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

# Modeling CO in LES of Premixed Turbulent Jet Flames with Flame-Wall Interaction: *A posteriori* Analysis

Kai Niemietz[1]*, Michael Gauding[1], Heinz Pitsch[1]
*Lead presenter: k.niemietz@itv.rwth-aachen.de
[1] Institute for Combustion Technology, RWTH Aachen University, 52056 Aachen, Germany

In stationary gas turbines, the low-load operation range is often limited by carbon monoxide (CO) emissions. Under very lean conditions, the oxidation of CO can occur on relatively long timescales. In wall-bounded flows, the CO chemistry is further complicated by heat loss, flame-wall interaction, and turbulence, making CO emissions difficult to predict for reduced-order models. In this study, a novel CO model is implemented and evaluated *a posteriori* in large-eddy simulations (LES) of premixed turbulent methane jet flames with flame-wall interaction. The LES model is validated with data from a direct numerical simulation (DNS) of the same configuration, which was specifically designed to capture relevant aspects of gas turbine combustors [1].

The LES combustion model is based on a premixed flamelet approach with tabulated chemistry, compiled from 1D detailed chemistry calculations. Both freely propagating and strained counterflow flamelets at various unburnt temperatures are combined in the chemistry table to capture the local flame physics. In the LES, the thermo-chemical quantities are retrieved from the chemistry table using multiple control variables, such as a combustion progress variable, an enthalpy term to consider wall heat losses, and the OH radical as an indicator of turbulent strain. Additionally, a transport equation for CO is solved, including transport effects not considered in the chemistry table and allowing CO to develop on its own timescale.

While global flame characteristics can be adequately reproduced with lower-dimensional tables, the proposed high-dimensional model is necessary for accurate predictions of CO emissions. Solving the additional CO transport equation significantly enhances the accuracy, which is especially relevant in the near-wall region, where CO concentrations deviate from those predicted by the tabulated flamelets.

## References

[1] Niemietz K, Berger L, Huth M, Attili A, and Pitsch H. Direct numerical simulation of flame-wall interaction at gas turbine relevant conditions. *Proceedings of the Combustion Institute.* 2023;39(2):2209-2218.