurance data will correlate strongly with precipitation and surface water floods.”

Referee's Comment: The authors chose three different spatial aggregation units: regional, basin, and local scale. With this, the study ignores the Modifiable Areal Unit Problem (MAUP) as described in Openshaw (1984). The size and shape of the aggregation units may influence the results of the test. This arises because the authors do not explicitly differentiate between losses to houses due to pluvial floods and riverine floods as exemplarily shown by Bernet et al. in this special issue (<https://doi.org/10.5194/nhess-2017-136>).

Response: As mentioned before, we decided to work by aggregating the data on a basin level and for the MAB region, because the available data are too sparse to support our statistical assessment on a municipal scale. On the other hand, the floods in question, as we have explained before, are pluvial floods. Furthermore, we considered another spatial aggregation based on the Spanish State Meteorological Agency

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(AEMET) warning areas, obtaining similar results (included in the supplementary material).

Referee's Comment: The interpolation of the rainfall measurements of the single stations and the aggregation method to the different spatial units is not described.

Response: Due to the existence of few meteorological stations, for precipitation data we used the maximum over 24 h recorded for each basin and event. There was no interpolation process. In order to better clarify this point, we add: “Because the available data are too sparse to support our statistical assessment on a municipal scale, we assessed the precipitation-compensation link for Catalonia as a whole. That is, we sampled pairs of the response variable (i.e. the compensation series) and the maximum 24 h precipitation for each basin, and pooled them into one sample for the entire region (Catalonia) to correlate them. For each event there can be more than one pair of values, depending on the number of affected catchments. From now on we will use the expression “flood case” for each pair of values corresponding to a basin affected by a flood event. This area is large enough to have a fairly large sample size for analysis, but small enough that the causes of flood damages are likely to be similar across the area.”

Referee's Comment: The authors analyse insurance claims in the period 1996-2015. While the compensations are adjusted with the consumer price index, the increase in the total stock resp. changes in the overall exposure to potentially flooded areas in this period are not considered. In the study period, a relatively high increase in the total building stock should be expected due to the construction activities before the financial crisis in 2008. Thus, the losses in the insurance dataset may be supposed to a remarkable instationarity.

Response: We agree with the reviewer. Modelling insurance compensations is a complex issue due to the limitations in observational data and the concurrence of a variety of factors that affects them. For instance, in order to statistically link rainfall and insur-

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ance compensation, both precipitation and monetary data would need to be compiled precisely and consistently over time and across the region. While precipitation data follows a formal quality control, the data for insurance compensations are no standardised. For instance, the value of assets exposed and insurance coverage may change over time (Barredo et al., 2012). Unfortunately, precise data on the value and location of assets exposed are not available. However, we show that rainfall data can be used to extract information on damages in Catalonia. To do so, we applied a logistic regression model to gauge the probability of large damaging events given a certain precipitation amount. That is, our aim is not to estimate the precise magnitude of the monetary compensation, but to estimate when a “large” damaging event will occur given a certain precipitation amount. In addition, we take into account the relative impacts of socio-economic factors on damage, considering not only the total damage, but also the damage per capita (DPC) and damage per unit of gross domestic product (DPW).

Referee's Comment: The analysis of the correlation between precipitation and compensation paid was made on the basis of the recorded flood events (or flood episodes). The definition of a flood event (above 75th percentile) is not made transparent resp. not clearly enough described.

Response: We have changed this part of the study. In order to define a flood event we used the INUNGAMA database (Barnolas and Llasat 2007; Llasat et al., 2016a), from which we took the event dates and duration. This database records all the flood events that have affected Catalonia, most of them caused by in situ precipitation (surface water floods).

Referee's Comment: The paper has to be reworked fundamentally.

Response: The revised manuscript has been thoroughly rewritten. One of the most important points is that we now model the compensations with a logistic regression strategy, testing the sensitivity of our results to the different threshold used to define the events. We have carried out a major overhaul of the data processing and the

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methods and techniques applied. We are confident that these major changes have improved the statistical significance of the analyses, and improved the clarity of the results presented.

References:

Barnolas, M. and Llasat, M. C.: System Sciences A flood geodatabase and its climatological applications: the case of Catalonia for the last century, (2005), 271–281, 2007.

Bernet, D. B., Prasuhn, V. and Weingartner, R.: Surface water floods in Switzerland: What insurance claim records tell us about the damage in space and time, *Nat. Hazards Earth Syst. Sci.*, 17(9), 1659–1682, doi:10.5194/nhess-17-1659-2017, 2017.

Cortès, M., Llasat, M. C., Gilabert, J., Llasat-Botija, M., Turco, M., Marcos, R., Martín Vide, J. P. and Falcón, L.: Towards a better understanding of the evolution of the flood risk in Mediterranean urban areas: the case of Barcelona, *Nat. Hazards*, 1–22, doi:10.1007/s11069-017-3014-0, 2017.

Falconer, R. H., Cobby, D., Smyth, P., Astle, G., Dent, J. and Golding, B.: Pluvial flooding: New approaches in flood warning, mapping and risk management, *J. Flood Risk Manag.*, 2(3), 198–208, doi:10.1111/j.1753-318X.2009.01034.x, 2009.

Kim, Y. O., Seo, S. B., & Jang, O. J. (2012). Flood risk assessment using regional regression analysis. *Natural hazards*, 63(2), 1203-1217.

Llasat, M. C., Marcos, R., Llasat-Botija, M., Gilabert, J., Turco, M. and Quintana-Seguí, P.: Flash flood evolution in North-Western Mediterranean, *Atmos. Res.*, 149, 230–243, doi:10.1016/j.atmosres.2014.05.024, 2014.

Llasat, M. C., Marcos, R., Turco, M., Gilabert, J. and Llasat-Botija, M.: Trends in flash flood events versus convective precipitation in the Mediterranean region: The case of Catalonia, *J. Hydrol.*, 541 (September 2002), 24–37, doi:10.1016/j.jhydrol.2016.05.040, 2016a.

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Openshaw, Stan, 1984. The Modifiable Areal Unit Problem. Geo Abstracts Univ. of East Anglia, Norwich (Catmog: concepts and techniques in modern geography).

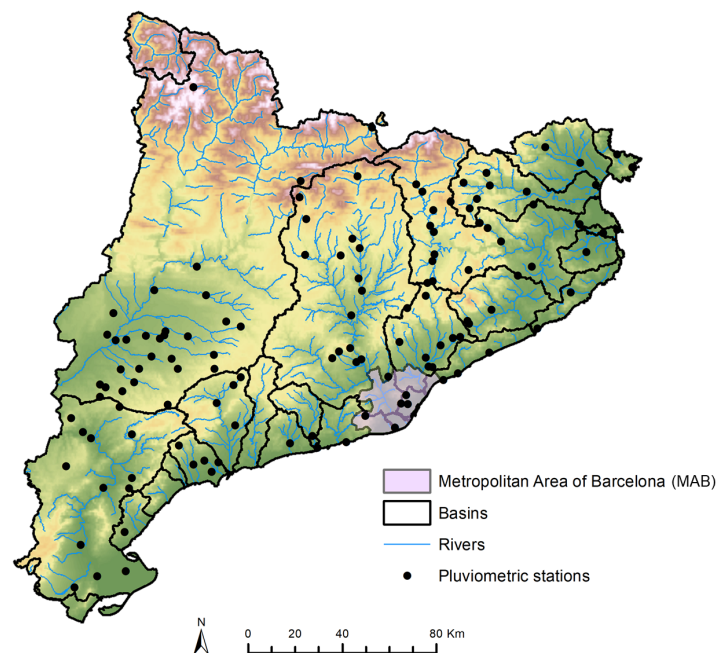
Wobus, C., Lawson, M., Jones, R., Smith, J., & Martinich, J. (2014). Estimating monetary damages from flooding in the United States under a changing climate. Journal of Flood Risk Management, 7(3), 217-229.

Please also note the supplement to this comment:

<https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-278/nhess-2017-278-AC1-supplement.zip>

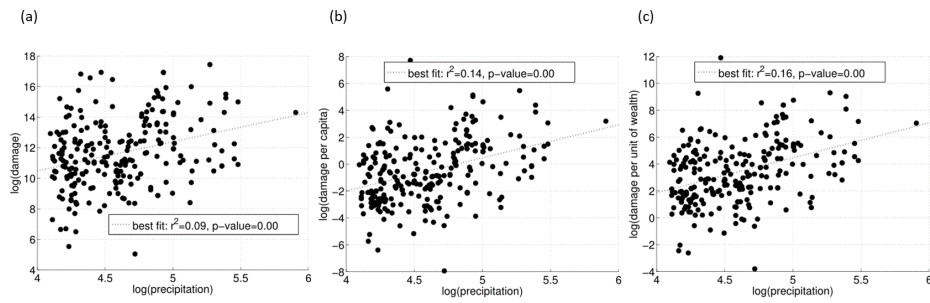
Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2017-278>, 2017.

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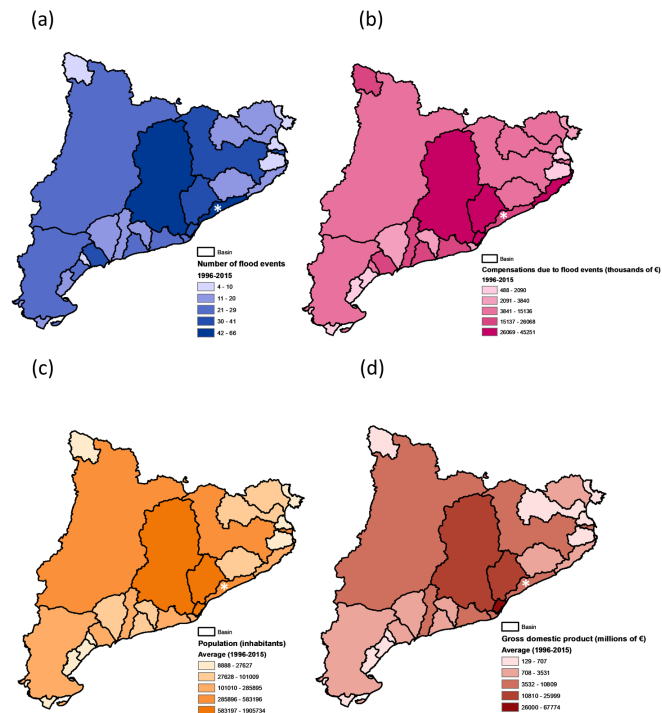
**Fig. 1.** Map of Catalonia showing the aggregated basins, the Metropolitan Area of Barcelona (MAB), the main rivers and the pluviometric stations used.

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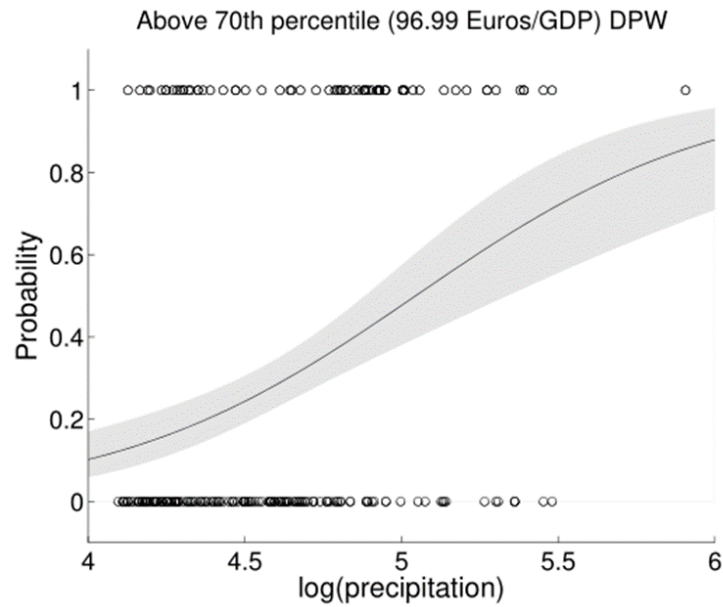
**Fig. 2.** Scatter plot between basin-aggregated maximum precipitation in 24 h and (a) total damages (D); (b) damage per capita (DPC); and (c) damage per unit of wealth (DPW), for flood events recorded in Catalo

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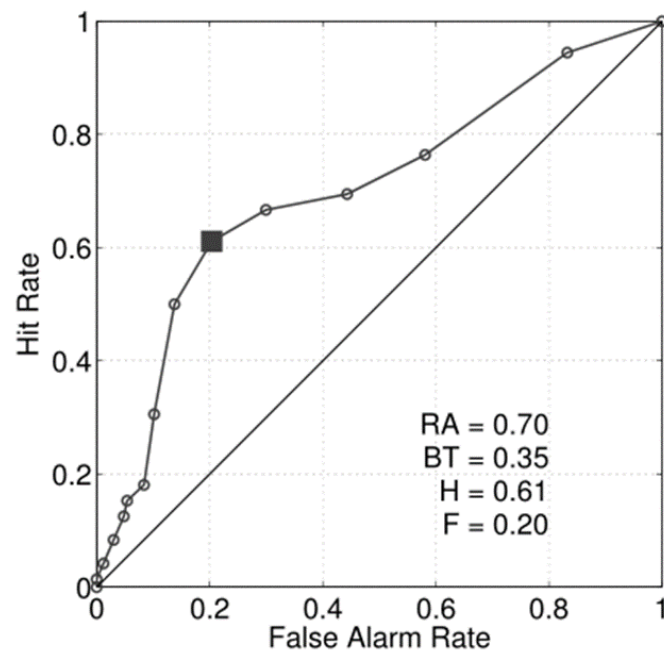
**Fig. 3.** Basin distribution of (a) flood events (1996-2015); (b) total insurance compensations for floods made by CCS (1996-2015); (c) average total population; and (d) average gross domestic product. Asterisk

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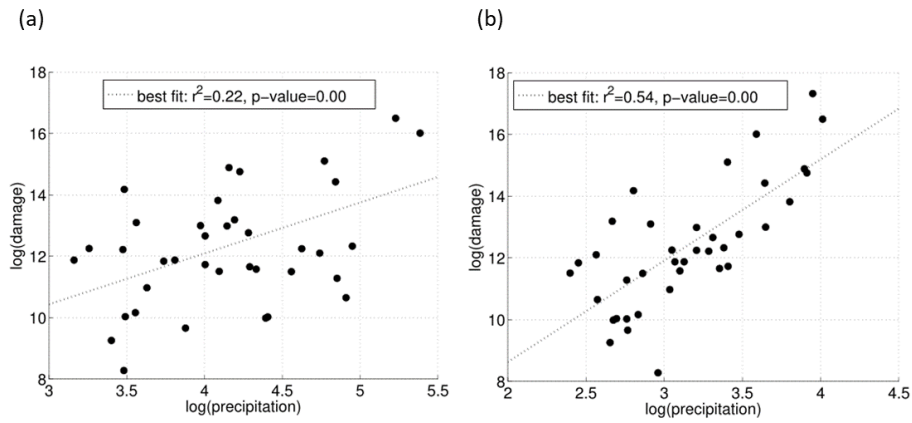
**Fig. 4.** Example of logistic regression result to model DPW damages above the 70th percentile as a function of precipitation (log-transformed). The solid line indicates the best estimate while the shaded band

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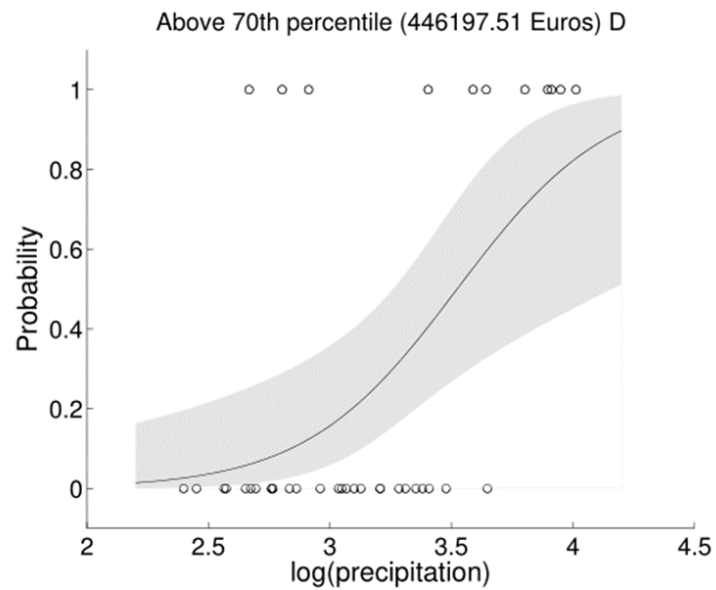
**Fig. 5.** Relative operating characteristic (ROC) diagram for above 70th DPW predictions using the logistic regression of Eq. (1). The open dots indicate a set of probability forecasts by stepping a decision th

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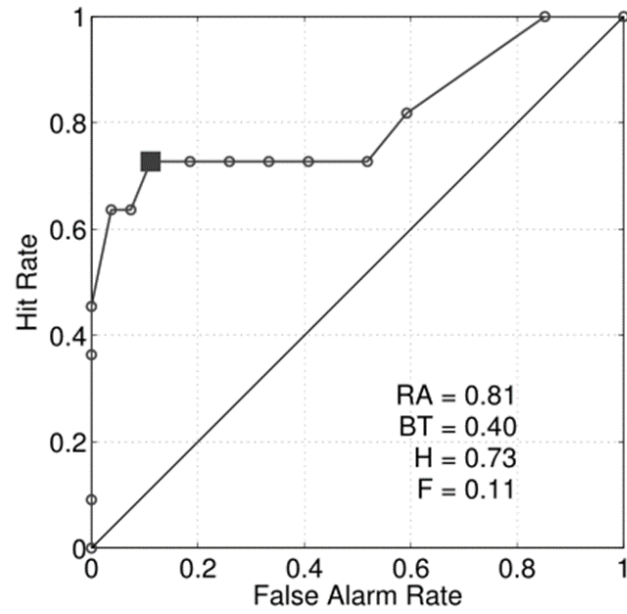
**Fig. 6.** Scatter plot (a) damages (D) versus 24 h precipitation and (b) damages (D) versus 30 minute precipitation.

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**Fig. 7.** Example of a logistic regression result to model damages (D) above the 70th percentile as a function of 30 minute precipitation for the MAB. The solid line indicates the best estimate while the shaded

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**Fig. 8.** Relative operating characteristic (ROC) diagram for predictions for damage indicator D above the 70th percentile for the MAB using the logistic regression of Eq. (1). The open dots indicate a set of p