

Reviewer Comment

The reviewer recommended incorporating recent studies by Luo et al. (2024; 2025; 2026) on the influence of large-scale atmospheric circulation, ocean-atmosphere variability, background warming and antecedent moisture conditions on fire weather and wildfire risk. The reviewer suggested that these studies could help contextualize the interannual variation in fire-danger index performance, particularly the low AUC values observed in 2002, 2019 and 2023.

Response

We thank the reviewer for this valuable suggestion. We have revised the Introduction and Discussion to incorporate the recommended literature and explain its relevance to the interpretation of our results.

First, we added a new subsection, **Section 1.3, “Large-scale climate controls on fire weather,”** to the Introduction (**lines 66-83**). This subsection discusses evidence from eastern Siberia, Canada and the southwestern United States to illustrate how fire weather can reflect interactions between background climate conditions, atmospheric circulation and ocean-atmosphere variability. We then relate this broader context to the need to evaluate fire-danger indices within the ecosystems where they are intended to be applied, recognizing that the relative importance of these processes may differ between forest systems and grassy savannas.

The following text was added to the Introduction:

“Although fire-danger indices use local meteorological conditions to estimate fire danger, these conditions can themselves be influenced by broader climate processes. Large-scale atmospheric circulation and ocean-atmosphere variability can alter temperature, atmospheric moisture and precipitation over timescales ranging from individual fire seasons to decades. Luo et al. (2024) demonstrated that declining summer Arctic sea ice in eastern Siberia was associated with background warming that accounted for approximately 79% of the increase in vapour pressure deficit (VPD) during 2004–2021, while changes in atmospheric blocking contributed to the remaining increase. Similarly, the extreme Canadian wildfires of 2023 were associated with persistent atmospheric blocking, elevated temperatures, precipitation deficits and low soil moisture, with Pacific Ocean variability contributing to the circulation patterns involved (Luo et al., 2025). Luo et al. (2026) also attributed substantial portions of the increase in winter fire-

weather risk in the southwestern United States to anthropogenic ocean warming and internal Pacific Decadal Oscillation variability. These studies demonstrate that fire weather can reflect interactions between background climate conditions, atmospheric circulation and oceanic variability.

The relative importance of these processes depends on the biome, season and timescale considered. In forest systems, prolonged atmospheric and soil drying can precondition vegetation for extensive burning, whereas in grassy savannas, rapid changes in fine-fuel moisture may be particularly important for determining daily fire occurrence. These differences reinforce the need to evaluate fire-danger indices in the ecosystems where they are intended to be applied. For Botswana, it remains uncertain which indices most effectively distinguish days with detected fires from days without detected fires across different seasons.”

We also revised the opening of Section 1.4, “Knowledge gaps in African fire danger assessment,” to strengthen the transition from the discussion of large-scale climate controls to the research gap **(lines 85-86)**. The revised opening explicitly links the need to evaluate fire-danger indices within their ecological and climatic settings to the limited representation of Africa in comparative fire-danger assessment research. The revised sentence reads:

“Despite the importance of evaluating fire-danger indices within their intended ecological and climatic settings, Africa remains poorly represented in research comparing their performance.”

This change improves the continuity of the Introduction by moving from the discussion of factors influencing fire weather and the context-dependent performance of fire-danger indices to the limited evidence available for Africa.

Lastly, we revised the discussion to interpret the low AUC values observed in 2002, 2019 and 2023 in light of possible interannual differences in rainfall, fuel availability and broader climate variability. The revised discussion draws on Matt Jolly et al. (2015) and Archibald et al. (2010) to explain how rainfall and fuel availability may affect the relationship between fire weather and fire occurrence in savannas. It also incorporates Luo et al. (2024, 2025, 2026) to place the observed variation in predictive performance within the broader context of climate influences on wildfire risk.

The following text was added to the Discussion (**lines 370-384**), with the opening sentences revised to improve the interpretation of the year-by-year AUC results:

“The year-by-year AUC values in Table 3 show considerable variation, with broadly similar patterns across indices. This indicates that the ability of the indices to distinguish between days with and without detected fires varied substantially between years. In 2002, 2019 and 2023, AUC values were low across the indices with some approaching 0.5, indicating little discrimination between fire and non-fire days. These results suggest that the relationship between the meteorological conditions represented by the indices and observed fire occurrence was weaker in these years. One possible explanation is that interannual differences in rainfall and fuel availability altered the relationship between fire weather and fire occurrence (Matt Jolly et al., 2015). Above-average rainfall in savannas can promote grass growth and increase fuel loads, potentially making subsequent fire activity more dependent on fuel availability than on concurrent weather conditions (Archibald et al., 2010). This explanation remains tentative because rainfall anomalies and fuel availability were not directly examined in the present study. More broadly, studies from other regions have demonstrated that wildfire risk can be influenced by interactions between background warming, atmospheric circulation and ocean-atmosphere variability, as well as by antecedent moisture conditions (Luo et al., 2024; Luo et al., 2025; Luo et al., 2026). Such processes may alter the meteorological conditions under which fires occur and consequently, the extent to which fire-danger indices discriminate between fire and non-fire days. Their contribution to the interannual variation in AUC observed in Botswana, however, requires further investigation.”

These revisions incorporate the suggested literature while distinguishing between the results demonstrated by our analysis and potential explanations that were not directly tested. In particular, we have not attributed the low AUC values in the specified years to particular climate drivers, as ENSO, the Pacific Decadal Oscillation, atmospheric blocking, rainfall anomalies and antecedent moisture deficits were not explicitly analyzed. Instead, we identify these processes as relevant context for interpreting the results and as potential directions for further investigation. We believe these changes strengthen the scientific context and interpretation of the manuscript without extending the conclusions beyond the evidence provided by the study.

References added or cited in the revised text

- Luo, B., Luo, D., Dai, A., Xiao, C., Simmonds, I., Hanna, E., Overland, J., Shi, J., Chen, X., Yao, Y., Duan, W., Liu, Y., Zhang, Q., Xu, X., Diao, Y., Jiang Z and Gong, T. Rapid summer Russian Arctic sea-ice loss enhances the risk of recent Eastern Siberian wildfires. *Nature Communications*, 15, 5399. <https://doi.org/10.1038/s41467-024-49677-0>, 2024
- Luo, B., Xiao, C., Luo, D., Fu, Q., Chen, D., Zhang, Q., Ge, Y., and Diao, Y. Atmospheric and oceanic drivers behind the 2023 Canadian wildfires. *Communications Earth & Environment*, 6, 1–12. <https://doi.org/10.1038/s43247-025-02387-x>, 2025.
- Luo, B., Luo, D., Chen, D., Cai, W., Dai, A., Simmonds, I., Ye, K., Chen, W., Li, J., Xiao, C and Li, F. Recent escalation of winter fire-weather risk in the southwestern United States: Roles of anthropogenic warming and the negative Pacific Decadal Oscillation. *Global Change Biology*, 32(9). <https://doi.org/10.1111/gcb.71113>, 2026.