<u>Review for "The Community Fire Behavior Model for coupled fire-atmosphere modeling: Implementation in the Unified Forecast System"</u>

The manuscript introduces the Community Fire Behavior Model (CFBM), a newly developed fire behavior model designed for seamless coupling with different atmospheric models using the Earth System Modeling Framework (ESMF). The key objective of CFBM is to provide a flexible and modular framework for simulating coupled fire-atmosphere interactions without requiring model-specific interpolation procedures. This approach is intended to foster broader collaborations and model integrations beyond the traditional Weather Research and Forecasting (WRF) model with fire extensions (WRF-Fire).

The current review starts with specific comments in each section of the manuscript and finishes with a general comments section, followed by a final decision section.

<u>The fire behavior model:</u>

- The input data interface remains dependent on Geogrid from WPS, which necessitates pre-processing via WRF. Consider addressing whether the model can be decoupled from WRF-specific tools.
- The results could benefit from improvements to the fire initialization since the method presented seems to mismatch fire and atmosphere dynamics. The authors should consider using a spin-up period during the perimeter initialization.
- The two available options for fire wind interpolation require further explanation. Additionally, if wind reduction factors are applied, their implementation and rationale should be discussed.
- The manuscript should specify whether Lambert-Conformal projection is the only supported coordinate system in CFBM. If additional projections are supported, this should be clarified.

<u>Experimental setup:</u>

- The downscaling from a 3 km atmospheric grid to a 100 m fire mesh presents notable limitations:
  - The atmospheric resolution is too coarse to adequately capture fire-atmosphere interactions.
  - The fire mesh resolution is also too coarse to properly resolve fire spread parameterizations.
- The rationale behind different configurations between WRF and UFS regarding vertical layers and time steps should be justified. For instance, the use of different number of vertical layers and time steps?

<u>Validation:</u>

- Adjusting wind height to better match fire progression raises concerns about the validity of the model's predictive capability. It should be clarified whether this adjustment is an empirical correction or an inherent part of the modeling approach.

- The similarity of results between one-way and two-way coupling suggests that the two-way coupling mechanism has not been adequately validated. Further evidence of feedback interactions is needed.
- The validation would benefit from quantitative evaluation metrics such as the Jaccard index or Sørensen–Dice coefficient to assess model performance systematically.
- While the manuscript acknowledges underestimating fire spread in some regions and overestimating in others, it does not provide sufficient explanation for these discrepancies. A sensitivity analysis on parameter uncertainties (e.g., fuel properties, and wind corrections) would strengthen the discussion.

<u>Other Minor Comments:</u>

- Line 156: The phrase "substantial portions of new code" requires further clarification regarding the specific novel contributions.
- Line 166: The term "atmospheric dependencies" is ambiguous and requires clarification.
- Lines 166-167: The phrase "the WRF grid to the WRF-Fire grid" is misleading, as both the atmospheric and fire grids are components of WRF-Fire.
- Lines 167-168: The statement "The calculation of the fire grid latitude and longitudes..." appears misplaced within the section.
- Lines 168-169: The manuscript does not adequately describe the improved approach for geolocation determination or how it enhances accuracy.
- Line 174: The methodology for handling grid mismatches and specifying the fire domain should be explicitly detailed.
- Line 176: ... the three-dimensional horizontal wind components (U and V variables in WRF).

<u>General Comments:</u>

- The manuscript presents limited innovations in fire physics, appearing to largely replicate WRF-Fire, with minor modifications following Mandel et al. (2011) and Muñoz-Esparza et al. (2018). The novelty of the contribution should be better articulated.
- The study is restricted to a single fire event (Cameron Peak Fire), which limits the generalizability of the findings. Expanding the analysis to multiple fire events with varying topographies and meteorological conditions would improve the robustness of the conclusions. If additional events cannot be incorporated, at a minimum, a sensitivity analysis should be conducted.
- The computational trade-offs of coupling CFBM with other atmospheric models should be acknowledged and compared to existing solutions such as WRF-Fire.

Final Decision:

The manuscript is not recommended for publication mainly for the following reasons:

1. Misalignment with the journal's scope: The manuscript presents a well-structured refactoring of the WRF-Fire codebase to create a more modular and flexible fire behavior model. While the core fire physics remains largely unchanged, the restructuring enhances model interoperability, making it easier to couple with different atmospheric models using ESMF. This modularity is a valuable contribution to fostering broader collaborations within the fire modeling community. However, for this journal, which emphasizes advancements in geophysical modeling, the paper would benefit from further developments that go beyond code refactoring, such as improvements in fire physics or additional parameterizations. The reviewer suggests submitting this manuscript to another journal with a different scope after resolving the issues in the following point.
2. Issues with validation methodology:
    a. Discrepancies in model configurations (e.g., different vertical levels and parameterizations).
    b. Inappropriate scales that likely weaken fire-atmosphere feedback.
    c. Validation primarily relies on qualitative comparisons, which are insufficient for rigorous model evaluation.

A final recommendation is that instead of using a real-world fire case with significantly different configurations and scales between the coupled components, the authors should consider an idealized test case that allows for a more controlled and rigorous evaluation of the coupling framework.