The NIST Northeast Corridor Urban Testbed

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+ many additional partners

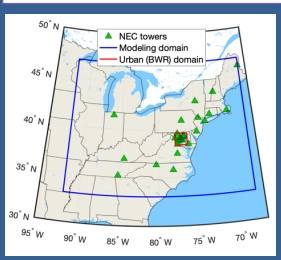
1. NIST Urban Testbeds

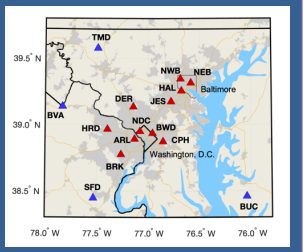
The NIST urban testbed program consists of three urban greenhouse gas (GHG) measurement projects designed to develop and test methods for emissions estimation in urban regions: Indianapolis (INFLUX, influx.psu.edu), Los Angeles, (megacities.jpl.nasa.gov), and the Northeast Corridor (NEC). Here we present an overview and plans for the project.

Right: Locations of urban GHG studies (NIST and other)

2. NIST's Urban Tower Networks

- Tower-based observation networks have been established by partners (Penn State, Earth networks, and Scripps Institution of Oceanography) in all three urban testbeds (see oral presentation by Jooil Kim on LA urban network).
- Carbon dioxide (CO_2), methane, and carbon monoxide observations are made continuously using high-precision instruments calibrated to WMO scales.
- Data is made publicly available at data.nist.gov through 2020.
- Planned update to X2019 CO_2 scale for the 2021 data release (both in LA and NEC).
- Many tower sites also have equipment to collect whole air samples using NOAA/GML flasks that are measured for many additional gas species, and isotopes including radiocarbon (w/ GNS science).

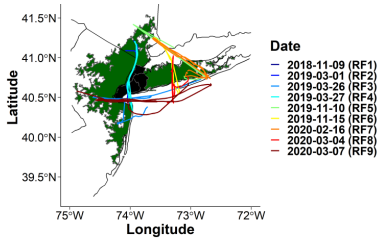




The Northeast Corridor (NEC) tower network comprises a regional network (left) and a denser urban network focused on the Washington DC/Baltimore urban areas (right). Plans include expanding the density of the network to Philadelphia and NYC. Regional analyses can determine emissions in multiple urban areas while constraining the background conditions. Urban analyses can better inform emissions with finer spatial resolution.

3. Airborne sampling

- University of Maryland, Purdue, & Stonybrook University conducting flight campaigns in Indianapolis, DC and NYC areas.
- Measurements of CO_2, CH_4; sometimes include CO, O_3, NO_2, & turbulence / meteorology
- Mass balance, scaling factor, and full model inversion analyses using flight GHG data.
- *Flight campaigns will continue at regular intervals.*

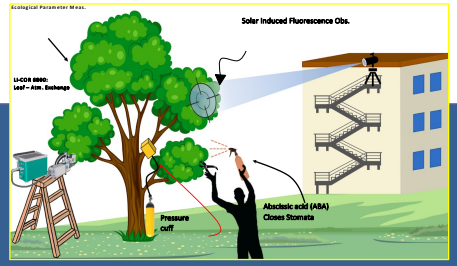


Stonybrook U./Purdue U. flight tracks used for GHG flux estimation. Figure from Hajny et al, 2022.

Refs: Lopez-Coto et al., ES&T (2020, 2022), Pitt et al., Elementa (2021), Ren et al., JGR (2018); Balashov et al., ACP (2019), Hajny et al., Elementa (2022).

4. Additional NEC activities

- Airborne turbulence measurements (Stonybrook U.) and high-resolution tracer modeling around powerplants using WRF-LES
- Planning deployment of low-cost CO_2 & AQ sensors; HALO (wind Lidar system); Mini-MPL for PBL depth (see poster by Tyler Boyle on low-cost CO_2 sensors).
- Eddy covariance flux towers (Penn State) in Indianapolis and in the Washington area to diagnose CO_2 and CH_4 fluxes in cities (including suburban vegetation) (Wu et al., 2022).
- SIF-Biosphere testbed (FOREST project) on NIST campus in Maryland, collab. w/ BU, Bowdoin & others. Goal to assess SIF measurements and linkage to GPP to improve biosphere modeling (Marrs et al., GRL)
- Bottom-up emissions modeling collaboration with NOAA: GReenhouse gas And Air Pollutant Emissions System (GRAAPES).

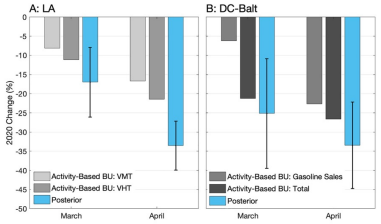


Schematic of SIF testbed (NIST FOREST project), courtesy D. Allen & L. Hutyra

5a. Anomaly detection in CO_2 in NEC & LA

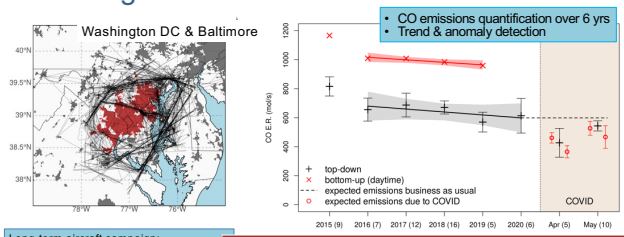
A recent study (Yadav et al., GRL, 2021) examined the decline in anthropogenic CO_2 emissions LA and in DC/Baltimore during the March & April 2020 lock-downs.

Emissions estimated by an atmospheric inversion with tower data showed declines in 2020 in both cities relative to the same months in 2018 and 2019 and attributed the decline using traffic & fuel sales data.



Decrease in CO_2 emissions from LA (left) and Washington/Baltimore (right) determined from atmospheric inversion modeling using tower network data. (Yadav et al., 2021)

5b. CO trends in Washington DC using airborne monitoring

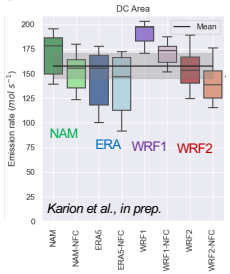


Long-term aircraft campaign:
- 70 flights over 6 years
- Bayesian inversion framework

Lopez-Coto et al., ES&T (2022) estimated CO emissions using an atmospheric inversion with aircraft data over 6 years. Downward trend matches expected trend in US EPA's National Emissions Inventory.

5c. Urban CH_4 emissions using NEC tower observations

- Top-down estimates of methane emissions in Washington DC (right) using tower observations and 8 different transport model configurations (based on 4 meteorological models) in an atmospheric inversion for 6 months.
- Box plots show monthly emissions estimates over 6 months, so variability within each configuration includes temporal variability.
- We can test weather models against observations (of wind speed, PBL, etc) to help better understand these differences.



Karion et al., in prep.

https://www.nist.gov/topics/greenhouse-gas-measurements/urban-test-beds

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