Authors response to Anonymous Referee #2

We thank the referee for their time and effort in reviewing our manuscript.

Below we address your comments and say how we will incorporate the feedback into an improved manuscript. Author responses are in blue.

This study used CP-RCMs and hydrological model to study the flash flood frequency over the Alpine domain. The topic is interesting. I have some major comments shown below:

1. Although this study focuses on the flash flood changes in the future climate, it is necessary to show the changes in annual precipitation and heavy precipitation between future climate and current climate conditions in the study area. These changes can be compared with the flood changes.

   Pichelli et al. 2021 and Chan et al. 2020 compare the simulated precipitation of the CP-RCM simulations for the current and future climate (RCP8.5), which we found to be sufficient for the purposes of our study. The results of these evaluations will be more elaborately discussed in the revised manuscript in Section 2.2.

   Rudd et al. (2020) found that changes in threshold exceedances were larger for simulated future precipitation (RCP 8.5), when compared to changes in discharge threshold exceedances when the CP-RCM simulations were used to drive a processed-based hydrological model. We deemed a replication of the work of Rudd et al. (2020) outside of the scope of our study, we will elaborate the change in precipitation over the study domain between the historical and future climate scenario in section 2.2 and the discussion.

2. What are the changes in snowmelt dominated flood in the future climate? In a warmer climate, it is expected to have significant changes in snow melt dominated flood.

   We have limited the scope of our study to the summer and autumn seasons as convective events are dominant in these seasons, so using convective-permitting climate simulations would provide most added benefit over coarser simulations of future climate scenarios (e.g. Pichelli et al., 2021, Lucas-Picher et al., 2021). Snow and glacier melt dynamics play a lesser role than in (late) spring.

3. What are the differences between the changes in hourly and daily flood frequency and peaks?

   For data processing considerations, in determining if the threshold is exceeded, we take the maximal hourly discharge of each day. We consider this the most relevant for our analysis. We consider changes is hourly and daily flood frequency out of scope. We will clarify the text in section 2.6 on this.

4. What are the differences in air temperature between the current climate and future climate conditions in the study area?

   We agree with the reviewer that this is a current lack in the literature as the analyses of convection-permitting regional climate models have focused on the simulation of precipitation. We will elaborate the manuscript here.

5. The major parameters of the hydrological models should be shown in the manuscript. What are the differences of parameters used in different catchment? Are there any parameters related to snowmelt or glacier melt?

   For the sake of brevity, we have kept the description of the model parameters concise and referred to Imhoff et al. 2020. We will elaborate the model description. More details on the model and the processes considered can be found in Van Verseveld et al., 2022.

   Glaciers are modelled with the two main processes: glacier build-up from the conversion from snow to ice, which is modelled with two parameters: threshold temperature for which precipitation falls as snow on a glacier and a snow-to-ice conversion fraction per timestep; and glacier melt using a degree-day model. Likewise, snowmelt is simulated with a degree-day approach (Imhoff et al., 2020, Van Verseveld et al., 2022 in review)

6. Figure 2, it is better to add the boundary of catchment on the figure.

   We thank the reviewer for the suggestion, we will do so.

7. Figure 3, it is better to add precipitation on the figure to compare with the simulated and observed flood.

   We thank the reviewer for the suggestion, we will consider doing so.

8. It is better to add more descriptions of RCM models, for example, the parameter scheme for convection and precipitation simulation.

Deep convection is resolved rather than parameterized in the used CP-RCM simulation. We chose to refer to the papers in which the used simulations are described for the descriptions of the parameterization schemes and dynamical cores used for the CP-RCM simulations.

References:

Steven C Chan, Elizabeth J Kendon, Ségolène Berthou, Giorgia Fosser, Elizabeth Lewis, and Hayley J Fowler. “Europe-wide precipitation projections at convection permitting scale with the unified model”. *Climate Dynamics*, 55(3):409–428, 2020. https://doi.org/10.1007/s00382-020-05192-8

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