Open-path dual-comb spectroscopy in urban areas

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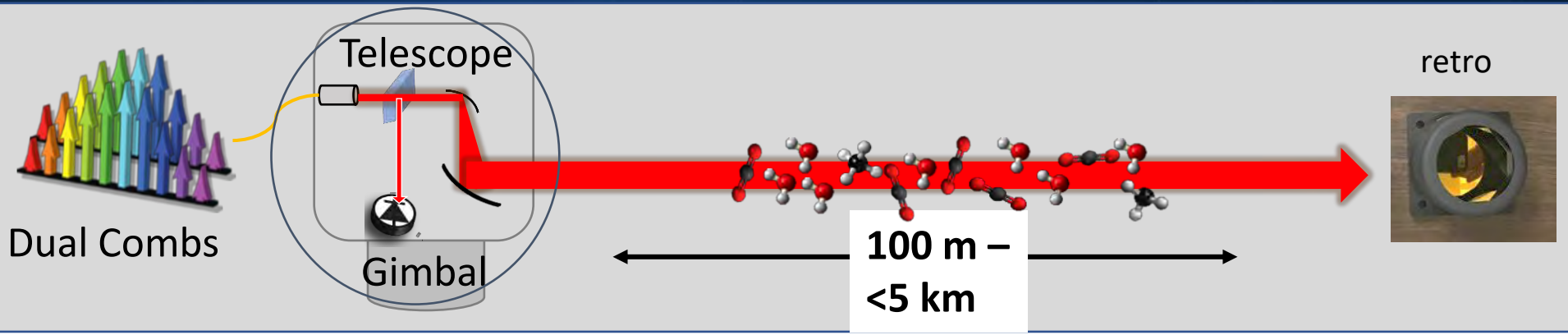
Open-path dual-comb spectroscopy



Broadband, high spectral resolution with no instrument lineshape and fast temporal resolution enables

- Multispecies detection
- Long open air paths – spatial averaging, no sample line bias
- Accurate concentration retrievals
- Multiple measurement paths
- ~minute time resolution

Near-infrared (NIR)
1-5 km
CO_2, CH_4, H_2O, HDO

Mid-infrared (MIR)
0.1-1 km
CH_4, H_2O, HDO, C_2H_6, HCHO, N_2O, small VOCs

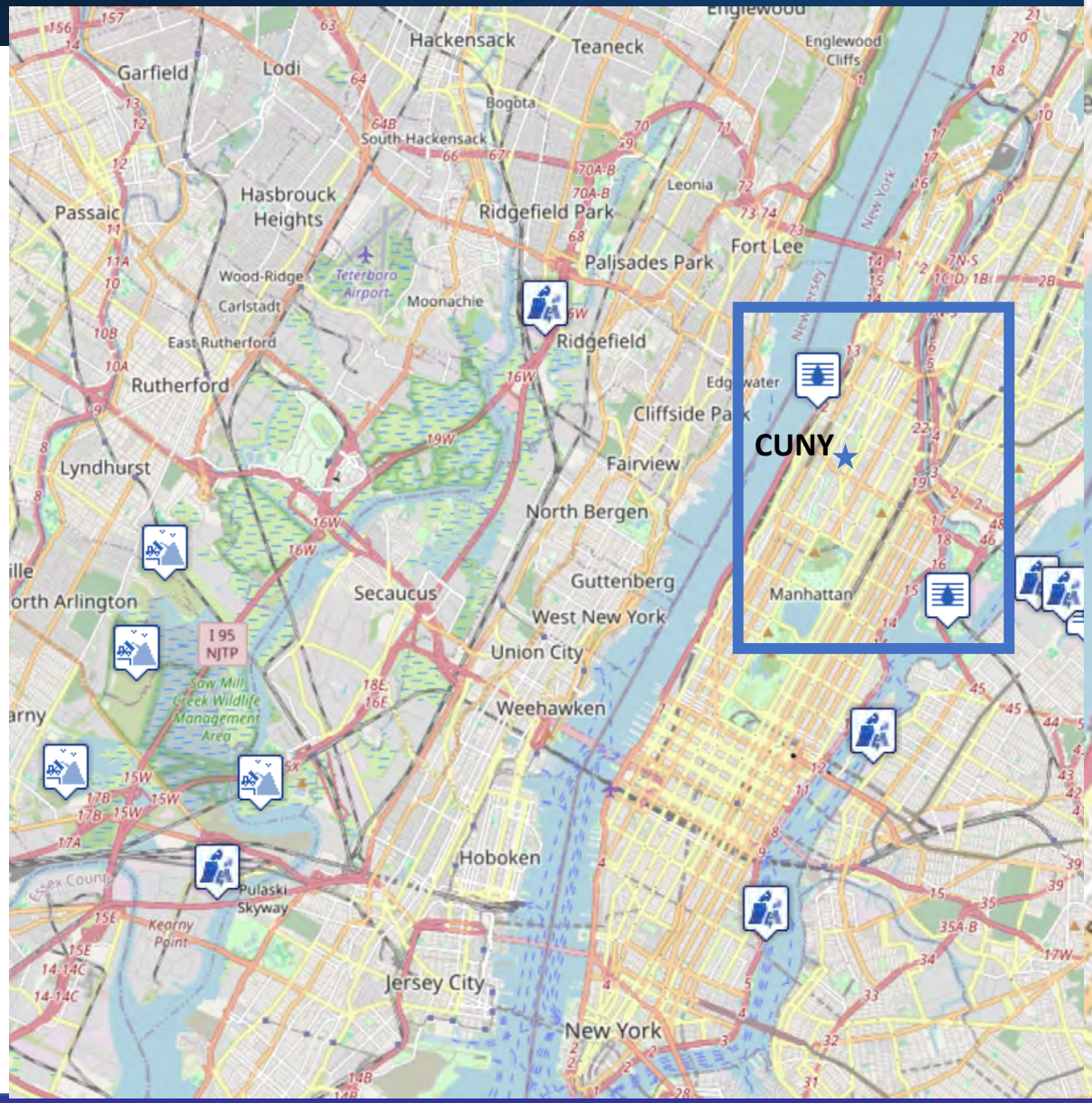
I Coddington Optica, 3, 414 (2016)
KC Cossel, Advances in Spectroscopic Monitoring of the Atmosphere, pp 27-93 (2021)

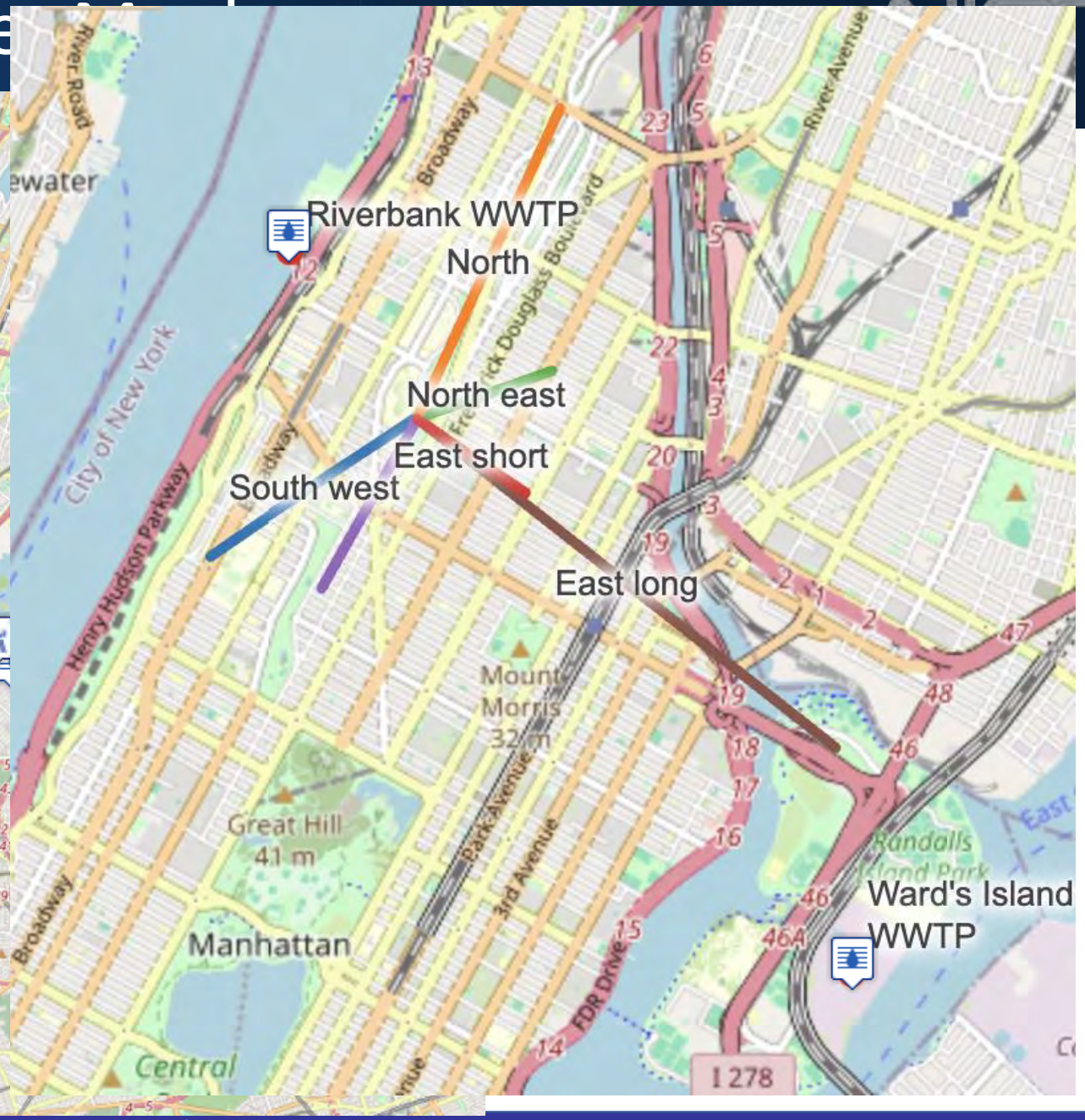
Contact: Kevin Cossel, kevin.cossel@nist.gov

Urban measurement goals

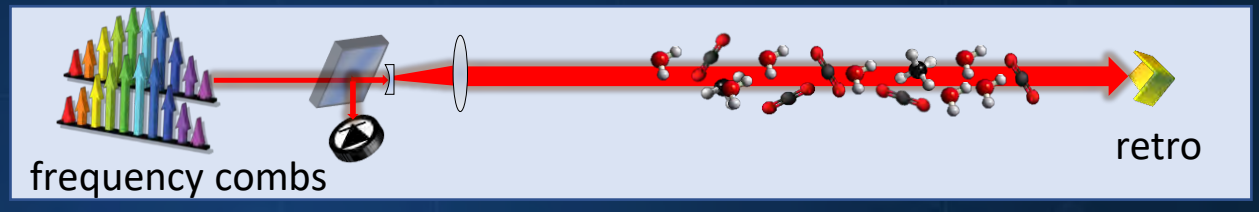
- Characterize urban emissions of GHGs and spatial-temporal variability
- Compare point and open-path measurements
- Estimate city or neighborhood-scale emissions
- Estimate emissions of major point sources
- Use C_2H_6 to apportion thermogenic, biogenic sources of CH_4
- Look at other tracers (e.g., N_2O) for source apportionment
- Look at sources of HCHO and relationship to ozone formation

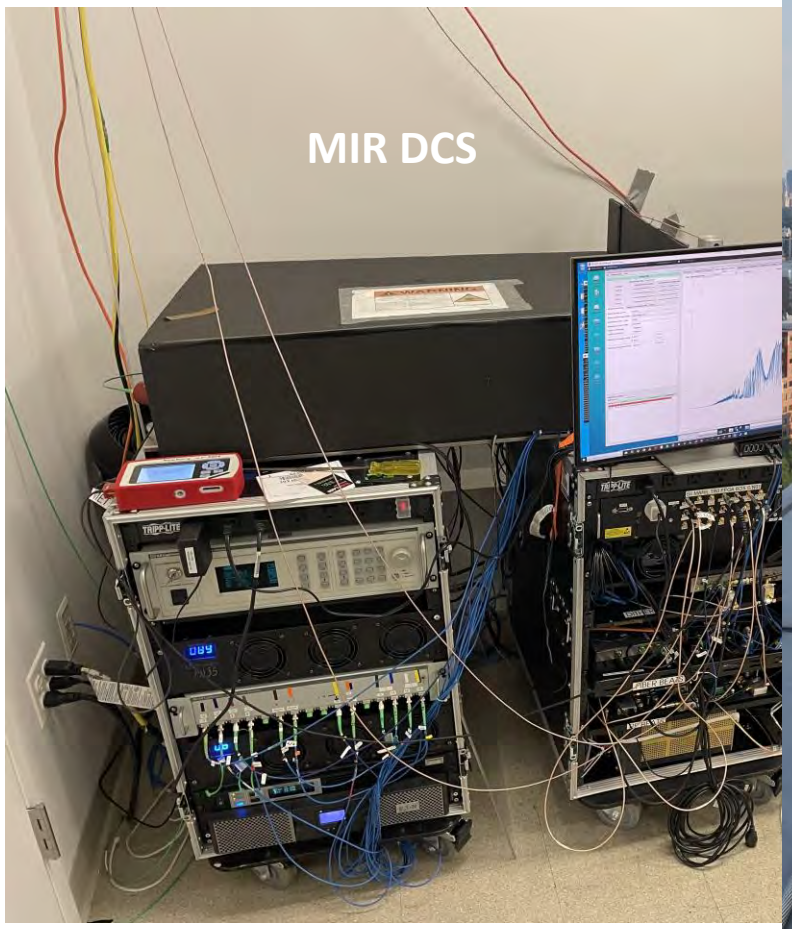
NYC: Measurement site in upper

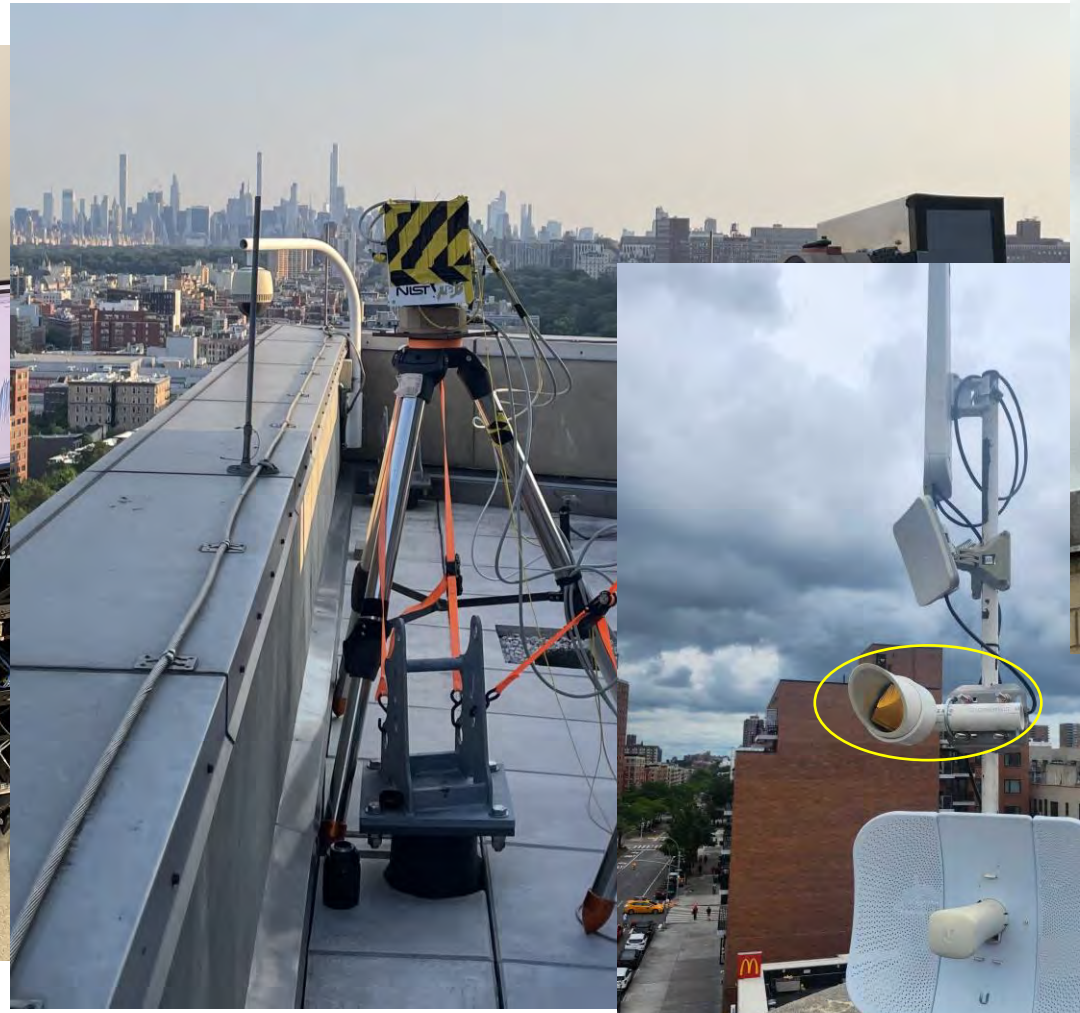


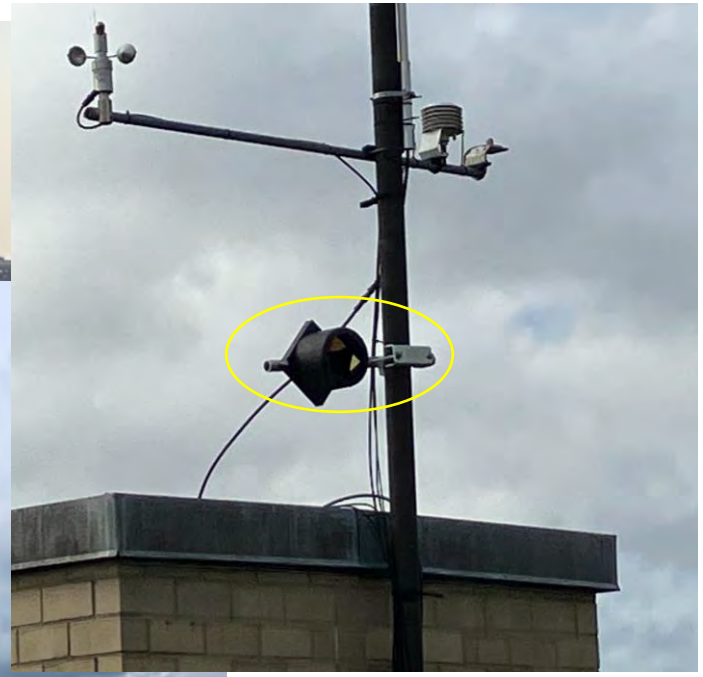


Setup

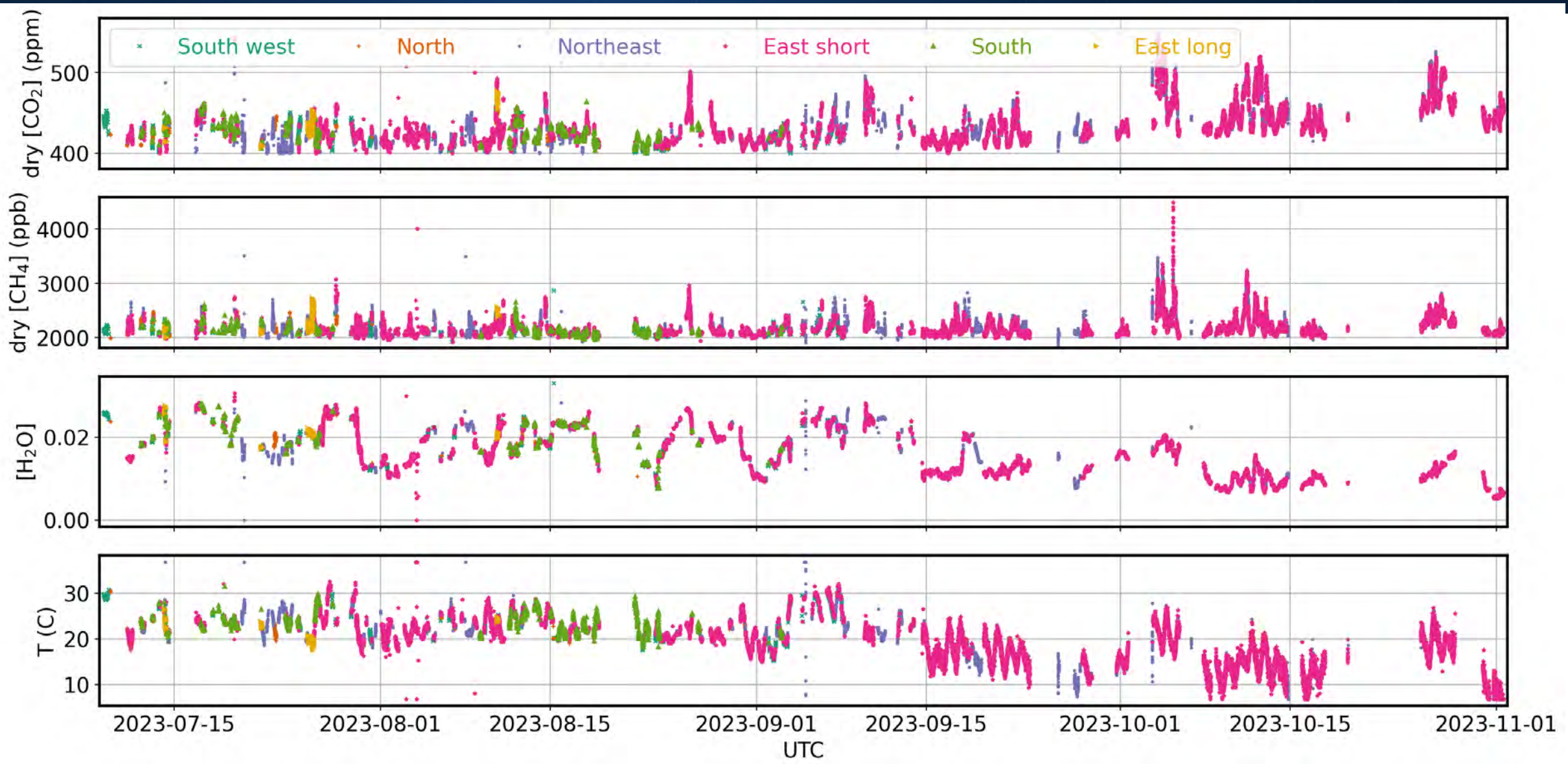




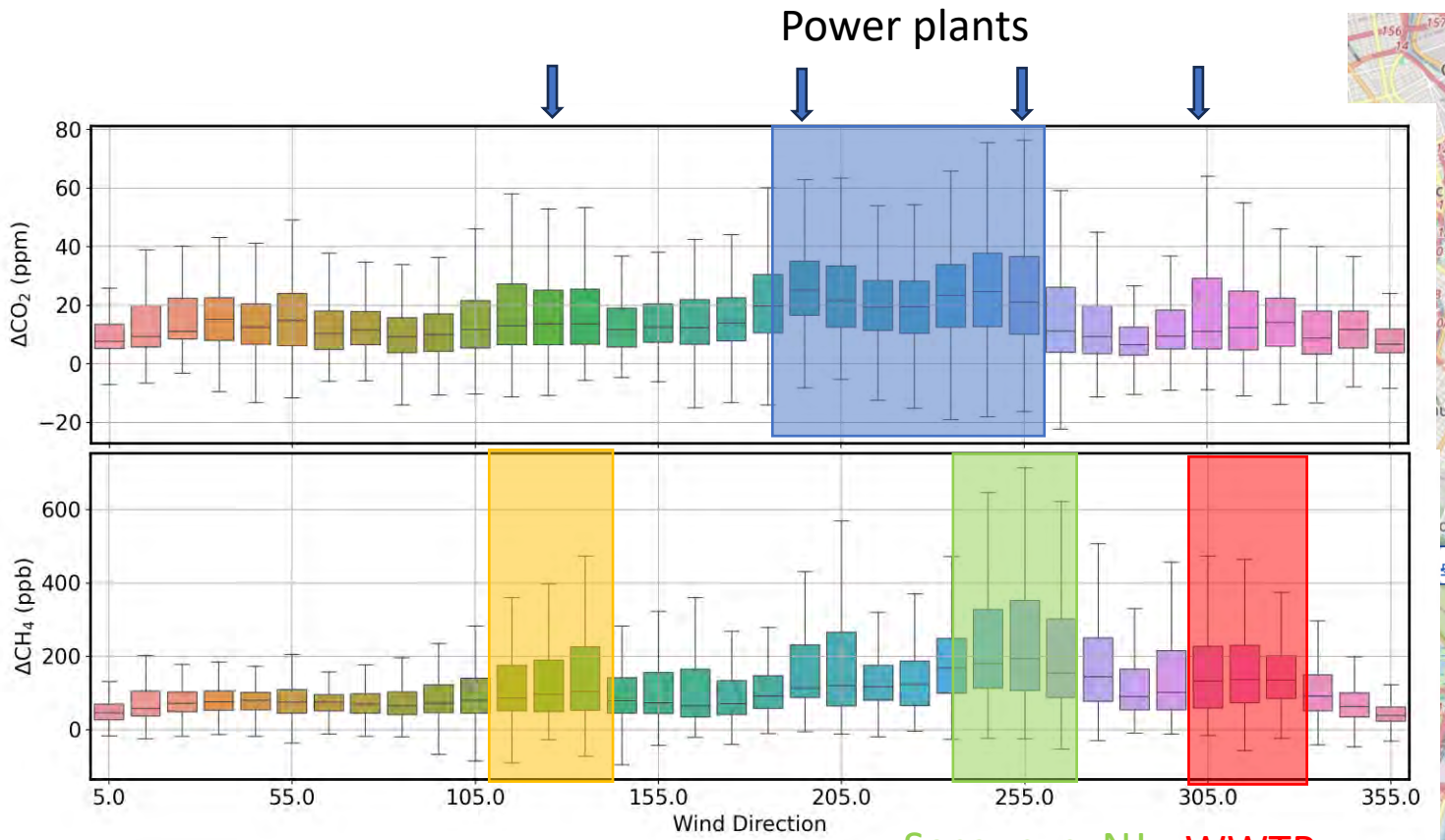




CO_2, CH_4, H_2O, and T measured for 3.5 months



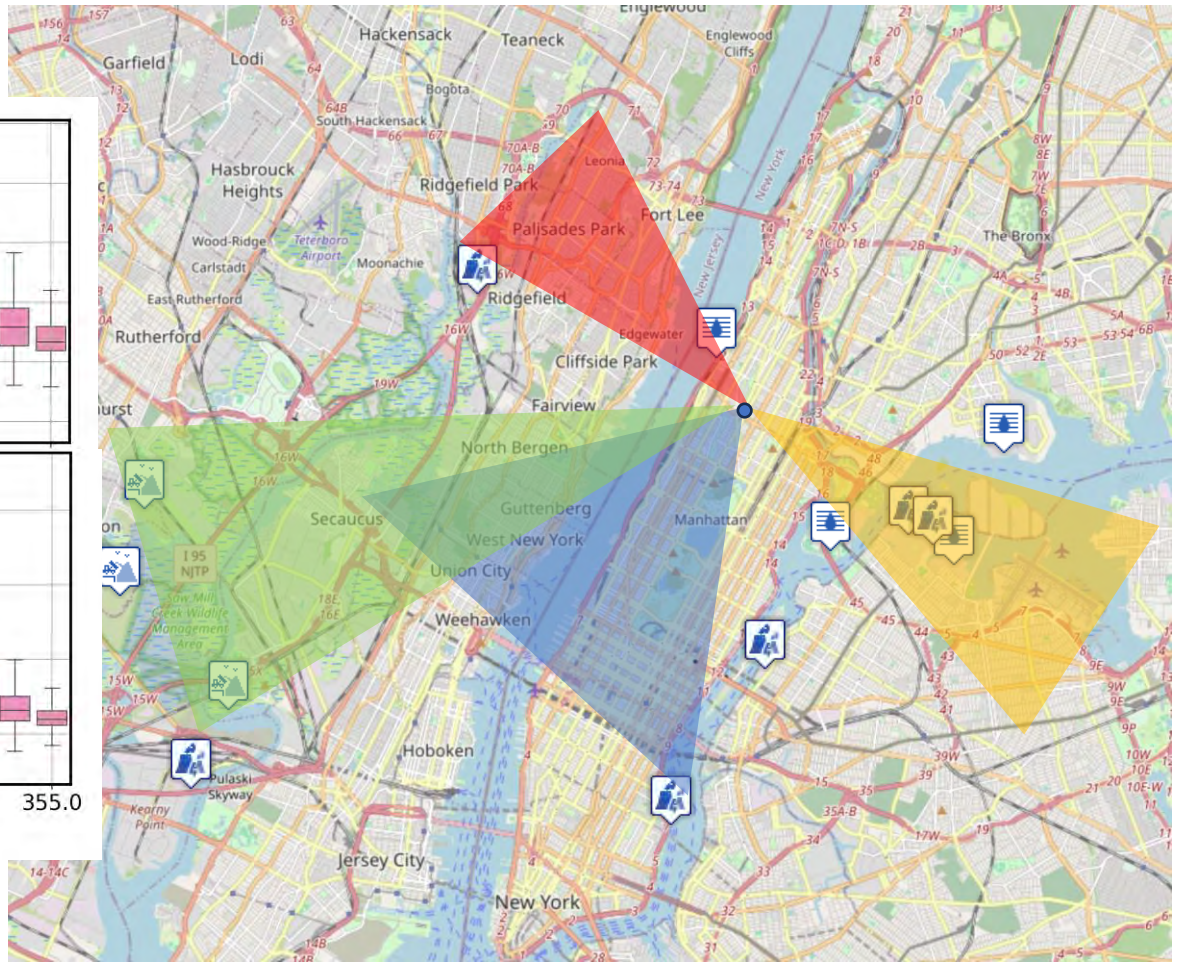
Enhancements vs wind direction



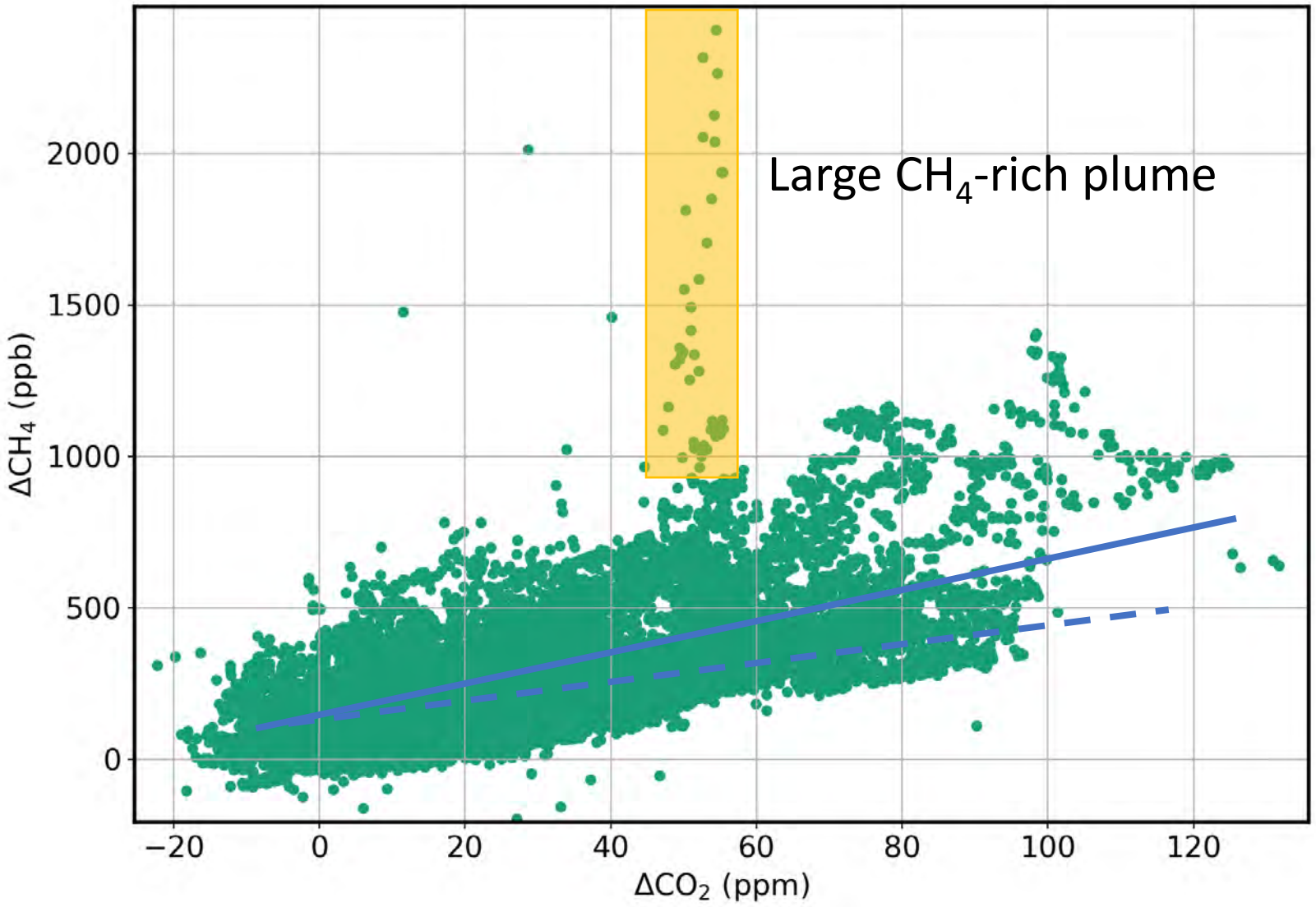
WWTP, power plant

Secaucus, NJ (landfills, wetlands)

WWTP



CH_4/CO_2 ratio for estimating ratio of emissions



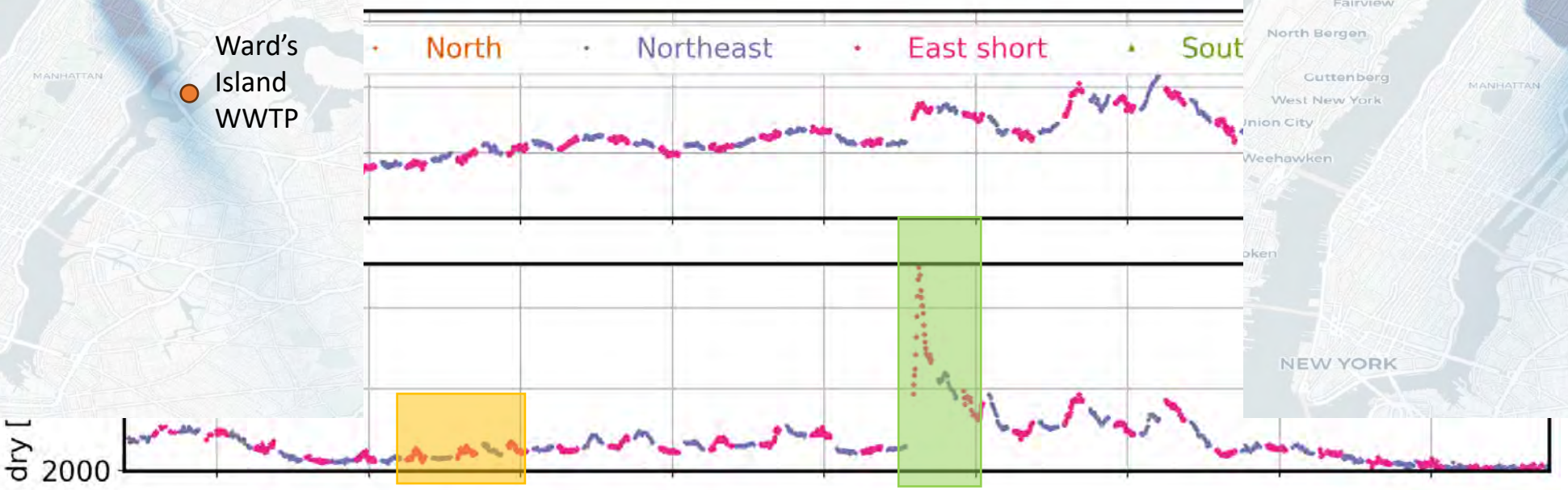
~5 ppb CH_4/ppm CO_2

Predicted from inventories: ~3 ppb CH_4/ppm CO_2

Indicates potential underestimate of CH_4 in inventory (PRELIMINARY!)

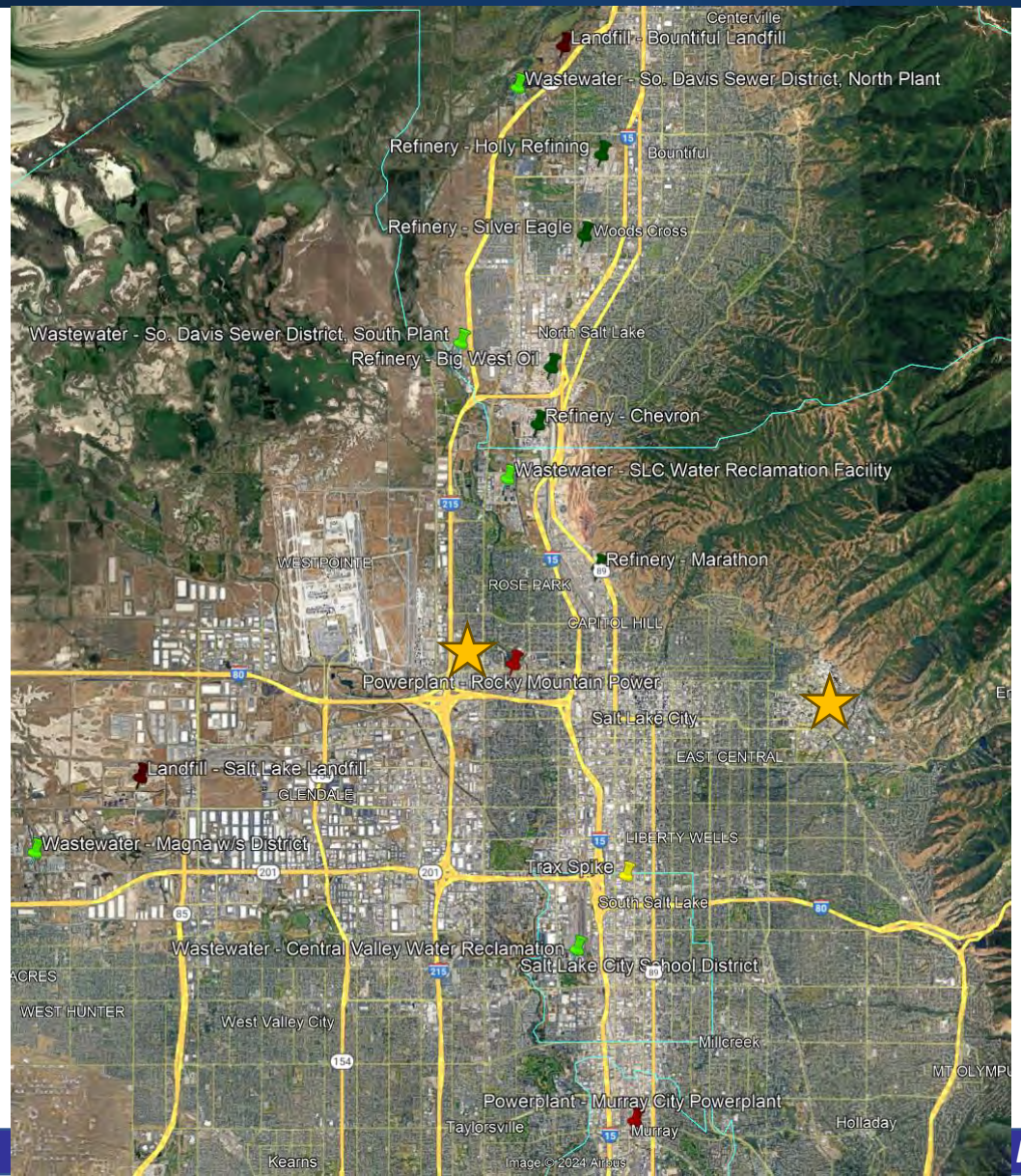
STILT model helps attribute plumes to WWTP

Ward's Island WWTP



Ward's Island WWTP

SLC deployment overview



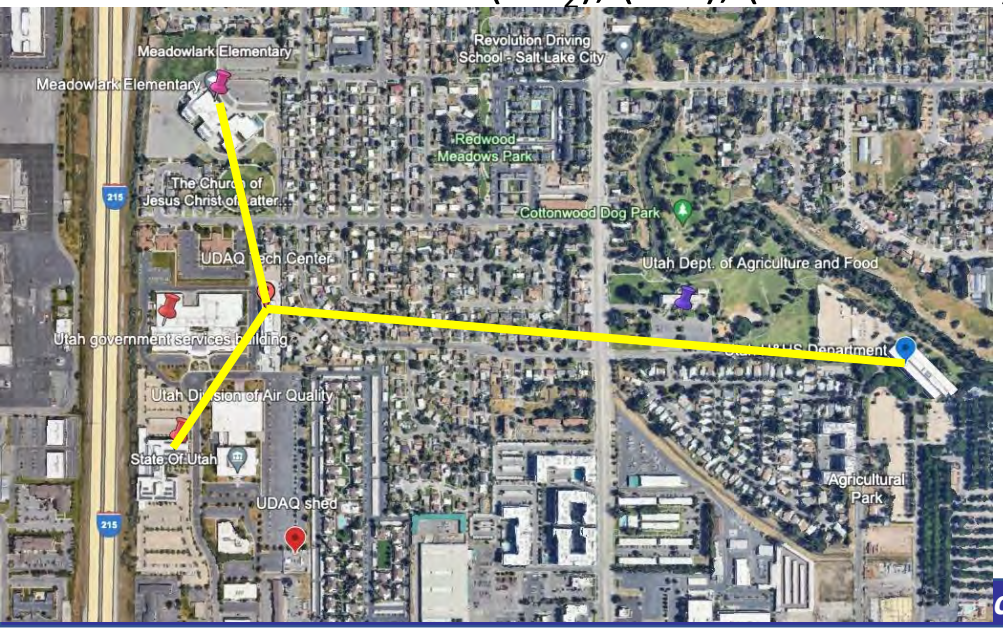
- Two systems deployed
- NIR (U of U)
  - Downwind emissions from city
- MIR (UDAQ Tech Center)
  - Source apportionment
  - HCHO for O_3 formation

- Map of identified CH4 emission sites (left)
- Stars indicate DCS sites (@ U of U and UDAQ)

DCS Deployments in SLC

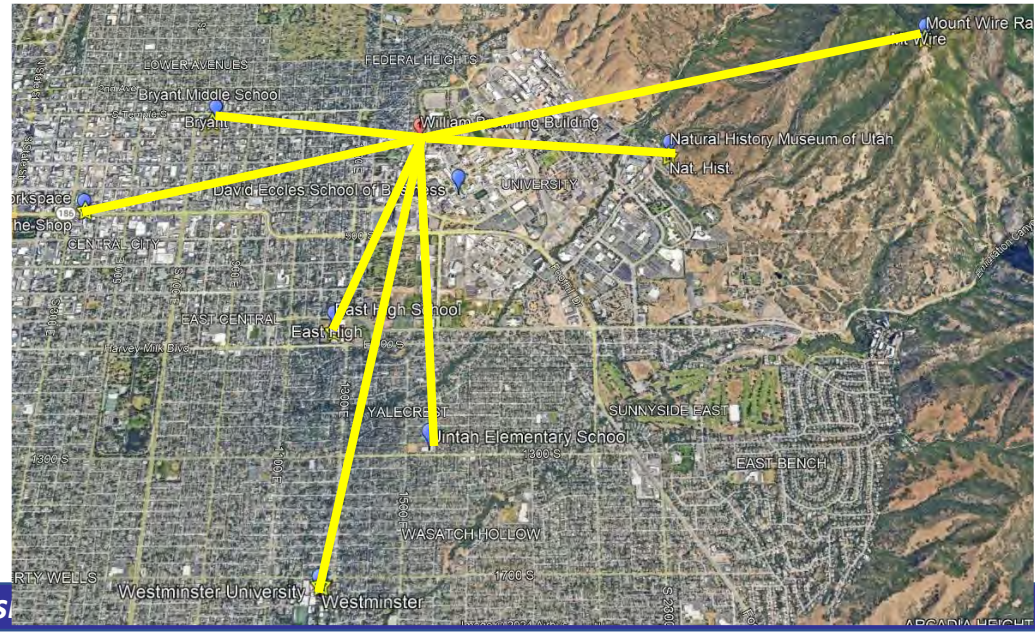
MIR DCS

- Location: roof of Utah Division of Air Quality building, west of downtown SLC
- 3 toggleable retro sites (all active): 275 m – 1.1 km
- CH_4, H_2O/HDO, C_2H_6, HCHO, N_2O, (CO_2), (HCl), (Other VOCs)



NIR DCS

- Location: roof of William Browning Building on U of U campus, east of downtown
- 8 installed retro sites (5-6 active): 1.8-4.6 km
- CO_2, CH_4, H_2O/HDO, (CO)



DCS Deployment- NIR

Panoramic view from WBB, 2nd tallest building on U of U campus

Eastern sites

- Large elevation difference between radio tower and foothills = vertical column
- Further distance from industrial sources, background measurements

Southern sites

- Longest open-path length
- Perpendicular to downwind from downtown SLC, highways
- 3 site options, w/ backup if return losses increase

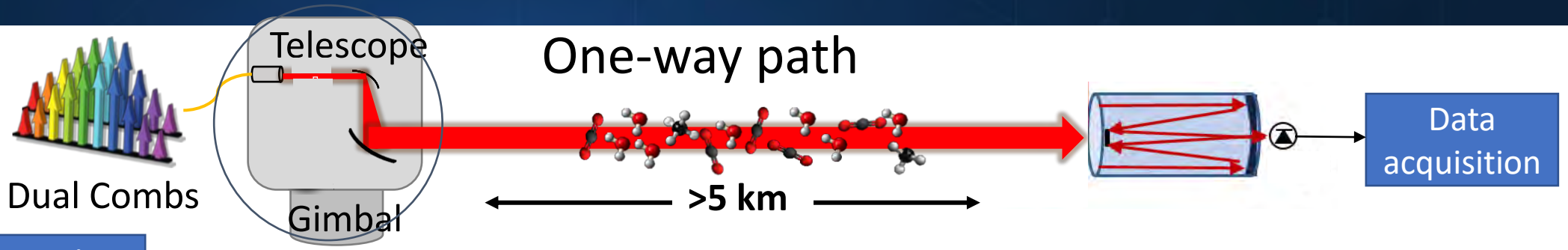
Western sites

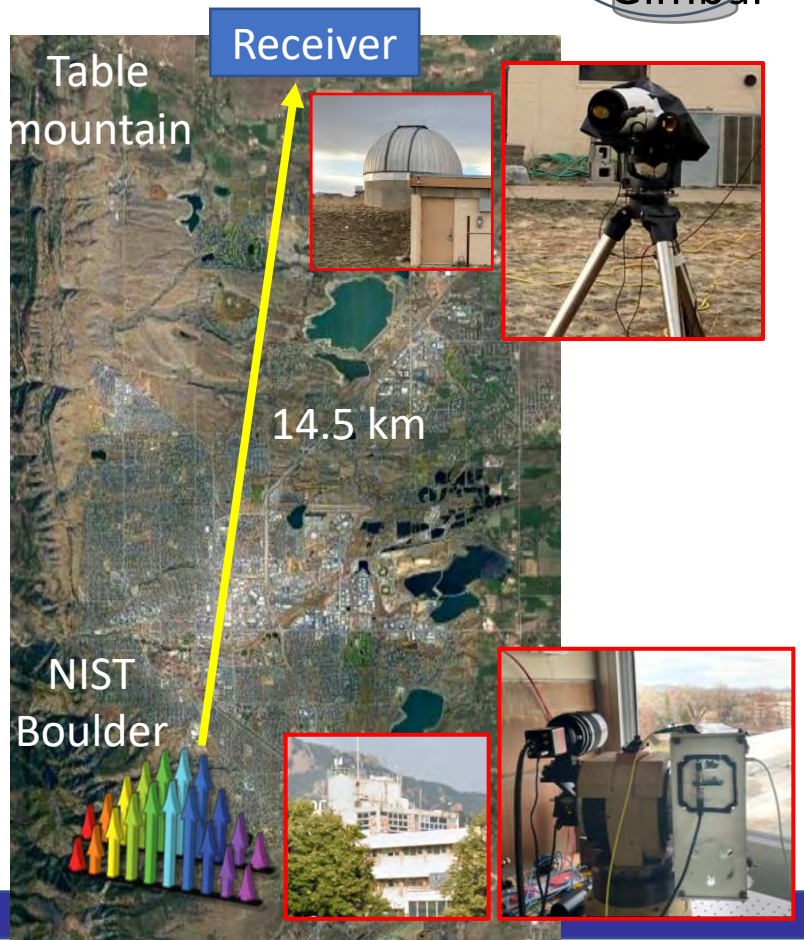
- South of older neighborhood (nat. gas emission sources)
- Overlaps with Trax line route, measurement comparisons

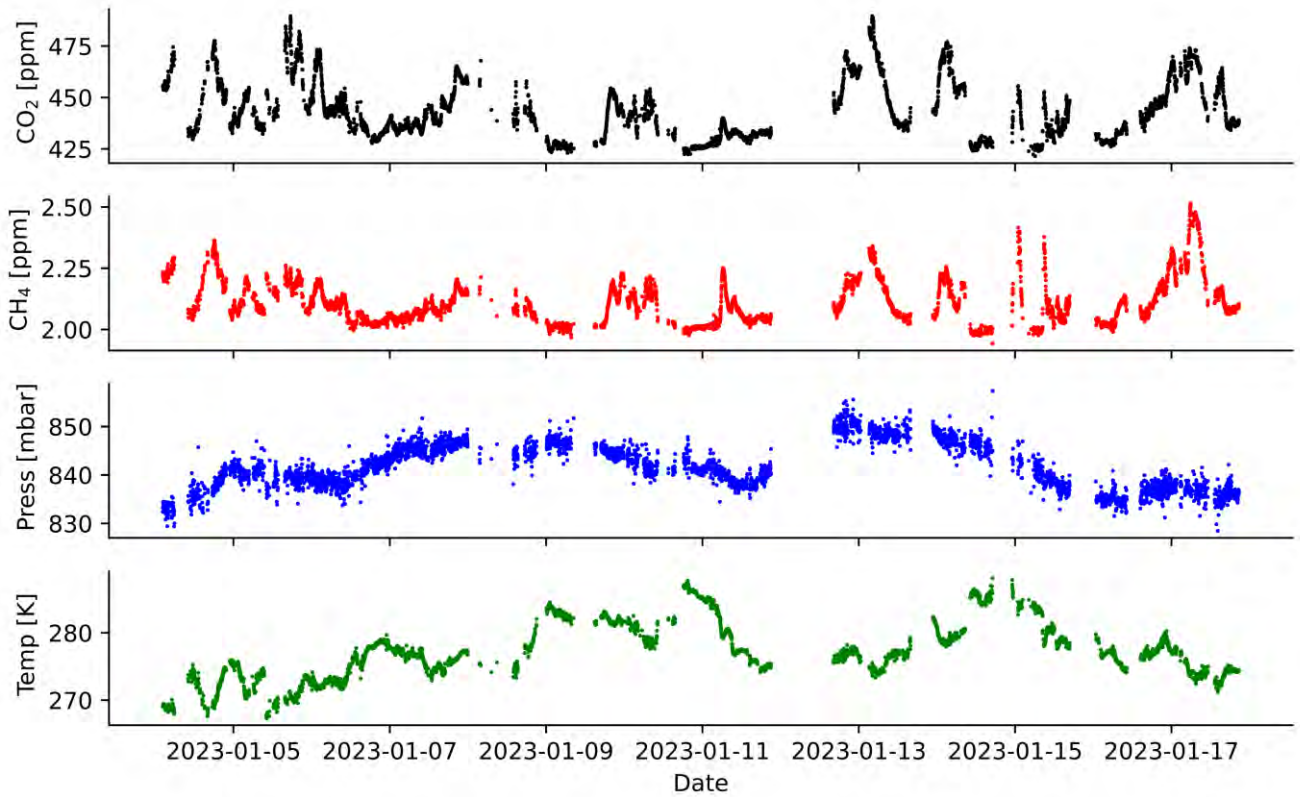
SLC status

- Data collection ongoing since mid-July (likely until end of Sept)
- Currently working of improving/automating retrieval code
- Next steps:
  - Comparison with airborne, mobile, in situ, EM-27 SUN, TRAX
  - Tracer-tracer correlations
  - STILT back trajectories

Future opportunity: extending the path length







AiRMAPS/BAQMMS?

- Coal mines? Potential for continuous area measurement of fluxes
- Downtown Baltimore?
- Over water?