EGU24-14031, updated on 24 Jan 2025
https://doi.org/10.5194/egusphere-egu24-14031
EGU General Assembly 2024

Evaluation of a UAV-Based Methodology for Measuring Flare Combustion Efficiency

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This work will present a quantitative evaluation of the potential for measuring gas flare combustion efficiency using an aspirating sensor platform mounted under an uncrewed aerial vehicle (UAV). The UAV sensor package contains lightweight commercial gas analyzers capable of precise measurements of atmospheric methane (CH_4), ethane (C_2H_6), carbon dioxide (CO_2), and carbon monoxide (CO). By sampling the flare's plume of combustion products with the help of a UAV, flare efficiency measurements can be safely and remotely completed without affecting the flare's operation. The relative mole fraction of the measured major carbon containing species can be used to close a carbon mass balance, which permits calculation of a local carbon conversion efficiency of the flare. However, because the composition of the flare plume can be inhomogeneous as well as turbulent, it is not straightforward to determine whether the measured incomplete combustion products are representative of total inefficiencies. Further uncertainty arises if the flared gas contains additional hydrocarbon species (e.g., C3+ hydrocarbons) that may not be directly measurable by the UAV platform. To address these challenges, controlled experiments were completed on large scale (100-mm diameter) flares burning within Western University's Boundary Layer Wind Tunnel. With the wind tunnel running in an open circuit configuration, the UAV/sensor package was suspended within the wind tunnel test section downstream of the flare where it measured combustion efficiency while being moved in and out of the combustion plume. Results were compared with known combustion efficiencies for identical operating conditions obtained following the established method of Burtt et al. (J. Energy Inst. 2022). Further, combustion efficiency measurements from operating flares will be made using the developed sensor to validate the proposed measurement approach. Ultimately, this tool could close a known gap in our ability to quantify carbon conversion efficiency and methane slip from flares under field conditions as required under emerging measurement, reporting, and verification (MRV) programs.