Leveraging Sky-LOSA Field Measurements and Laboratory Experiments to Model Global Black Carbon Emissions from Gas Flaring

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Abstract

Atmospheric concentrations of black carbon (BC) have critical implications on earth's climate (Gustafsson and Ramanathan, 2016) and public health (e.g., Cushing et al., 2020). One important anthropogenic source of atmospheric BC is gas flaring, a common practice in the oil and gas industry where extraneous gases are disposed of by open-atmosphere combustion. Although gas flaring is thought to be a relatively small contributor to global BC emissions (Stohl et al., 2013), the location of flaring activities implies that it has disproportionately large negative effects on the sensitive arctic climate (e.g., Popovicheva et al., 2017). Unfortunately, however, efforts to characterize and mitigate emissions of flare BC are hampered by a lack of quantitative emissions data. Consequently, overly simplistic, single-valued emission factors are commonly used within climate models and emissions inventories, causing industry and governmental institutions alike (IPIECA, 2014; Raga et al., 2018; U.S. EPA, 2012) to identify the need to improve the present understanding of BC emissions from flares.

This work leverages measurements of flare BC yield from laboratory experiments (McEwen and Johnson, 2012; Mehr, 2020) and field measurements using sky-LOSA (including Conrad and Johnson (2017) and newly computed results) to provide insights into global BC emissions from gas flaring. These laboratory and field data are first used to derive a new combustion regime-dependent flare BC emission factor model. Coupling this model with satellite-based estimates of globally flared volumes (NOAA, 2020) and estimated ranges of flare gas composition (as in Huang and Fu (2016)) under a Monte Carlo framework permits development of global and country-specific flare BC emissions inventories with robustly calculated uncertainties. Implications of these results are discussed in the context of emissions reduction targets and current inventory estimates based on simple emission factors.

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