Geophysical Research Abstracts
Vol. 21, EGU2019-18897-2, 2019
EGU General Assembly 2019

CO_2 , CH4 and CO emissions in the Washington DC / Baltimore Metro Area: Results from aircraft flux inversions

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The North-East Corridor (NEC) Testbed project is the 3rd of three U.S. urban greenhouse gas (GHG) emissions testbeds designed to advance and establish reliable measurement methods for quantifying and diagnosing GHG emissions. The first two NIST testbeds are the INFLUX experiment and the LA Megacities project. As with the other testbeds, the NEC project uses atmospheric inversion methods to quantify sources of Greenhouse Gas (GHG) emissions in the urban areas. Its initial phase is located at the southern end of the Northeast corridor in the Washington, D.C. and Baltimore area and consists of a network of 16 high-accuracy measurement locations placed on communication towers, regular aircraft campaigns, and bottom-up inventory development.

In this work we present results of an aircraft campaign conducted in February 2016, where two airborne platforms were used to quantify GHG emissions from the Washington DC/Baltimore area: the Purdue University Beechcraft Duchess, housing the Airborne Laboratory for Atmospheric Research (ALAR), and the University of Maryland Cessna 402B research aircraft. Both aircraft flew simultaneously for 5 days, mostly during the afternoon hours, collecting GHG concentration and meteorological data. Urban GHG emission rates from the area were then estimated from data collected by both aircraft with a Bayesian inversion framework.

A set of inversions (N=15,480) were performed using an ensemble of transport models (6 members) and prior fluxes (9 for CO_2, 4 for CH4 and 4 for CO). The ensemble of transport models along with the wind speed and direction errors provided the means to estimate the model-data mismatch error covariances. In addition, we used a Lagrangian approach to estimate the contribution of nearby outside sources providing a time varying background that included uncertainties that was then further optimized in the inversion.

Results were consistent across inventories and transport models, reflecting day to day variability in the emissions. The flat prior (equal emissions across the domain) had the largest variability in results due to the loose initial constraint it imposes on the inversion. However, average total posterior emissions were similar to the rest and showed a clear distinction in source distribution, where CO and CO_2 emissions were allocated to the urban areas, while CH4 showed a broader spatial distribution. The inversion analysis differentiates between cities, locating them, and correcting the emissions accordingly. Diagonal model-data mismatch error covariance provides larger estimates while background selection impacts the mean estimates and the variability. The ensemble approach can effectively reduce the uncertainty in the estimates as compared with the posterior uncertainty provided by the inversion for a single realization. In addition, up to 98% of the day to day variability in the CO_2 posterior is explained by rapidly changing emissions during the flight being sampled at different times by the aircraft (similar to aliasing). The ACES inventory scaled to totals of 2016 was close to the average estimated CO_2 emissions. Methane estimated emissions were 2.7 times the EPA-CH4 inventory and the CO estimated emissions were 0.63 times the NEI inventory.