Dear anonymous referee #2,

Thank you for the opportunity to revise our manuscript, titled “Projected changes in forest fire season, number of fires and burnt area in Fennoscandia by 2100” (egusphere-2024-741). We appreciate the insightful comments and suggestions provided by the reviewers, which have greatly contributed to improving the quality of our work. We have carefully considered all feedback and have made the necessary revisions. Below, we provide a detailed, point-by-point response to each of the reviewers' comments. Our responses are in blue and the line numbers (L) refer to the manuscript. The cited references are provided at the end of the letter.

We hope that these revisions address all the concerns raised by the reviewers. We believe that these changes have strengthened the manuscript, and we look forward to your favorable consideration of our revised submission.

Thank you once again for your time and valuable feedback.

Sincerely,

Outi Kinnunen
Finnish Meteorological Institute
outi.kinnunen@fmi.fi

Review of “Projected changes in forest fire season, number of fires and burnt area in Fennoscandia by 2100” by Kinnunen et al. In this paper, Kinnuen et al. projected the length of forest fire season, number of fires and burnt areas in Fennoscandia by 2100, based on simulations from three models that are driven by projected meteorological conditions under climate change scenarios of RCP4.5 and RCP8.5. Overall, the research is well conducted. The results are well articulated and the discussion is appropriate. The topic is suitable and meaningful. The paper is publishable after some revision. I provide the following suggestions for the authors to consider when revising their paper. It seems that air humidity is overlooked in this research. It is true that relative humidity is related to air temperature; as air temperature increases, relative humidity decreases; this will lead to an increase in fire activities. However, variation of absolute humidity is independent of air temperature. It is reported that trend of fire activities is decreasing in some regions during some of the past decades, possibly due to a wetter atmospheric environment. Is air humidity considered? How? Please provide more information on FDI, as it is a key variable in this research.

We thank you for all your comments and suggestions regarding the article. Thank you for your kind words. We are grateful for your support.

Air humidity is not explicitly used in the model equations. The drying power is estimated using the Nesterov index, which depends on daily maximum temperature, dew point and precipitation. However, the dew point is estimated from the daily minimum temperature. Therefore the fire danger index, FDI, doesn't depend on the atmospheric humidity. Our model shows a decrease in the fire risk with increase in precipitation. We will provide more information on FDI. We hope that these changes will help the reader understand the content better. Details of the changes are presented below.

Specific

Abstract: In addition to the range of the variation in the fire variables, the mean values are also important.

We thank you for the feedback regarding the abstract. We will add the standard deviation for model regional mean, for example (20–52) days to the from (20±7) days to (52±12) days and modify all the respective statistical results accordingly and similarly to the result section.

L19, “Newer the less”->“Nevertheless”.

Edited as suggested

L19, “point”-> “pointed”.

Edited as suggested

L79, because FDI is a key variable in the simulation, please explicitly express how FDI is estimated. Is there a formula for FDI? What decides environmental dryness, relative humidity, soil moisture or both?

We will add more info about FDI to make it clearer. On line 73 we explain the moisture content of fuel.

We will move the equation of FDI from line 126 to lines 78-79 and number it as equation 1. We will reworde the sentence: The FDI is calculated from environmental dryness, temperature and the availability of fuel (Reick et al., 2021) as follows

$$FDI = \max(0, 1 - \text{fuel moisture}/\text{moisture of extinction}) \qquad (1)$$

We will change the sentence in line 125-126: Fire duration Dfire depends on population density PD and fire danger index FDI (Eq. 1) as follows (Lasslop and Kloster, 2017)

We will change the equation number in line 127 and 128 to 2.

L100, please explain RCP4.5 and RCP8.5 more explicitly. For example, scenarios without additional efforts to constrain emissions ('baseline scenarios') lead to pathways ranging between RCP6.0 and RCP8.5 (IPCC, AR5).

We thank you for the feedback regarding the explaining RCP 4.5 and RCP 8.5.

“The increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to 1986–2005 is likely to be 1.1°C to 2.6°C under RCP 4.5 and 2.6°C to 4.8°C under RCP 8.5. The Arctic region will continue to warm more rapidly than the global mean. “ IPCC, 2014

We will add a characterisation of the RCP:s according to these details in the text.

L149, “for the whole domain”, is this area-weighted average?

Thank you for this important and helpful comment – it's given us a better understanding of how to make the text clearer. It would be good to be more specific about the context of our calculations. We noticed that the expression 'whole domain' was being used in a different way in the next section. What we meant was that we calculated the yearly averages for each of the grid points we modeled. In the results section, we use the term 'whole domain' when we present the average change across the entire land grid point domain, rather than in a specific location. That's the mean of the values you'll see in the maps. We'll make a few changes to lines 149-152 (in **bold**), the result section (which we'll explain later) and the figure captions (A9, A13 and A15)

From the daily output values, for every modeled grid point, yearly averages were calculated for the summer months (JJA) of FDI, air temperature, precipitation, fuel moisture and number of very high and extremely high FDI days or for the full year for ignition rates, number of fires and burnt area. ***Changes in the variables*** *were presented as the difference between averages of the period 2071–2100 and the reference period 1981–2010.* ***We calculated the mean of average changes over the domain in land grid points.*** *The change in monthly climatologies* ***(air temperature, precipitation and GPP)*** *was calculated as a difference between periods 1981–2010 and 2017–2100 in six locations. The relative change was calculated as a ratio of the average of each period, 2071–2100 and 1981–2010* ***for litter flux, soil respiration and amount of fuel***. *The relative CO2 flux change over time was calculated by comparing the 30-year moving average with the 1981–2010 mean value to smooth out the annual variations and show the overall trend. The time series were created to analyse the trend in the variables, such as the start and end dates of the fire season. The difference between the average start day and end day of the fire season was calculated to see whether the fire season changed more at the beginning or at the end of the season.*

Figure A9. Averages over all the climate projections **for summer months** a) fire danger index (unitless), b) number of high fire danger days [day] **and for annual** c) number of fires [$km^{-2}yr^{-1}$] and d) burnt area [km^2yr^{-1}] in the reference period 1981–2010.

Figure A13: **Annual** average ignition rate…

Figure A15. The distribution of **annual** average burnt areas in 1981–2010 (blue) and 2071–2100 (orange) [km^2 per grid point] in Finland under two climate change forcing scenarios and three global climate driver models

L122, change to “Lasslop et al. (2014).”

According to comments from referee #1, the reference will change to Pierce (1970)

L136, which 9 fire variables? Which 3 derived variables?

We agree that this information should be added. We’ll reworde the sentence like this: The monthly or annual means for 9 daily simulated fire variables (FDI, number of fires, burnt area, CO2 flux, GPP, litter flux, soil respiration, fuel and fuel moisture) and 3 derived variables (start day, end day and number of very high and extremely high FDI days) are in dataset Kinnunen (2024).

L136, change to “simulated”.

Edited as suggested.

Section 3.1 and 3.2. When discussing the results, the authors provided the mean values and ranges for simulated fire variables, including start and end dates, number of fires, and burnt areas from scenarios. The authors sometimes only provided the ranges for the variables, especially in section 3.2. Please provide the mean values for the simulated results. When doing so, please also explicitly indicate that the mean and associated standard deviation are based on what. Is it an areal mean? Yearly mean? A mean of three models?

We apologize for being incoherent. We have now double-checked the values and the text. We noticed that the standard deviation of average 2071-2100 was the same as for period 1981-2010 in tables 3 and 5. We will correct that and add standard deviation for changes. Moreover, we'll change the order of the tables as well as the sentences referring to them respectively. This will improve the readability of the text.

We will add the standard deviation for the presented means. For example (20–52) days to the from (20±7) days to (52±12) days. The averages are calculated for the land grid points, which we try to point out in the text. We will make a few changes to sections 3.1, 3.2 and the abstract.

L230, “temperature and precipitation are the leading cause of …” How about air humidity?

Unfortunately, the fire risk is not explicitly affected by air humidity in the model. The Nesterov index calculations does not include air humidity, but the dew point is estimated from the daily minimum temperature as it is explained in lines 73-76. The drying power is estimated using the NI as follows:

$$\begin{cases} NI = \sum T_{max}(T_{max} - T_{dew}), \text{precipitation} < 3\,\text{mm/day and } T_{min} - 4 \geqslant 0, \text{when } T_{dew} = T_{min} - 4 \\ NI = 0 \end{cases}$$

Conclusions: More quantitative results, in the mean and associated variations, are beneficial to the audience.

We concidered your comment, however. we decided to not add any quantitative results to the conclusions that they are already presented in section 3, discussed in section 4 and summarised in the abstract.

References:

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Lasslop, G. and Kloster, S.: Human impact on wildfires varies between regions and with vegetation productivity, Environmental Research Letters, 12, 115 011, https://doi.org/10.1088/1748-9326/aa8c82, 2017

Pierce, E. (1970), Latitudinal Variation of Lightning Parameters, Journal of Applied Meteorology , 9, 194–195.

Reick, C. H., Gayler, V., Goll, D., Hagemann, S., Heidkamp, M., Nabel, J., Raddatz, T., Roeckner, E., Schnur, R., and Wilkenskjeld, S.: JSBACH 3 - The land component of the MPI Earth System Model: Documentation of version 3.2., Berichte zur Erdsystemforschung, doi:10.17617/2.3279802, 2021