Response Letter of X Li's to reviewer' comments on MS No. essd-2024-187

I was pleased to review the revision of this manuscript. In most cases, I feel that the authors responded to my suggestions and answered my comments. I also understand now why the authors did not include analysis of the data including the chronosequence. The points below are where I think additional information is still required.

Response: Thank you for all your efforts for and time spent on our manuscript.

These suggestions are very helpful for improving the quality of our manuscript. I'm sorry that I didn't dispel all your concerns in the first revision. On the basis of your suggestions, I made some modifications to this manuscript as advised. I hope this revision will address your concerns.

Line 79-80: Post fire soil moisture is more complex that you've described in the introduction. I don't feel that referencing one paper is sufficient. Most of what I've seen in the literature suggests that soil moisture is typically higher at burned sites than at unburned sites as a result of reduced evapotranspiration.

Response: Agreed and done. Forest fire can increase or decrease soil moisture content. In general, the near-surface (<30 cm) soil moisture contents increased in the short term after fire, while for deep (>1 m) or in the long term, soil moisture contents decreased. Thus, we changed to the: in Lines 84-95,

"*Forest fires also can cause significant changes in soil moisture contents, which in turn affects ground thermal regimes (Nossov et al., 2013). Due to the fire-induced thaw of permafrost, the charred moss layers with lowered infiltration rates, lower transpiration rate and reduced evapotranspiration in severely burned areas, surface soil moisture contents (generally less than 30 cm in depth) at burned sites were significantly higher than those at unburned sites (Kopp et al., 2014; Potter and Hugny, 2020; Yoshikawa et al., 2003). However, affected by soil texture, permafrost thaw after fire can also lead to a decrease in soil moisture contents (Li et al., 2022b; Nossov et al., 2013). In summary, in a short term, forest fires will decrease rates of transpiration, raising soil moisture contents; in a long-term (more than a decade), the increased ALT and recovery of vegetation will reduce soil moisture content at burned sites as compared to that at unburned sites (Yoshikawa et al., 2003).*"

Line 80-83: The addition of this sentence does not address my previous comment "A relatively large amount of organic layer remains after the fires at all of the site (minimum 20 cm). I think it's important to note this somewhere in the paper, as this minimizes post-fire changes (less active layer thickening and ground temperature increase) than if, for example, less than 5 cm remains." It's not about the vegetation regeneration, rather it's about the antecedent organic layer thickness and what remains after the fire. More context is needed.

Response: Agreed and done. The postfire thickness of the soil organic layer and its impact on soil thermal conductivity was the most important factor for determining postfire soil temperatures and thaw depth. With the restoration of vegetation, the organic layer accumulates again and the thickness of residual organic layer after fire

has a significant influence on the permafrost. Therefore, according to your suggestion, the relevant content of organic layer thickness was mentioned in the ***Introduction*** and the ***2.1 Study area descriptions and monitoring networks***, and these sentences were added:

"*In Interior Alaska, organic layer thickness decreased from 21 to 4 cm after fire, resulting in thaw depth increasing from 72 to 152 cm, mean annual surface temperature rising from −0.6 to +2.1 ℃ and mean annual deep temperature going up from −1.7 to +0.4 ℃ (Nossov et al., 2013).*" In Lines 72-76.

"At severe burned sites in AL, GL, and MH, measurements of organic matter thickness were taken 7, 14, and 29 years after fires, so it was possible that the organic layer thickness exceeded 20 cm due to the re-accumulation of organic matter. At severe burned site in MG, the organic matter residue after combustion was in a fluffy state with the thickness of 20 cm. When the re-accumulation or residual organic matter exceeded 20 cm, this would slow the rate of active layer thickening and soil temperature increase after fires, as well as the permafrost would gradually recover with the re-accumulation of organic layer." In Lines 221-228.

Line 94-102: This doesn't fully address my comment. My concern is that you describe permafrost and post-fire impacts very generally throughout the introduction and rest of the manuscript, without providing context that your sites are in a particular type of environment. It affects your results and conclusions. You can't make broad conclusions for all types of environments based on a certain subset of sites. I think more context needs to be provided in the introduction to put your sites in context.

Response: The descriptions of all studies in this part are in the boreal forest and permafrost region, and the purpose of this example (a certain subset of sites) is to show the significant changes after fire. Our study area is also located in boreal forest and permafrost region. Therefore, we have made the following revisions, and hope to take care of your concerns. In Lines 99-102, 111-123, 124-126, 175-177.

"It contains 1100–1500 Pg carbon in boreal permafrost regions (1 Pg=10^{15} g), approximately twice of the carbon pool in the atmosphere (Hugelius et al., 2014), accounting for nearly half of the global belowground organic carbon pool (O'Donnell et al., 2011a)."

"Therefore, in the boreal permafrost region, wildfire exacerbate rates of permafrost thaw and alter soil organic carbon dynamics in both organic and mineral soils. In addition to soil organic carbon, forest fires potentially also reduce soil nitrogen contents, inducing shifts in nutrient cycling in the boreal forest and permafrost regions (Certini, 2005; Knicker, 2007; Kolka et al., 2017). However, there are inconsistent reports on the effects of forest fire on soil phosphorus and potassium. Some studies show a significant post-fire reduction in phosphorus and potassium while other studies indicate an evident increase after light burns, but a reduction after severe burns, and nearly unchanged stocks of potassium and phosphorus (Gu et al., 2010; Neff et al., 2005; Zhao et al., 1994). As a result, wildfires in boreal permafrost regions had been

considered to trigger strong positive feedbacks on climate warming via massive emissions of biogenic major greenhouse gases (Koven et al., 2015; Ramm et al., 2023).”

“Located on the southern margin of Eastern Asian boreal forests and permafrost regions, the Da Xing’anling (Hinggan) Mountains in Northeast China are prone to frequent and massive wildfires.”

“A permafrost monitoring network has been established in four burned areas in the northern Da Xing’anling Mountains in Northeast China in boreal forest and discontinuous permafrost regions (Figure 1).”

Line 217: You provided more information in your response to my original comment and it would be helpful to add some to the text in this section. For your reference here is what I’m referring to from the original review:

> Line 201-203: Why were these thresholds chosen?
> Response: This is the common method of international fire severity division, and it is also a standard means of division. According to the Cocke et al., (2005) and Roy et al., (2006), the dNBR optimality values for these average changes are 0.241 for grass and 0.57 for shrub. Therefore, these values are selected as threshold values through the classification of fire severity by vegetation burn status and the comparison with dNBR (Key and Benson, 2006; Escuin et al., 2008).

Response: Agreed and done. Added this sentence in the text. In Lines 254-257.

“*According to the Cocke et al. (2005) and Roy et al. (2006), the dNBR optimality values for these average changes are 0.241 for grass and 0.57 for shrub. Therefore, through vegetation burn status and the comparison with dNBR values (Key and Benson, 2006; Escuin et al., 2008), fire severity is thus divided into four categories*”

Line 292: COVID-19 epidemic should be “pandemic”.
Response: Agreed and done. Changed the “epidemic” to the “pandemic”. In Line

Line 459: The addition of this text does not address my original comment fully. The original comment was “Here you say SMC is decreasing, but you only have one measurement in time. How can you say it is decreasing? You haven’t described the chronosequence at all in the results, so I don’t think it’s fair to conclude this.” I realize now why you did not describe the chronosequence (editor’s request), but it still makes understanding the conclusion difficult for the reader.

Response: Agreed and done. From Figure 9, SMC at the burned site is significantly lower than that of the unburned site. To be more convincing about the results, we have modified the sentence to the “*This is evidenced by rising ground temperature, thickening active layer, and evidently changing SMC and soil nutrient contents.*” In Lines 490-491