Reviewer 2

Miller et al. (2023) present a detailed analysis of the climate change impacts on fire weather across a study region in Central Europe that is historically not fire-prone. They accomplish this by using the Single Model Initial-Condition Large Ensemble (SMILE) of a regional climate model to: a) study the temporal and spatial trends in the Fire Weather Index (FWI), a commonly used indicator of fire weather; b) disentangle the contribution of natural variability from climate trends in the median and extreme percentiles of the FWI as inferred from two metrics: time of emergence (TOE) and temporal evolution of the current fire danger return period.

Overall, I found the manuscript to be well-written, and I appreciated the clear presentation of the analysis techniques and results throughout the text. The subject matter is quite important and within the purview of NHESS's scope. However, I think there are several areas where the authors could improve the discussion in the manuscript, either through clarification of confusing statements or by illustrating their argument with an additional figure or two. Once these changes are incorporated, I would be happy to review the manuscript's suitability for publication. Please find my comments listed below.

Thank you very much for editing our manuscript and critically reflecting on our results. We highly appreciate your constructive comments and implemented your feedback.

Comments:

- L130: The phrasing of this statement lends me to believe that FWI is calculated using antecedent weather over the previous 52 days. This is, however, not the case based on the documentation for FWI available here: https://cfs.nrcan.gc.ca/publications?id=19927

  Thank you for raising your concerns regarding this statement. We reread the documentation of the FWI (provided in your link) and realized that the time delay of 52-days in the Drought Code refers to the drying rate and not the antecedent weather conditions. We revised the section and dropped the statement about the previous 52-days.

  Old: *The CFFWIS uses meteorological conditions of the atmosphere on the day of interest (temperature, relative humidity, wind speed at noon and 24-h accumulated precipitation) and antecedent weather conditions up to 52 days to estimate fire behavior and fuel moisture (Van Wagner, 1987).*

  New: *The CFFWIS uses meteorological conditions of the atmosphere on the day of interest (temperature, relative humidity, wind speed - all at noon and 24-h accumulated precipitation) and antecedent weather conditions represented in fuel moisture codes to estimate fire behavior and fuel moisture (Van Wagner, 1987).*

- L146: I appreciated the authors quoting the units for FWI. However, these units are conspicuously missing in the relevant tables and figures in the rest of the text (Table 1, Figure 4, 5, 6, 7)

  Thank you for comment, which we highly value. According to Van Wagner (1987), the unit of the FWI is *I* or *HWR* (fire intensity represented by energy output rate (H) per fuel consumed per unit area (W) and rate of spread (R)). We could add this unit to the tables and figures of our manuscript, but we think this will add confusion to readers which are not familiar with the field. However, we updated the labels in the Figures to FWI to indicate that the color bar refers to the FWI and not to one of the FWIs subindices.

- L204: "...and 99th percentiles [of the FWI] in the present climate period" (missing text)

  Thank you for pointing this out - we added "of the FWI" in L204.

  Old: *We calculate the return periods on the basis of the 90th, 95th, 98th and 99th percentiles of the present climate period (1980–2009) to account for 10-, 20-, 50- and 100-year FWI events in the four subregions.*

  New: *We calculate the return periods on the basis of the 90th, 95th, 98th and 99th quantiles of the FWI of the present climate period (1980–2009) to account for 10-, 20-, 50- and 100-year FWI return levels in the four subregions.*

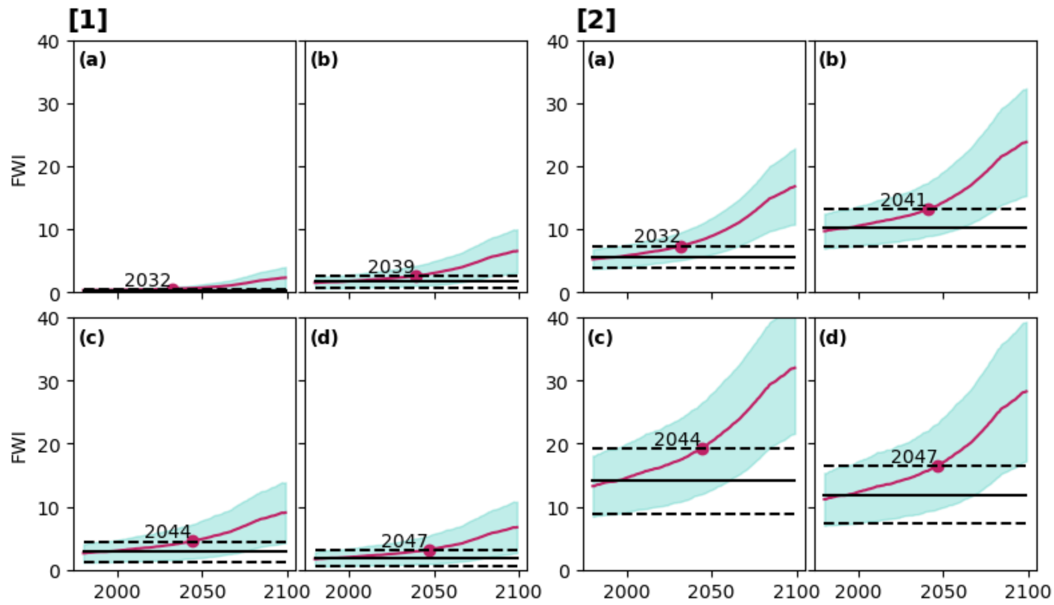
- L208: "We then compute the non-exceedance probability of the present percentiles given the future cumulative distribution" -- Present percentiles and future cumulative distribution of what quantity? The writing here can be improved, in general, to clarify whether the percentiles are with respect to all 30 years of the whole ensemble or of one model within the ensemble.

  Thank you for highlighting the missing description. Since this section was highlighted by RC-1 (general comment 1) as well, we edited this section carefully and provided a more detailed description of how we derive the return periods:

  New*: From 1980 to 2099, we create centered 30-year windows for each ensemble member to determine its empirical distribution function and the FWI quantiles corresponding to the different return periods of the present climate period. We map the non-exceedance probability of the present percentiles given the empirically derived cumulative distribution of each member. From the non-exceedance probability, we estimate the return periods using the function T = μ/(1 − p) where T is the return period, μ is the inter-arrival time between two events (1/183 days in a fire season) and p is the non-exceedance probability (Coles, 2001). We derive p from the rank r with p = r/n (2) where n is the total sample size by using the rv_histogram.cdf function of the Scipy package in Python (Virtanen et al., 2020). Due to the centred window approach, the first full 30-year window is 1995 and the last full 30-year window is 2084. Therefore, we crop the resulting time series to 1995 to 2084.*

- L240-241: "This finding indicates that the distribution of the FWI extremes resembles the distribution of the FWI median." -- This statement seems unintuitive: wouldn't the distribution of median and extreme FWI (which contains temperature as a predictor) diverge in a warming world? Perhaps this is an artifact of how the TOE is calculated with SMILEs and there is not enough variability, or that 90th percentile isn't extreme enough in the future. It would be great to see a version of Fig. 7 with the 95th and 99th percentile as well.

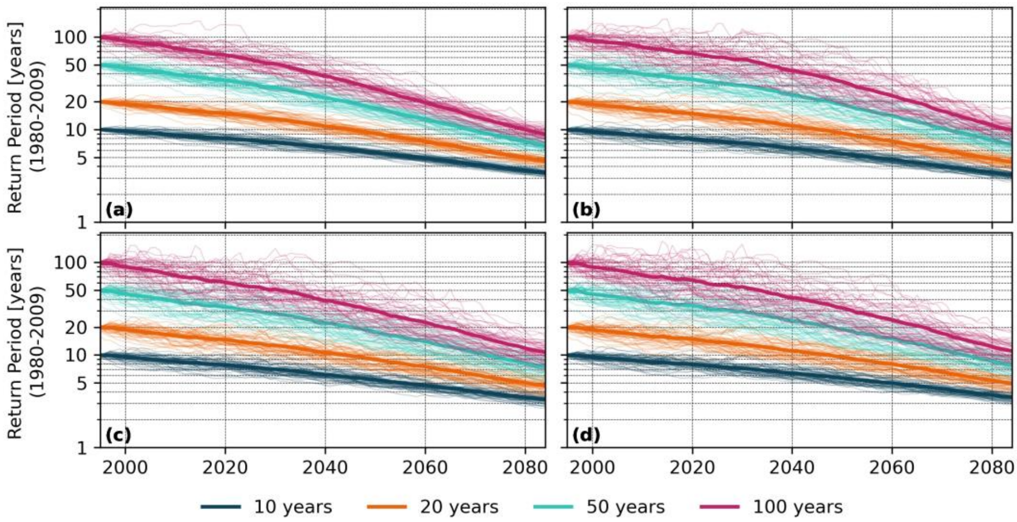
  Thank you for your comment, which we highly appreciate. Indeed, it is counter-intuitive, that the variability (turquoise shading in Fig. 7) appears to be the same for the 50th and 90th percentile. Variability should increase for the 90th percentile and yet, it looks smaller than for the 50th percentile. The reason for this is that we initially did not display the results for the two percentiles on the same scale. When plotted on the same scale (Figure 9 in this response to the reviewer), it becomes apparent that indeed and as expected the variability is substantially larger for the 90th than for the 50th percentile. We adjusted Fig. 7 in the manuscript to a common y-axis between the 50th and 90th percentile (s. below), which clearly shows that the distribution of median and extreme FWI is not the same, as stated previously. We therefore removed this line and updated Fig. 7.



Trends of the median ([1], 50th percentile) and extreme ([2], 90th percentile) FWI between 1980 and 2099 differentiated by subregion: (a) Alps, (b) Alpine Foreland, (c) Southgerman Escarpment, (d) Eastern Mountain ranges. The ensemble mean trend is derived on a fire season basis and represented by solid pink lines smoothed over a 30-year window. The ensemble's standard deviation is represented by shaded blue areas. Black solid and dashed lines represent the ensemble mean and spread of the present climate period (1980–2009). The TOE, marked with a pink dot and year annotation, is reached when the ensemble mean (pink line) crosses the upper boundary of the ensemble standard deviation in the present climate period (black dashed line)

- Figure 9: Why is the ensemble mean of the 100-year return period only about ~75-80 years for all 4 subregions?

We created centered 30-year windows (between 1980 and 2099) for each member to determine the FWI percentiles corresponding to the different return periods of the present climate period (all 50 members). The first full 30-year window is 1995 and the last full 30-year window is 2084. Therefore, the ensemble mean of the 100-year return period for the present all member pool is 100 in the year 1995. This is not shown in the Fig. 9 of the preprint. We updated the figure and methods section (s. your comment on L208) accordingly.



Changes in present return periods (1980–2009) of the 90th, 95th, 98th and 99th FWI percentile throughout the 21st century (1995–2084), distinguished by subregion: (a) Alps, (b) Alpine Foreland, (c) Southgerman Escarpment, (d) Eastern Mountain Ranges. The thick solid line represents the CRCM5-LE mean, while thin lines represent the ensemble members.

- L293: "...which has to be discussed..." -- improve phrasing.

  We rephrased this section in correspondence to RC-1 (comment 68).

  Old*: Another aspect, which has to be discussed, is the strong tiling pattern visible in figure 5 [2] in the months June and August. This tiling pattern is already visible in the extreme values of the input variables. We provide a sensitivity analysis of the FWI in the Appendix (s. figure C1), where the tiling occurs for temperature and relative humidity in the 95th 295 percentiles as well. The pattern correlates with invariate fields from the geophysical baseline parameterization of the CanESM2, e.g. bedrock depth. Over the areas where the strong tiling occurs, bedrock depth is about 5m. The water storage potential of the ground is especially high in this area compared to its surrounding areas with an average bedrock depth between 1 or 2 meters. Such high storage potential can affect evaporation and leads to a higher cooling in areas with high bedrock depths which results in lower 300 temperatures and higher relative humidity.*

  New: *Though the CRCM5 reproduces the response structures much finer than CanESM2 and adds robust high-resolution features (Böhnisch et al., 2020), we find in the northern parts of the study area tiling patterns corresponding to the geophysical baseline parameterization of the CanESM2 (see Figure A3). The tiling occurs in the sensitivity analysis provided in Figure A.3 for temperature and relative humidity in the 95th percentile, when the FWI is calculated with a factor of two for temperature and relative humidity. The pattern correlates with the bedrock depth of the CanESM2, which might affect the water storage potential of the ground. Over the areas where the tiling occurs, bedrock depth is about 5m, which is relatively high in comparison to the surrounding areas with an average bedrock depth between one or two meters. Such high storage potential can affect evaporation and leads to a higher cooling in areas with high bedrock depths which results in lower temperatures and higher relative humidity. The tiling occurs only under very extreme FWI conditions (95th percentile) and might lead to an overestimation of our results in the extreme FWI (90th percentile) for the Southgerman Escarpment.*

- L293: "...tiling pattern visible in figure 5 [2]..." -- [2] seems to be a typographical error.
  The tiling pattern is not visible in Figure 5 anymore, because we changed to a discrete color scale (s. RC-1 comment 58).