

Response to reviewers

Manuscript: Evaluation of angular resolution of the finite volume method on the predicted accuracy of wildfire thermal radiation

We thank both reviewers for their helpful comments. The responses below describe the completed revisions, with locations identified by manuscript section, figure and table. The revision includes quantitative surface statistics, additional angular-refinement calculations, measured memory use, clearer figures.

Reviewer 1

Comment: *The manuscript investigates the effect of angular resolution in the finite volume method on predicted surface incident radiation in wildfire radiation modeling. This is a relevant and useful topic, since angular discretization directly affects ray effects, heat-flux accuracy, and computational cost. The authors compare buoyancy-driven and wind-driven fire cases and provide practical recommendations for selecting angular resolution. The objective is clear, and the decoupled radiation-only approach is appropriate for isolating the numerical influence of angular discretization. However, the authors should address following comments before publication:*

Response: We have clarified the scope and terminology, corrected the case and timing information, and added coordinates and sampling locations to the figures. The revised manuscript now includes quantitative near-source/far-field surface statistics, additional 64-16 calculations, and measured total memory for the two representative 64-12 configurations.

Major comment 1

Comment: *The manuscript appears to use 64-12 as the reference or converged solution. Please clarify whether this case is truly angular-converged or simply the finest resolution tested. If no finer case was tested, the statement should be softened.*

Response: We use 64-12 as the comparison baseline for the archived angular configurations and have added 64-16 calculations for both frozen fields. Increasing the zenith count from 12 to 16 at 64 azimuthal divisions gives near-source/far-field differences of 1.88%/2.78% in the calm case and 0.46%/2.02% in the windy case, relative to 64-12. Section 3.4 and Table 3 now report this additional zenith-sensitivity assessment.

Major comment 2

Comment: *The findings show that buoyancy-driven and wind-driven flames show different sensitivity to angular resolution. The authors should more clearly explain why the attached flame in the wind-driven case is less sensitive near the fire source, whereas the detached and unsteady buoyant flame requires finer angular discretization.*

Response: Section 3.2 now provides a geometric interpretation based on the angular extent of the emitting region. An extended, attached hot region can occupy a broader range of incident directions at a nearby receiving point than an elevated, localized region viewed from farther away. This interpretation connects the observed angular sensitivity to flame attachment, source size and geometry, and source-to-receiver distance. The similar near-centre profiles in the calm case are included in this discussion.

Major comment 3

Comment: *The decoupled approach is reasonable for isolating angular-discretization effects. However, the statement that this strategy does not affect the purpose may be too strong. In fully coupled wildfire spread simulations, radiation can influence fuel preheating, pyrolysis, flame dynamics, and spread rate. This limitation should be stated more carefully.*

Response: Section 2.3 now describes the radiation-only calculation using fixed LES temperature and species fields. Varying the angular discretization on these prescribed fields isolates its effect on ground-surface incident radiation. The Conclusions use the same definition of the assessed quantity and computational setting.

Major comment 4

Comment: *Tables 1 and 2 provide useful timing and memory information, but the timing trends are not entirely clear. For example, in the windy case, the 48-8 case appears faster than the 40-6 case. The authors should specify whether the reported values are wall-clock time or CPU time, and whether the processor number, decomposition strategy, and solver settings were identical.*

Response: Tables 1 and 2 now use the final OpenFOAM ClockTime values, in seconds, rather than the master-process CPU times previously copied from ExecutionTime. The timer includes initialization after creation of the Time object, the radiation solution and final write, and excludes queueing and decomposition. Table 1 now reads 74, 120, 379 and 1037 s; its four rows all used 3 nodes and 192 MPI ranks. Table 2 now reads 125, 822, 314 and 652 s, with allocations of 1/64, 1/64, 2/128 and 4/256 nodes/ranks, respectively. In particular, the 48-8 job used twice as many ranks as 40-6. The jobs ran on different nodes. We report the archived Scotch decomposition, GAMG intensity solver settings and two radiation sweeps, and interpret runtime together with these parallel allocations and iterative settings.

We additionally measured peak total memory in two representative 64-12 radiation runs: 1324.85 GiB for the calm case and 1606.54 GiB for the windy case. The manuscript defines the reported value as the maximum total resident memory of all solver processes sampled at common 2 s intervals. These measurements are given in Section 3.3 alongside the historical timing tables.

Minor comment 1

Comment: *Please define the angular-resolution notation, such as 16-2, 32-4, and 64-12, clearly at first use and in figure captions.*

Response: The N_ϕ - N_θ notation is now defined in the Abstract and Section 2.2 as the azimuthal and zenith division counts. Section 2.2 gives the 64-12 example, and the relevant contour and line-plot captions explain the labels.

Minor comment 2

Comment: *Some conclusions use strong wording such as "ray effects vanish." Unless a quantitative criterion is provided, it may be better to write "ray effects become visually negligible" or "are substantially reduced."*

Response: The Abstract, Section 3 and the Conclusions now describe the reduction of visible ray effects and quantify the differences between angular configurations. Section 3.4 and Table 3 provide the area-weighted surface comparisons and the additional 64-16 results.

Minor comment 3

Comment: *The limitation related to non-sooting flames is important and should be mentioned earlier in the methodology, not only in the conclusion.*

Response: Section 2.1 identifies the two cases as non-sooting flames and specifies CO₂ and H₂O as the participating gases represented by WSGG. The Conclusions retain this computational setting when summarizing the results.

Minor comment 4

Comment: *Several language issues should be corrected, for example: "unburn vegetables" to "unburned vegetation/fuels," "The chose of numbers" to "The choice of the numbers," "buoyance driven" to "buoyancy-driven," and "Keven-Helmholtz" to "Kelvin-Helmholtz."*

Response: We have reviewed the manuscript for language and terminology. "Unburn vegetables" has been replaced by "unburned fuels", the choice of angular division counts is expressed grammatically, and "buoyancy-driven" is used consistently.