Creating an Emissions Map for Benzene Based on Fossil Fuel CO_2 emissions: "HESTIA Benzene"

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Urban emissions are an important component of the global atmospheric burden of many trace gasses. These emissions are estimated through a variety of methods, each with its own set of advantages and disadvantages. In this work, we present an effort to use tracer ratios to fossil fuel CO_2 in order to estimate benzene (C_6H_6) emissions at Indianapolis, Indiana, as part of the Indianapolis Flux Experiment (INFLUX). INFLUX is a multiinstitutional experiment that combines trace gas measurements with high-resolution modeling and surface energy balance to evaluate urban emissions and provide a test bed for urban experiments.

Initially, we used the measurements of C_6H_6 and fossil fuel-derived carbon dioxide (CO_{2FF}) from INFLUX to obtain an approximate ratio of C_6H_6:CO_{2FF} based on the measurements. We then combined county-level C_6H_6 emissions from the U.S. Environmental Protection Agency's National Emissions Index 2014 (EPA NEI 2014) with CO_{2FF} estimates obtained from the Vulcan data product. We subdivided these emissions into eight sectors, Residential, Commercial, Industrial, On-Road, Non-Road, Rail, Utility, and Airport. For each sector, we calculated a unique C_6H_6:CO_{2FF} ratio. Once we obtained the estimated sectoral emission ratios, we used the Hestia data product for Indianapolis (Gurney et al., 2012) as a base, and multiplied each sector in the Hestia product by our estimated ratios. We then transported the Hestia-derived emissions for each of these sectors using footprints generated for each of the towers at Indianapolis by the Weather Research Forecast chemistry model (WRF-chem). This generated so called "receptors", or simulations of the tower measurement sites.

We compared the receptor data to the real-world tower measurements and found the predicted receptor C_6H_6 ratio to be too large. This was expected due to overestimation of On- and Non-Road C_6H_6 (mobile sector) in the EPA NEI (e.g., Borbon et al., 2013). Once we reduced the mobile sector C_6H_6 by a factor of 2 (ref), we obtained good agreement between the real-world measurements and the receptor values (Figure 1). Using these results, we present a new method for estimating benzene emissions based off of a fossil fuel CO_2 emissions model.

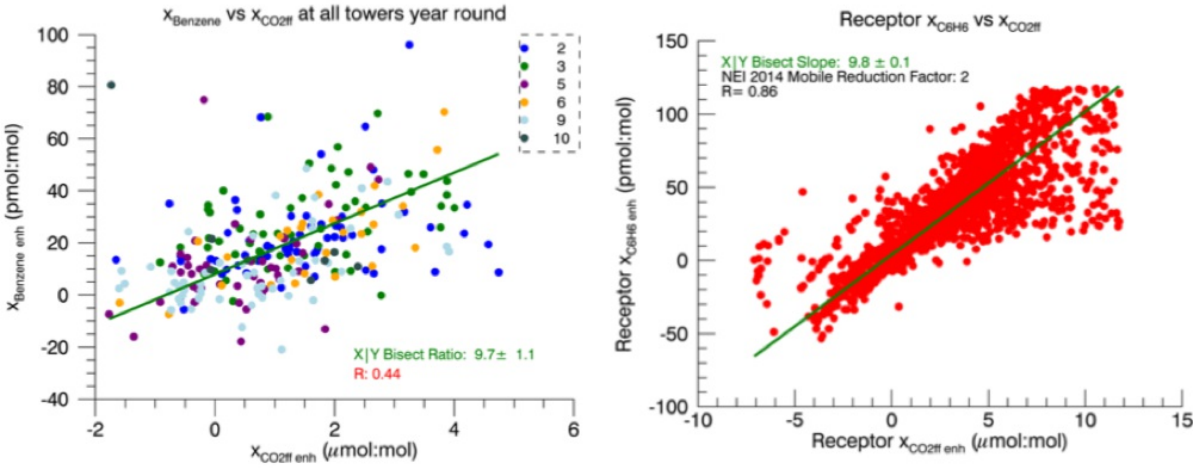

Figure 1. Plot benzene vs CO_{2FF} from INFLUX towers 2, 3, 5, 6–9, and 10 (left) and our receptor predicted benzene and CO_{2FF} (right). The receptor plot includes all days from 11/2012–10/2013, while data on right is all data from INX towers for 2011–2016. Slopes indicate C_6H_6:CO_{2FF} ratios. Receptor data has had mobile sector ratios reduced by a factor of 2.