First of all, the authors want to thank the referees for the work and time devoted to review the manuscript. We know that all comments will serve to improve the quality and understanding of the work and we hope we have properly answered all the suggestions.

Lines are referred to the track-changes manuscript.

Reviewer #2:

The study addresses the analysis of the future evolution of river floods in the city of Ourense (NW Spain), where flooding of the Miño river can cause significant damage. In particular, the historical and future precipitation data from the CORDEX project are used as input in a hydrological model (HEC-HMS) which, in turn, feeds a 2D hydraulic model (Iber+). For each model, hydrological simulations were carried out considering both historical (1990-2019) and future (2070-2099) periods.

Major comments follow.

In the Introduction the novelty of the study with respect to the state-of-the-art knowledge must be emphasized and the main objectives of the study must be better clarified.

We agree with the reviewer. The novelty of the study and the main objectives have been clarified in the new version of the manuscript (Lines 58-76).

"For all the above mentioned, the main aim of this study is focused on the analysis of the future evolution of risk river flows in the regional domain delimited by the international Miño-Sil basin (NW Spain), and specifically, on the associated floods caused in the city of Ourense. Ourense is the local domain where flooding of the Miño river can cause significant damages (Fernández-Nóvoa et al., 2020). For that, the integration of hydrological-hydraulic models, together with specific information on flood thresholds in the area under scope, will allow a detailed analysis of those particular events capable of causing a significant impact in the study area. In this sense, most of the previous studies dealing with flood projections analyzed the expected changes in extreme flows and floods associated with different probabilities or return periods (Te Linde et al., 2011; Huang et al., 2013; Arnell and Gosling, 2016; Alfieri et al., 2017; Padulano et al., 2021). Here, the particular flows that effectively cause damage in Ourense city, not necessarily associated with characteristic return periods, as well as the specific areas that will be most affected by the associated floods, will be analyzed. This approach allows the analysis to be adapted to the particular characteristics of the area under scope, thus contributing to addressing one of the most important challenges facing the scientific community for the coming decades: assessing the implications of climate change on extreme events at the local level. To achieve these objectives, the river flows in the Minho-Sil basin will be simulated for an entire historical period of 30 years and also for an entire future period of 30 years using data provided by climate models, analyzing not only the changes in the probability of risk flow situations but also the evolution of flood risk in particular areas of the city. The results will provide detailed information to decision-makers to help them take accurate and effective measures to mitigate the damages associated with future extreme events. In addition, it is important to highlight that although the methodology developed is focused on the Miño-Sil river basin, it can be generalized to any basin and location, showing its potential in future applications."

Although in principle, the methodology seems appropriate, several details must be added to let the reader evaluate the correctness of the adopted approaches. In particular, the following key points should be better explained.

The capability of the EUROCORDEX RCMs models to represent precipitation over the area under investigation was tested by comparing RCMs precipitation data and field data by analyzing the entire distribution of precipitation data through the Perkins' test and also the extreme precipitation values through the P99 test. I assume that the Perkins' test is sensitive to the choice of the bin size and, in turn, the number of bins used to calculate the PDF. The authors should provide additional details on the test metrics and comment on this point, as well as on the advantage of this method with respect to statistical measures, such as bias, root mean square error, correlation, and trend analysis, commonly used to quantify model performance (see for instance doi.org/10.5194/nhess-20-3057-2020).

We agree with the reviewer that there are several analyses that can be suitable for validating the performance of climate models, depending on the scope of the study. Some works, such as the article recommended by the reviewer, use some statistical parameters such as bias, root mean square error, standard deviation, or mean values, among others, to validate climate models. However, these statistics are usually applied at monthly, seasonal or annual scales. In addition, some of them (e.g. means, standard deviations…) do not provide information of the entire data distribution, and therefore, a good fit in these statistics do not guarantee the adequate determination of some patterns of the data, which can have an important impact on the hydrological procedure. To develop our study, focused on flood analysis, we need to use the best available temporal scale, since floods are highly dependent on daily or even more precise time scales, and also corroborate the good determination of precipitation patterns, especially those referring to extreme events. Therefore, we need to validate those CORDEX models presenting a good skill to reproduce precipitation in terms of daily scale. In addition, as discussed in Perkins et al. (2007), the monthly, seasonal or annual analysis can hide biases or systematics errors that can be detected on the daily scale. Therefore, for the reasons commented above, we opted to maintain the validation of the CORDEX models using the PDFs, since, in addition, if the model is able to simulate an entire PDF, this also demonstrates the capability to deal with rare or very extreme values that can become more common in the future, as explain in Perkins et al. (2007). Therefore, we consider that this procedure is adequate for the purposes of our study. As for the number of bins, 20 bins were considered in the study (Table 2). Validation results show to be independent of the number of bins. We also complemented the test based on PDFs with the statistical analysis focused on analyzing the deviation of CORDEX models when representing extreme values, those able to cause flood situations. We consider that these analysis methods allow an adequate validation of the CORDEX models for the purposes of this study. Following reviewer recommendation, we provide additional details of the validation procedure, clarifying and explaining better this selection in the new version of the manuscript (Lines 139-153).

"The capability of each of the more than 30 RCMs models to represent precipitation over the area under the scope was tested comparing RCMs precipitation data and field data from pluviometers managed by MeteoGalicia for the common period 2008-2020. Although there are several valid approaches to validating CORDEX models (Perkins et al., 2007; Peres et al., 2020; Des et al., 2021) the present analysis is focused on testing both the entire distribution of precipitation data, the so called Perkins' test (Perkins et al., 2007) and also the extreme precipitation values (those above the 99 percentile, P^{99} test). One of the main advantages of the Perkins' test, based on probability density functions and developed on a daily scale, is that the good fit between the measured and simulated data proves the capability of the model to detect extreme values that can be unusual in the historical period but more common in the future due to the implications of climate change (Perkins et al., 2007). This allows selecting the most appropriate models according to the scope of this study, since the extreme precipitation events are usually behind the most important river floods. In addition, the complementary analysis focused on evaluating the deviation of the models in relation to the extreme precipitation values reinforces the validation process. In this sense, only those models surpassing 90% in the Perkins' test and with a deviation less than 25 % in the extreme values were considered. In addition, in order to reinforce the detection of those models especially suitable for representing extreme events in the area under scope, the comparison was carried out over the wet season (November-March) when the flood events take place (Fernández-Nóvoa et al., 2020)."

The transformation of precipitation into the corresponding river flow was carried out using the semi-distributed model HEC-HMS. The authors should provide additional information on the hydrological model used for rainfall-runoff transformation (including the loss method for assessing the net precipitation). Also, please explain how the historical and future flows of the river were obtained on an hourly scale, given that precipitation data were at the daily scale.

Additional details on the hydraulic modeling used for flood mapping are also required.

Additional information related to hydrological and hydraulic models was provided in the new version of the manuscript (see section 2.3 Hydrological and Hydraulic Models).

"**2.3 Hydrological and Hydraulic Models**

The transformation of precipitation into the corresponding river flow was carried out using the semi-distributed model HEC-HMS (Feldman, 2000; Scharffenberg, 2018; U.S. Army Corps of Engineers, 2018). This hydrological model was selected for being one of the most robust and widely adopted for hydrological procedures worldwide. In addition, this model has shown accurate results for the basin under scope as well as other nearby basins (Cea and Fraga, 2018; González-Cao et al., 2019; Fraga et al., 2020; Fernández-Nóvoa et al., 2020). In particular, Fernández-Nóvoa et al. (2020) shown an effective hydrological procedure for the area under scope using HEC-HMS and considering: i) the Soil Conservation Service (SCS) curve number for the rainfall infiltration calculations; ii) the SCS unit hydrograph to convert the rainfall excess in surface runoff; iii) the linear reservoir methodology to simulate the corresponding baseflow; iv) the Muskingum-Cunge method to deal with runoff propagation along the main channels. HEC-HMS is freely available on its official website (https://www.hec.usace.army.mil/software/hec-hms/).

The hydraulic model Iber+ was used to evaluate floods in Ourense city. Iber+ is a numerical tool that solves the 2D depth-averaged shallow water equations applying the finite volume method (García-Feal et al., 2018), and it is freely available on its official website (http://iberaula.es). In particular, the equations resolved by Iber+ model can be written as follows:

$$\frac{\partial h}{\partial t} + \frac{\partial hU_x}{\partial x} + \frac{\partial hU_y}{\partial y} = 0 \tag{1}$$

$$\frac{\partial hU_x}{\partial t} + \frac{\partial}{\partial x}\left(hU_x^2 + g\frac{h^2}{2}\right) + \frac{\partial}{\partial y}\left(hU_xU_y\right) = -gh\frac{\partial Z_b}{\partial x} - \frac{\tau_{b,x}}{\rho} + \frac{\partial}{\partial x}\left(v_t h\frac{\partial U_x}{\partial x}\right) + \frac{\partial}{\partial y}\left(v_t h\frac{\partial U_x}{\partial y}\right) \tag{2}$$

$$\frac{\partial hU_y}{\partial t} + \frac{\partial}{\partial y}\left(hU_y^2 + g\frac{h^2}{2}\right) + \frac{\partial}{\partial x}\left(hU_xU_y\right) = -gh\frac{\partial Z_b}{\partial y} - \frac{\tau_{b,y}}{\rho} + \frac{\partial}{\partial x}\left(v_t h\frac{\partial U_y}{\partial x}\right) + \frac{\partial}{\partial y}\left(v_t h\frac{\partial U_y}{\partial y}\right) \tag{3}$$

where h is the water depth, U_x and U_y represent the averaged horizontal velocities, g is referred to the acceleration of the gravity, ρ is the density of the water, v_t is the turbulent viscosity, Z_b is the bed elevation, and τ_b represents the bed friction. The bed friction is computed with the Manning formulation as:

$$\tau_{b,x} = \rho g h \frac{n^2 U_x |U|^2}{h^{4/3}} \qquad \tau_{b,y} = \rho g h \frac{n^2 U_y |U|^2}{h^{4/3}} \tag{4}$$

Iber+ is an implementation in C++ and CUDA of the Iber model (Bladé and Cea, 2014). This new and optimized code achieves a two-order of magnitude speed-up by using graphical processing unit (GPU) and high-performance computing (HPC) techniques. These improvements allow to overcome the time constrained limitations of this type of climatological studies which require a large number of simulations. Iber+ has shown to provide accurate results in several studies conducted in the area under the scope and in nearby areas (González-Cao et al., 2019; Fraga et al., 2020; Fernández-Nóvoa et al., 2020).

The good performance of both models to resolve hydrological and hydraulic procedures for the study area allowed their integration for the development of an Early Warning System over the Miño-Sil basin with a good capability to reproduce real events (Fernández-Nóvoa et al., 2020). Therefore, attending to the results obtained in this previous study, where both models were calibrated and successfully validated for the study area, the same configuration of both models detailed in Fernández-Nóvoa et al. (2020) was maintained to develop the present study. The catchment schematization followed is presented in Figure 3.**"**

The process for obtaining the river flow on an hourly scale was clarified in lines 154-158.

"Once the models that provide a good characterization of the precipitation for the study area have been selected, the precipitation provided by each one is used as an input in the hydrological model to simulate the river flow in the entire Miño-Sil basin. Thus, a hydrological simulation was carried out for each valid CORDEX model considering both historical (1990-2019) and future (2070-2099) periods. Although precipitation data from CORDEX is on a daily scale, it was added to the hydrological model on an hourly scale (dividing daily data by 24) in order to obtain river flows at this scale. Therefore, the historical and future flows of the river were obtained on an hourly scale"

Minor comments

A table summarizing the physical features of the catchment (mean slope, altitude, river length, time of concentration) and a land cover map must be added.

Done (See new Table 1, Figure 2 and lines 82-88).

"The area under scope is located in northwestern Iberian Peninsula (Figure 1a). It corresponds to the International Miño-Sil basin upstream Ourense city, encompassing more than 70% of the entire catchment, occupying near to 13,000 km^2 (Figure 1b). The basin under analysis ranges in altitude approximately from 110 to 2100 m.a.s.l., with an average slope of around 9.57º (Table 1). The basin presents an important variability of land uses, although it is mainly characterized by moors and heathland (25 %), broad-leaved forest (23 %) and complex cultivation patterns (17 %), according to the criteria provided by CORINE land cover data (CLC, 2018) (Figure 2). Special attention is focused on the Ourense city, where Miño river floods can cause important damage (Figure 1c). The Miño river, which has an approximate length of 134 km to Ourense, presents a pluvial regime, with an annual hydrologic cycle characterized by minimum river flows during summer months and maximum flows at the end of autumn and winter, when the extreme flood events can occur (Fernández-Nóvoa et al., 2017; 2020)."

Main characteristics of the basin under scope	
Location	*North-Western Spain*
Area (km^2)	*12822*
Mean slope (º)	*9.57*
Altitude range (m.a.s.l.)	*110-2100*
Mean altitude (m.a.s.l.)	*824*
Miño river length (km)	*134*
Mean slope of Miño river (m/m)	*0.0021*
Sil river length (km)	*234*
Mean slope of Sil river (m/m)	*0.0077*

Table 1: Main characteristics of the basin under scope (Miño-Sil basin to Ourense city), including the Miño river and its main tributary, the Sil river.

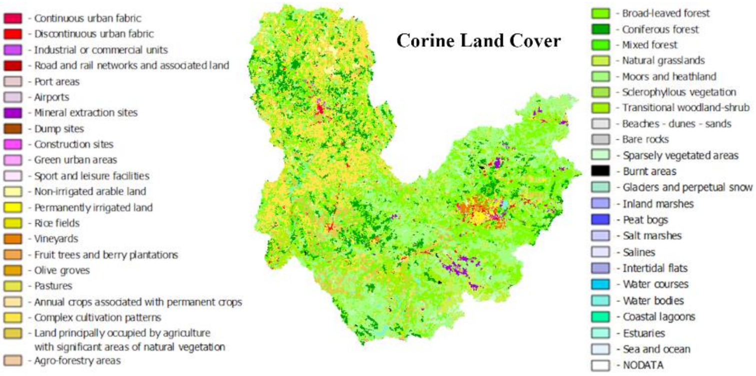

Figure 2: General land uses defined by Corine Land Cover and their distribution for the area under scope.

Please provide additional details on the catchment schematization within HEC-HMS (i.e., number of sub-catchments, connections among them and so on).

A map with the catchment schematization was added (new Figure 3).

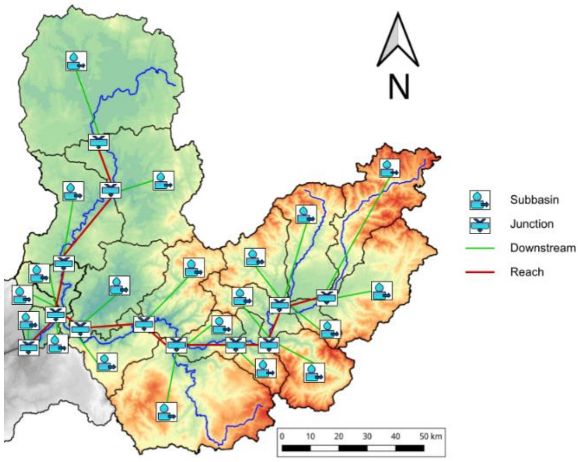

Figure 3: Map with the hydrological characterization of the basin under scope attending to its topographical features. *Subbasin* is referred to the divisions of the basin under scope, *Junction* is referred to the points in the flow network where multiple inflows combine, *Downstream* is referred to the point in the main river channel where each subbasin flows, and *Reach* represents the main river channels.

Please clarify the meaning of "supreme water depths".

To analyze the expected changes in maximum water depths reached in specific areas of the city subjected to floods, we determine the maximum water depth reached each day under flood conditions, and then, the average of these maximum values is calculated (mean of the maxima) and also the absolute maximum (highest value) is determined (referred as supremum value in the new version of the manuscript). Thus, the supremum value is referred to the highest water depth reached by water in each specific area taking into account all the days under floods. This was clarified in the text (lines 286-290).

"The multi-model mean of the maximum water depth reached during the floods in significant areas of Ourense was also calculated both for the historical period and for the future (Figure 10). For this analysis, the maximum value reached by water depth in each area for each day under flood conditions was determined, and the mean of these maxima (Figure 10a) and the supremum (Figure 10b) were calculated for each model and then averaged over all models."

L 70: replace "which supposes" with "encompassing".

Done.

Addendum to my previous comments It seems that the authors applied continuous hydrologic modeling with HEC-HMS. In this case, however, further input variables are needed, such as temperature. Please clarify!

The methodology applied do not need the input of more variables since is based on the Curve Number methodology, which requires only the precipitation data. This was clarified in the text (Section 2.3 Hydrological and Hydraulic Models).