International Conference on Numerical Combustion
Rome, Italy, October 14-17, 2025
www.icnc2025.com

A posteriori analysis of in-situ adaptive neural network-coupled binary trees for manifold-based models in LES of turbulent flames

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Manifold-based combustion models can decrease the cost of turbulent combustion simulations by projecting the thermochemical state onto a lower-dimensional manifold, allowing the thermochemical state to be computed separately from the flow solver [1]. Traditionally, solutions for the manifold equations have been precomputed and pretabulated, resulting in large memory requirements and significant precomputation cost even for simple problems. In-Situ Adaptive Manifolds (ISAM) [2] enables solutions to the manifold equations to be computed as the simulation progresses and stored using binary trees with In-Situ Adaptive Tabulation (ISAT) [3,4], allowing for the use of more general models [5]. While ISAT helps reduce the memory requirements compared to pretabulation approaches, as the manifold model complexity grows, the memory requirements of ISAT databases will still eventually become too large. Previous work has shown ISAT memory requirements can be reduced through the use of neural network-coupled binary trees (NNBTs) [6]. With neural network-coupled binary trees, portions of the binary tree are pruned and replaced with neural networks trained in-situ from the data contained in the pruned region of the tree. In this work, the performance of the NNBT approach is validated on fully coupled LES of canonical turbulent flames with manifold models of varying complexity. The computational timing, memory usage, and accuracy of the NNBT method is evaluated and compared to the same simulations using only ISAM.

References

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