Multi-species Atmospheric Inversion of Sectoral Greenhouse Gas Emissions in the Indianapolis Urban Environment

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A high-resolution atmospheric inversion system has been developed to quantify urban-scale carbon dioxide (CO_2) emissions over Indianapolis, IN. However, emissions estimates need to be decomposed into their constituent economic source sector contributions to be of great benefit to policymakers. We show here that, with the assistance of flask measurements of multiple trace gases, sectoral emissions can be retrieved at the city scale. With five automated flask samplers collecting weekly samples across the Indianapolis urban environment from 2012 to 2015, we demonstrate the benefits and limitations of directly calculating inverse emissions of fossil-fuel CO_2 (CO_2ff) source sectors with the aid of trace gases, assuming known CO_2ff-to-gas ratios for each sector. Analyses of Bayesian inversion results are first performed in a pseudodata framework built with the Hestia inventory product. We determine the required density of measurements and the characteristics of the trace gases able to separate sectoral contributions. In the second part, we present a real-data source sector inversion for traffic emissions (including off-road combustion engines) calculated using flask measurements of CO_2ff, carbon monoxide (CO) and acetylene (C_2H_2). Our results suggest that sectoral emissions require multiple trace gases with varying CO_2ff-to-gas ratios to quantify each sector accurately. With the appropriate combination of atmospheric tracers, we show that sectoral emissions of CO_2ff can be constrained by urban-scale inversions providing key information for monitoring and verifying mitigation policies at the city level.

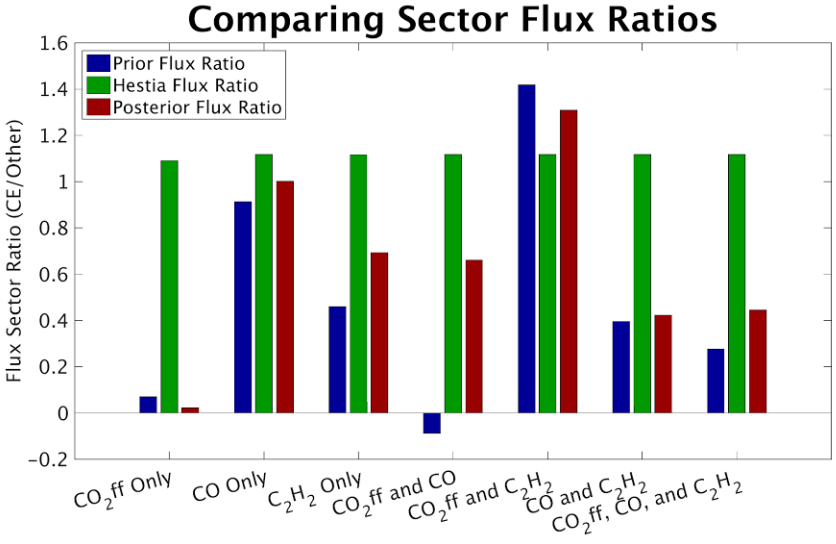

Figure 1. Ratio between combustion engine (traffic and off-road) emissions and the other sectors (airport, commercial, industrial, railroad, residential, and energy production) based on Hestia (in green), perturbed Hestia (a priori in blue), and after inversion (a posteriori in red). The different cases correspond to various combinations of atmospheric flask measurements of carbon dioxide (CO_2ff derived from $^{14}CO_2$), CO and C_2H_2 used in the different inversions over Indianapolis.