This manuscript presents the analysis of spatiotemporal fire-induced turbulence characteristics under varying ambient wind speeds and fuel loading. The fire-induced turbulence was characterized in terms of variances, TKE, sensible heat flux, and momentum fluxes along with their mean values. The field experiments are unique in a way that turbulence generated by low intensity head fires was measured by a sense network of the sonic anemometers above the ground. The small burn plots (10 m x 10 m) allow for more controlled fire spread and behavior to be observed and analyzed.

On the downside, the analysis of fire behavior presented is a bit too speculative and justifications of the interpretation are generally weak. My biggest concern about this manuscript is the lack of fire behavior analysis. I outlined my suggestions below to improve the manuscript. The dataset presented have potential to improve our understanding of fire-atmosphere interactions in very fine scale. However, I do not think the manuscript has an original contribution to wildfire research community to advance their/our current knowledge at this stage. The analysis needs to be a bit more in depth, and there appears to be data (IR camera, radiometers) to implement that.

Major comments

Time series of background wind speeds for each burn should be shown in addition to the mean values presented in Table 1 to make sure the background wind conditions did not change significantly during the fire. If it did, then the assumption of low vs. high wind case falls apart. This can be done by plotting wind speeds measured at the control tower before, during, and after the fire all together from the 4 burn experiments. I would suggest plotting 4 lines in 1 plot with different color.

In my opinion, showing fire spread across the 4x4 sensors measured by the IR camera is critical in terms of interpreting fire-induced turbulence in time and space. Fireline intensity and shape is rarely homogeneous or uniform in space and time in nature, and observed turbulence should be strongly affected in both horizontal and vertical directions. I assume that higher fuel loading does not necessarily mean higher fireline intensity or fuel/flame temperature. I suggest to create a plot with 3 panels for each burn to show the IR camera temperatures at 3 selected time stamps (so total of 12 plots). See Fig. 3 in Seitz et al. (2024) or Figs 2 and 5 in Katurji et al. (2021) as examples. The IR camera can show where the fire front was, by what time the fire reached the individual sonic anemometers, and how hot smoldering was. Also, make sure to show the location of 12 sonic anemometers in the plot.

Line 261: The crosswise variance was already dominant before the presence of fire during Burn 12, and the fire did not change this dominant flow/turbulence behavior as Fig. 9 and Table 9 show. Therefore, the sentence ‘First, during the burn period of Burn 11, … while in the Burn 12 experiment the cross-stream component is dominant.’ Is misleading and not accurate. It simply means that the ambient flow in the crosswise velocity direction was more turbulent in the area due to canopy structure for example.

Line 267: inaccurate estimation of the ignition time in Burn 12 should be corrected using the in-situ radiometer data. The data should be able to show when the fireline started crossing beneath the sonic anemometers. Alternatively, you can use the IR camera data to adjust the ignition time estimate.

Line 278: Figure 9 and Table 9 do not indicate that 'higher background wind speeds and/or increased fuel loading caused the cross-stream velocity variance to contribute significantly to the TKE than streamwise velocity variance. The results indicate that the fire did not modify the fact that *v*-velocity variance dominated the TKE under stronger background wind speed and higher fuel loading.

Line 280: I do not see how the fire intensity was measured or calculation. This is very important as the strength of fire-induced turbulence depends heavily on the fire/fireline intensity (as well as the degree of coupling between fire and atmosphere).

Line 281: The authors state that 'when fire intensity exceeds this threshold, TKE is mainly influence by the cross-stream wind component.' Again, I think this is not a correct interpretation of your result. See my previous comment (Line 261).

Line 283: It is more likely that higher fuel loading resulted in relatively high heat release during the smoldering phase. The authors can easily show this by analyzing radiometer and IR camera data. I am not convinced that it is due to the ignition-induced fire behavior unless the authors can show evidence of fire behavior at the time of ignition.

Results in general: Please compare your findings with Seitz et al. (2024) and discuss the similarities and contrasts between them because the analysis of this manuscript is essentially very similar but using different experimental data (i.e. different weather and fuel conditions) from the same field campaign. That will make this paper to contribute more to understanding of combustion processes and fire-atmosphere interactions.

Line 368: The authors state that 'This may result from the significant tilt of the convective plume under high background wind speed, …' Would it be possible to prove it by photo images (if available) or using thermocouple data? That would make the statement much more convincing.

Line 371: smoldering phenomena during the post-burn period can be easily quantified using the IR camera (and radiometer) data instead of saying 'This may be due to ….'

Line 383: The increasing distance from the smoldering boundary could be true, but there is no evidence of smoldering behavior (how hot, and spatial variability) is shown in this paper. This can be shown using the IR camera data. If the smoldering phase has strong impact on atmospheric turbulence, then it should be shown explicitly.

Line 390: How can we parametrize fire behavior using your data? It would be useful for fire behavior modelers to know this. Has anyone done that using experimental data in the past? If so, how?

Minor comments

Please make sure that the manuscript is correctly formatted. I see lots of missing space before '(' for example.

Also, I would suggest the terms 'streamwise velocity' to indicate the u-velocity that is rotated into the streamwise direction and 'crosswise velocity' to indicate the v-velocity. Make sure to keep the wording consistent throughout the manuscript.

Table1: add fuel moisture content if known. It affects fire intensity. I noticed that the RH is much lower during Burn 2.

References

Katurji, M., Zhang, J., Satinsky, A., McNair, H., Schumacher, B., Strand, T., et al. (2021). Turbulent thermal image velocimetry at the immediate fire and atmospheric interface. Journal of Geophysical Research: Atmospheres, 126, e2021JD035393. https://doi.org/10.1029/2021JD035393

Seitz, Joseph, et al. "Atmospheric turbulence observed during a fuel-bed-scale low-intensity surface fire." Atmospheric Chemistry and Physics 24.2 (2024): 1119-1142.