Investigation of Particulate and Gaseous Emission from Hydrogen Assisted Combustion of Kerosene

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BACKGROUND

- Hydrogen is a promising option as an alternative to the conventional jet fuel (Jet A-1). Along with its promising benefits in terms of emissions, a complete change of the fuel and airport infrastructure, and long development and certification process for new aircraft technology are required for its adoption. Due to these challenges, adopting hydrogen as sole energy carrier for civil aviation in short term does not seem feasible.
- Blending hydrogen with kerosene can be adopted in aero engines in civil aviation with minimal retrofitting. Blending hydrogen with kerosene combustion shows that it can significantly reduce CO and CO2 emissions especially at lean conditions but the effect of blending on NOx and soot emissions have not been established.

OBJECTIVE(S)

- Investigating effects of hydrogen blending on kerosene combustion in terms of chemical kinetics and emissions characteristics of:
  - NOx
  - CO
  - Polycyclic aromatic hydrocarbons (PAHs)
  - Soot number density, volume fraction, and particle morphology

HOW?

- Investigating and characterizing the gaseous and particulate emissions for hydrogen assisted combustion of kerosene (HACK). The investigation will be done numerically for 1D and 3D CFD simulations of laminar and turbulent flames
- The CFD simulations will be coupled with a novel Monovariate Population Balance Model (MPBM)[1] to simulate soot emissions along with NOx and CO emissions for Jet A-1/Hydrogen combustion.
- In-situ and ex-situ measurements on canonical laminar flames to investigate the effects of hydrogen blending on kerosene combustion, focusing on gaseous and particulate emissions

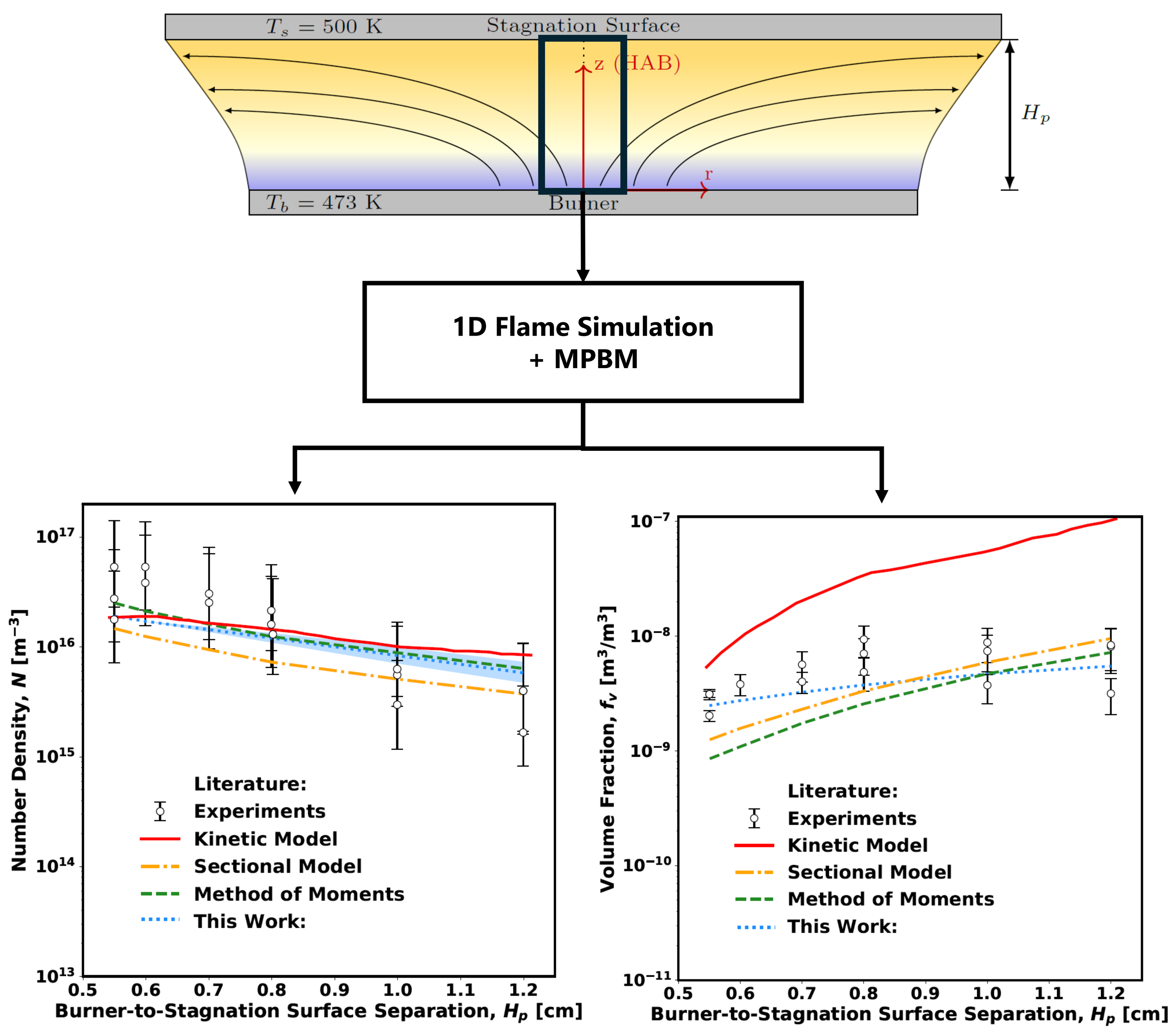

Fig: Comparison of modeling efforts for number density and volume fraction of soot from a Premixed C2H4/air Burner Stabilized Stagnation Flame. Figure is adapted from [2]

WHY?

- This research will give a more complete picture on how gaseous and particulate emissions from combustion of kerosene and blends of kerosene and hydrogen.
- The results can show whether hydrogen assisted combustion of kerosene is a viable option for emission reduction during taxiing at the airport and flight conditions
- The results from this study can be used as inputs for contrail and climate models for the investigation of environmental impact of new and current aircraft and aero engine configurations for various flight conditions.

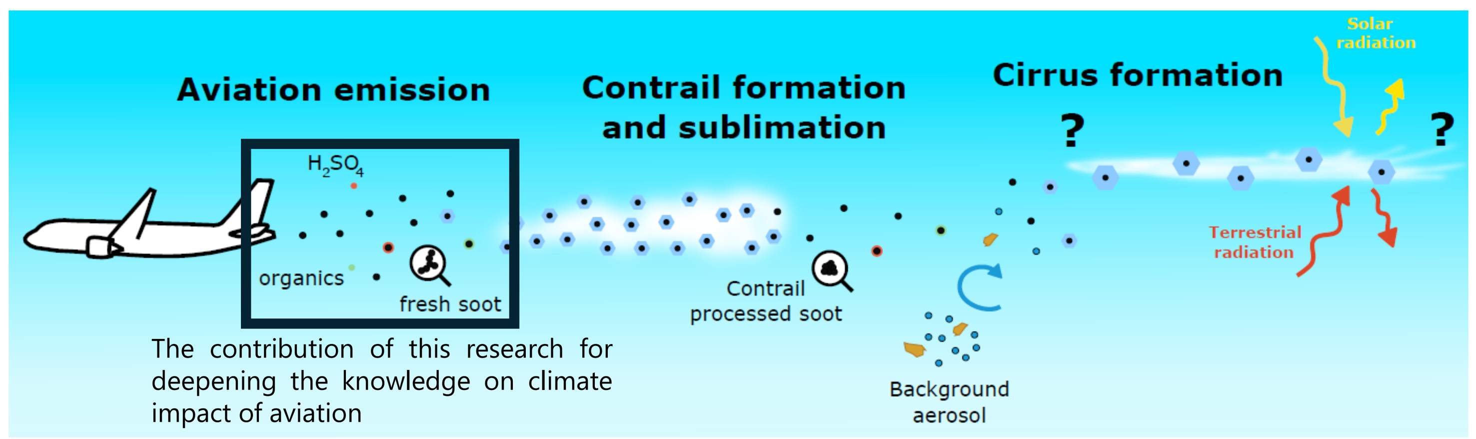

Fig: Schematic of main atmospheric processes associated with aviation soot-cirrus interaction [3]

[1] Kholghy, M. R., & Kelesidis, G. A. (2021). Surface growth, coagulation and oxidation of soot by a monodisperse population balance model. Combustion and Flame, 227, 456-463.
[2] Saad, D. M. (2021). (rep.). Soot dynamics in rich premixed flames by interfacing a monodisperse population balance model with chemical kinetic simulations. Zurich: ETH Zurich.
[3] Testa, B., Durdina, L., Edebeli, J., Spirig, C., & Kanji, Z. A. (2024). Contrail processed aviation soot aerosol are poor ice nucleating particles at cirrus temperatures. *EGUsphere*, *2024*, 1-22.

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