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Urban Spatial Monitoring of Pollutants using Light Rail-based Sensor Systems

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Introduction and Motivation

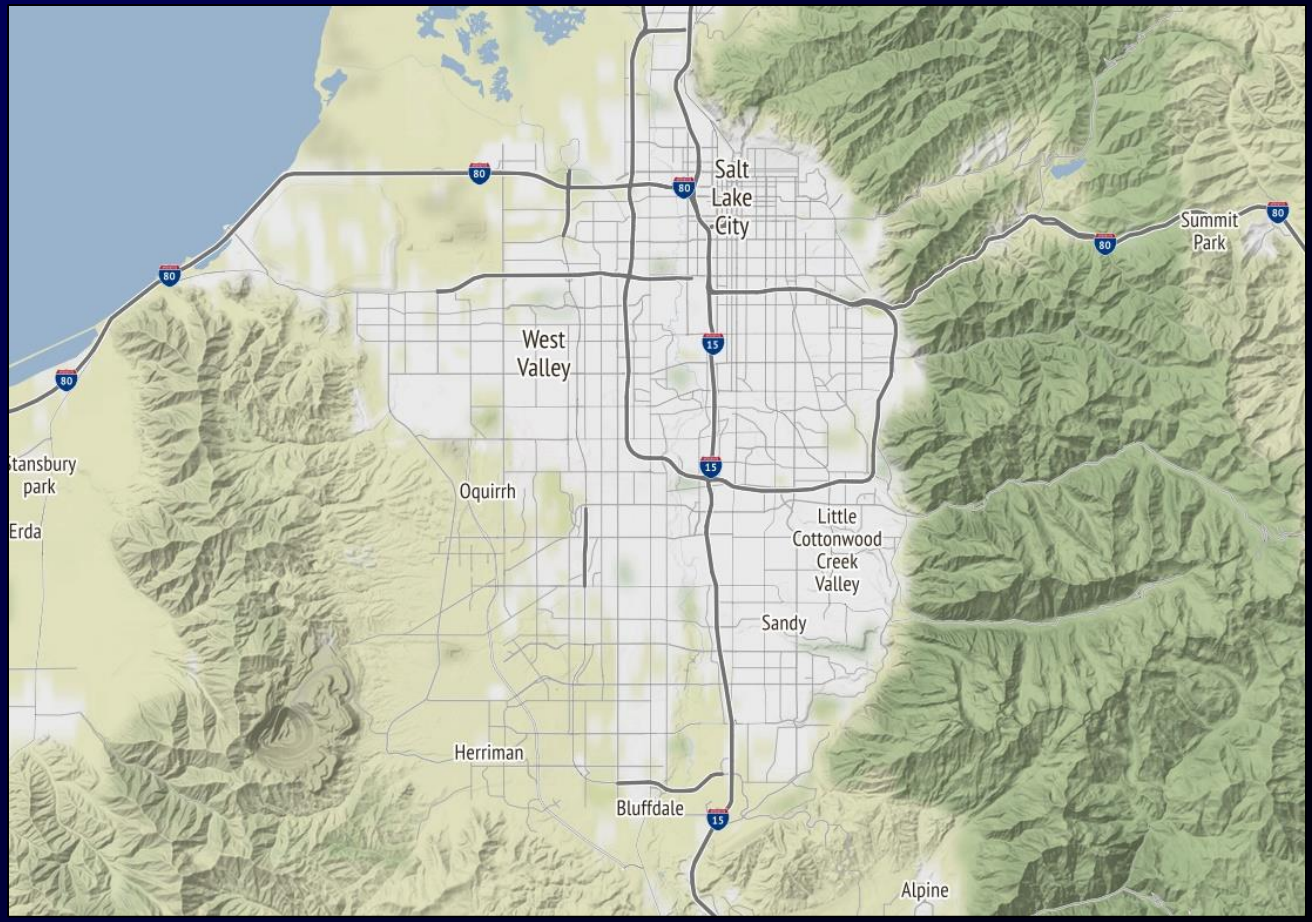
- Salt Lake Valley, Utah subject to seasonal air pollution episodes
  - Wintertime secondary particulate ($PM_{2.5}$) multi-day events
  - Summertime diurnal ozone (O_3) formation

- Spatial and temporal distributions of $PM_{2.5}$ and O_3 can be influenced by the local meteorology within the Salt Lake Valley region
  - Planetary boundary layer depth and stability
  - Diurnal mountain slope, valley, and canyon flows
  - Mesoscale lake/land breezes from the Great Salt Lake

- To better quantitively assess these distributions, mobile air quality platforms were installed on top of light rail trains within the valley
  - Initial pilot project (2014-2018) provided multiple insights into spatial variations of pollutants (Mitchell et al. 2018)
  - Operational project now underway (Mendoza et al. 2019)

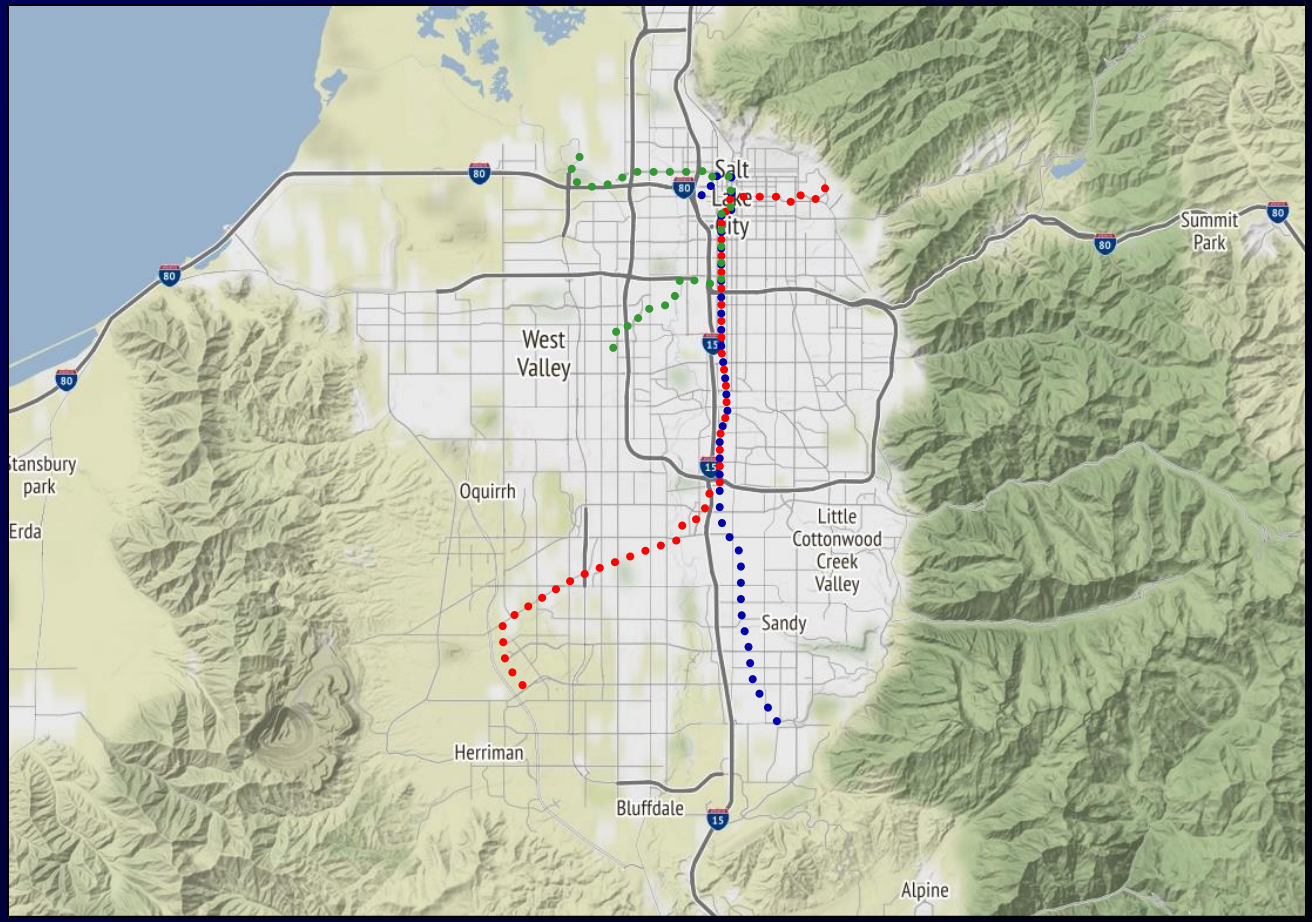
Light Rail Project Operational Deployments

- Majority of valley is surrounded by complex topography
  - Wasatch mtns east, Oquirrh mtns west, Traverse mtns south
  - Valley open to Great Salt Lake to the northwest



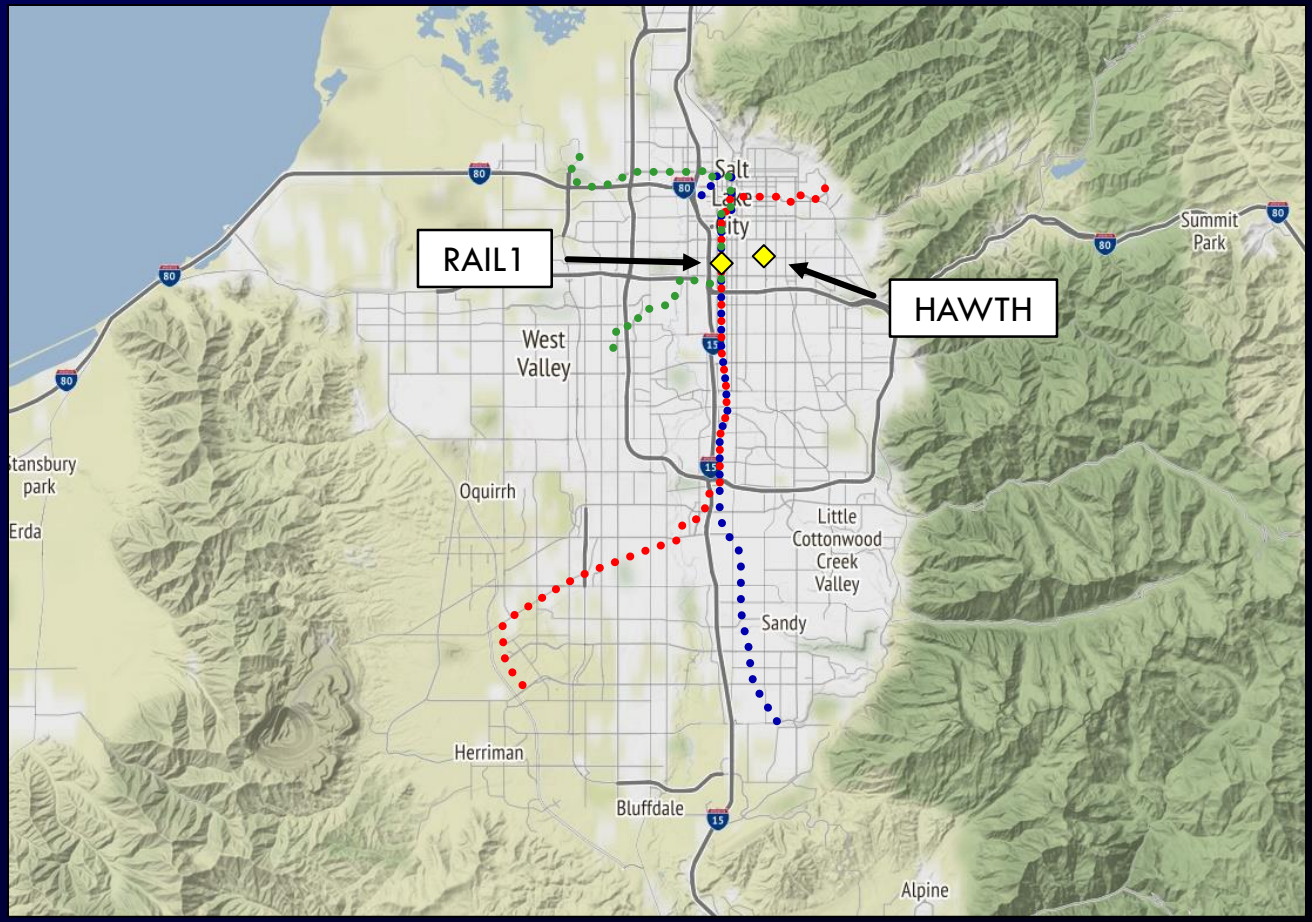
Light Rail Project Operational Deployments

- Utah Transit Authority TRAX Light Rail Car Commuter Lines
  - Red and green line cars instrumented Nov 2018
  - Blue line car instrumented Nov 2019



Light Rail Project Operational Deployments

- Two "validation" stationary sites also installed in Nov 2018
  - RAIL1: located where all 3 commuter lines intersect
  - HAWTH: adjacent to Utah Division of Air Quality sensors



Instrumentation and Data Logging

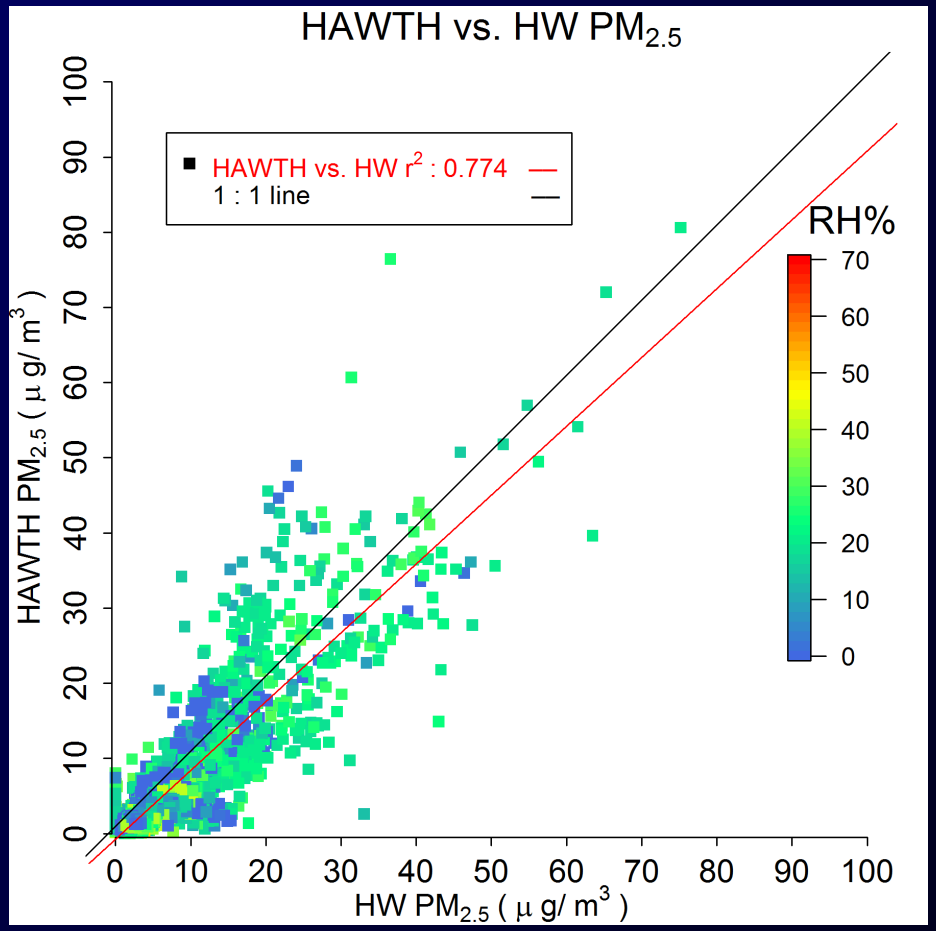
- Each light rail car carries the following instrumentation

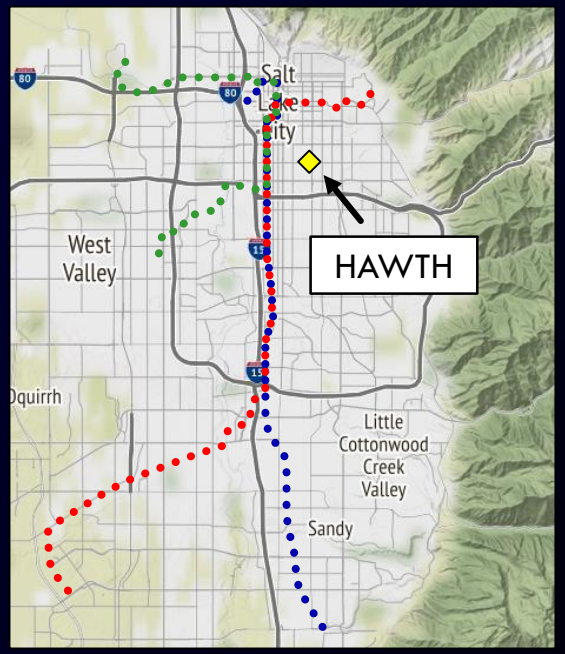
Instrument	Measurement/Purpose
Met One Instruments ES-642 Remote Dust Monitor w/ $PM_{2.5}$ Cyclone	$PM_{2.5}$ concentration measurements
2B Technologies 205 Ozone Monitor	O_3 concentration measurements
Garmin GPS	Precise location
CR1000 Data Logger	Local data logging and storage
Cellular Modem	Real-time data collection and debugging

- Validation sites contain ES-642, CR1000, and cellular modem
- Loggers locally collect and store measurements every 2 seconds
- Cellular communications used to collect most recent data off the data loggers every 5 minutes for storage and display/access

Comparison of ES-642 and FEM $PM_{2.5}$ Measurements

- Fixed site HAWTH deployed next to Utah Division of Air Quality equipment for instrumentation comparison and performance

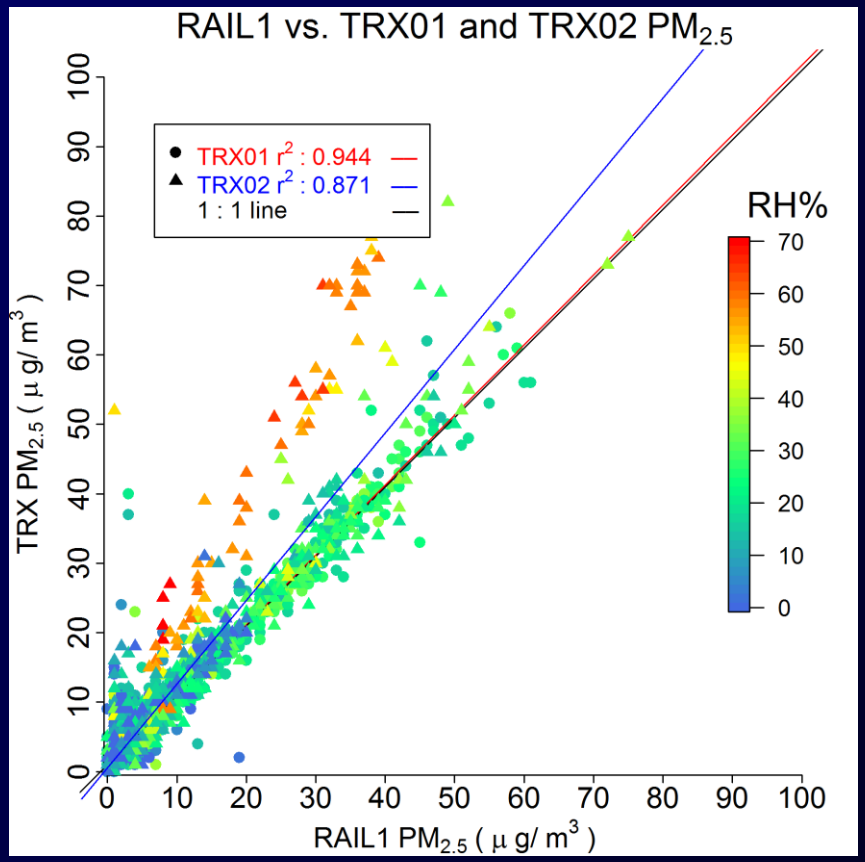


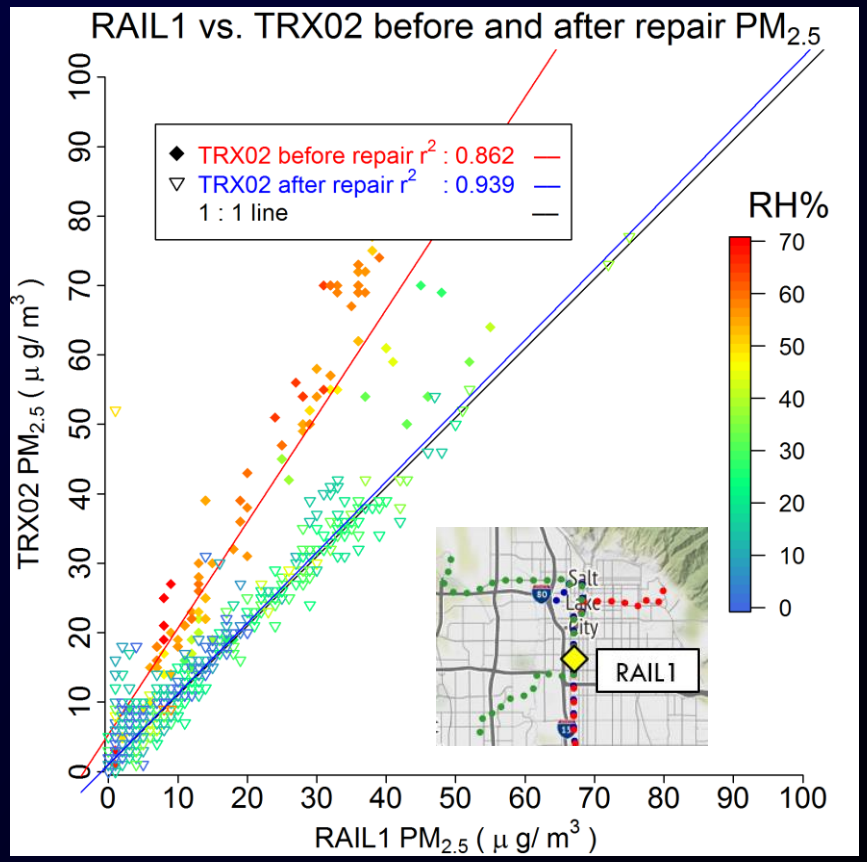


Mendoza et al. 2019

Data Validation QA/QC Procedures

- Fixed site RAIL1 deployed along rail section where all 3 train lines run to validate train-installed ES-642 measurements as they pass by





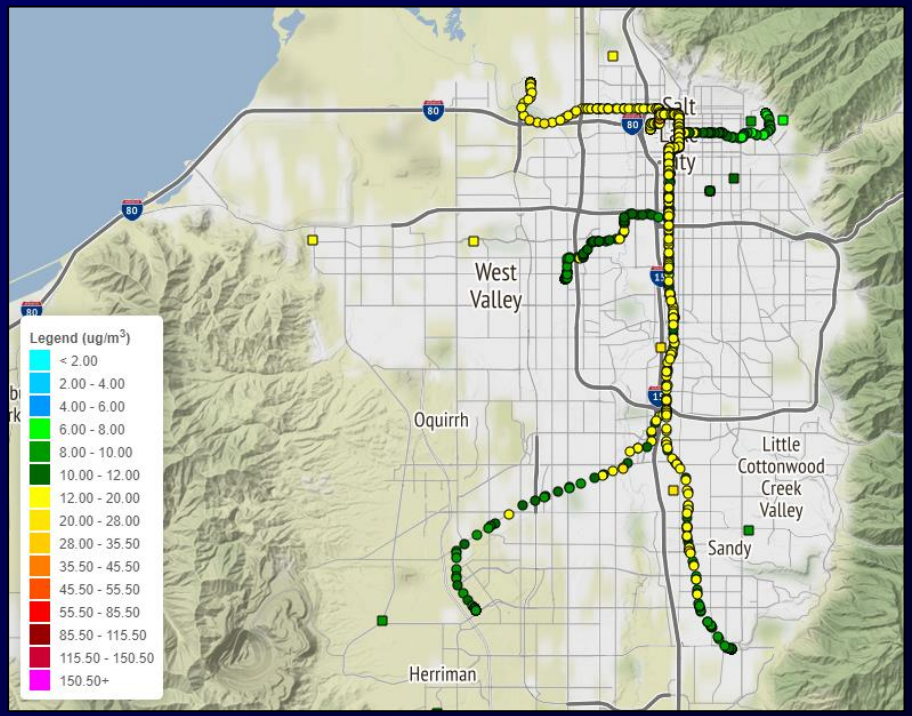
Mendoza et al. 2019

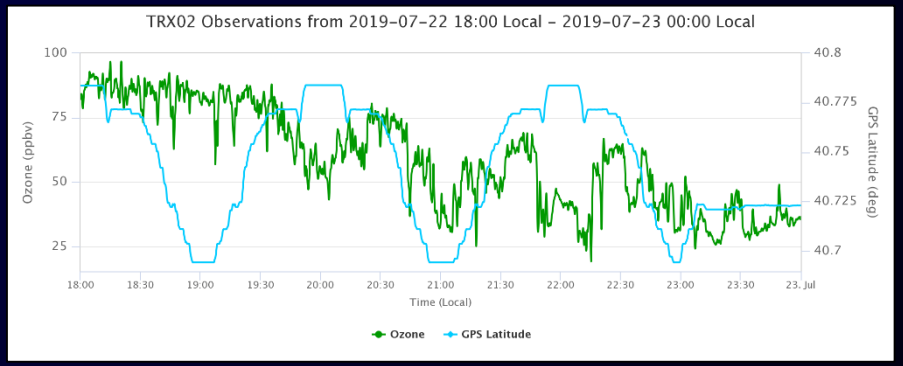
Data Validation QA/QC Procedures

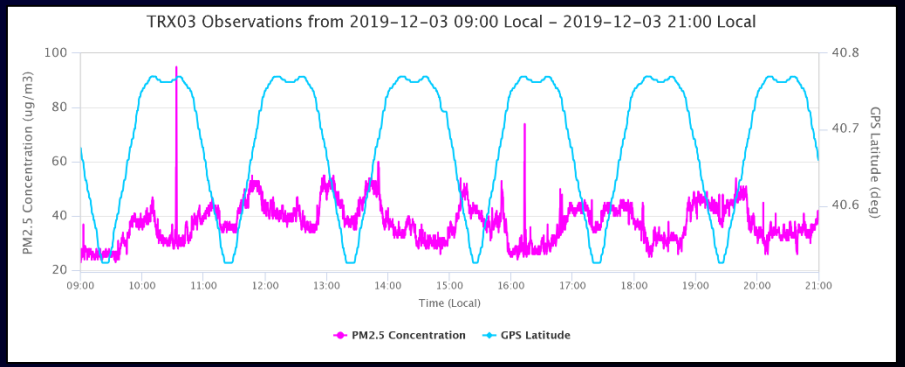
- Further QA/QC of the collected data taking place to identify
  - $PM_{2.5}$ and O_3 instrument flow rate errors
  - Periods of noisy and/or inaccurate observations
  - Periods of train maintenance (e.g. train inside repair depot)
  - High saturation/fog periods which impact $PM_{2.5}$ readings

Data Visualization and Access

- Interactive Web Displays (http://utahaq.chpc.utah.edu/) provide visual access to provisional real-time and historical observations





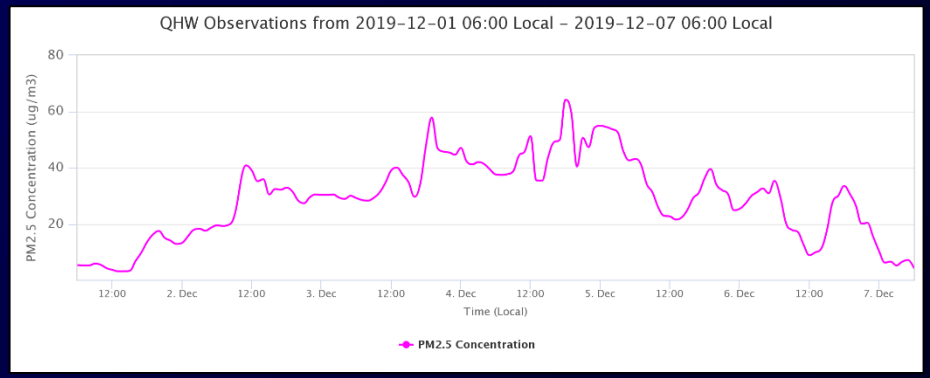


- Light rail car observations shown with other publicly-accessible air quality resources within the Salt Lake Valley

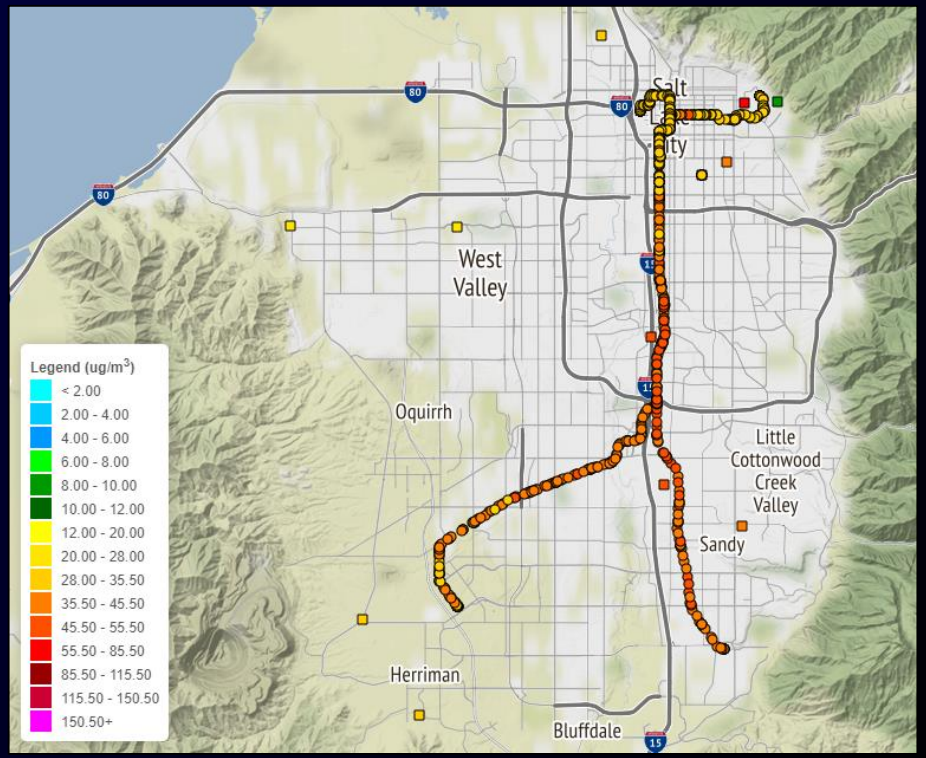
1-6 Dec 2019 High $PM_{2.5}$ Episode

- During $PM_{2.5}$ buildup phase, spatial variations observed by light rail deployments (western portion of valley and locations near canyon entrances observed lesser concentrations)

3 Dec 2019 5pm Local



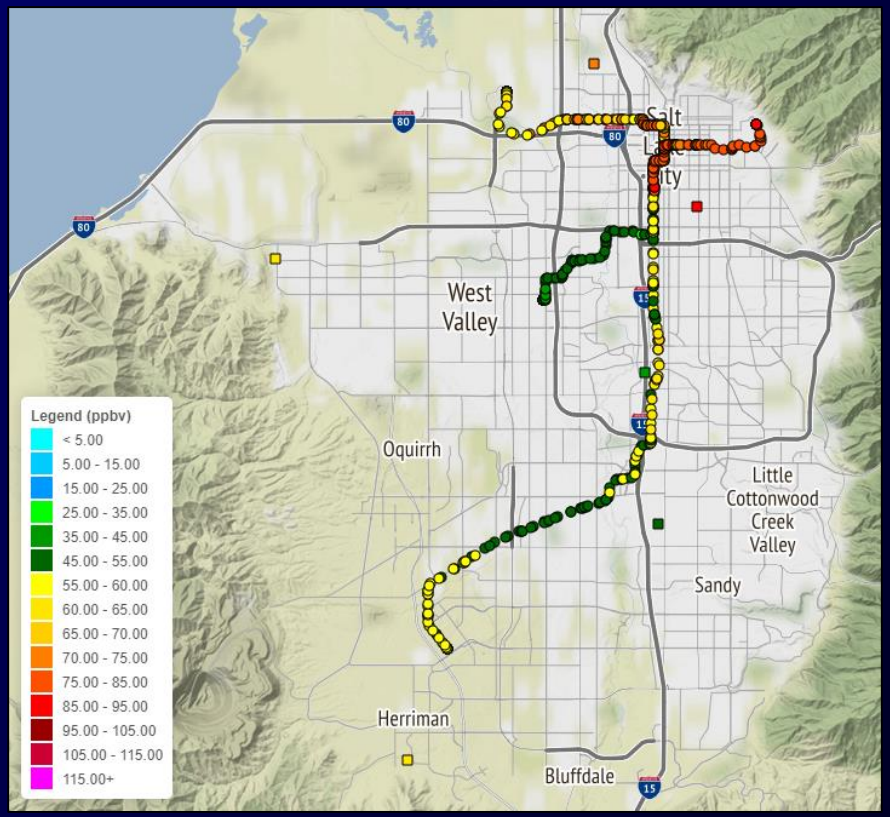
3 Dec 2019 8pm Local



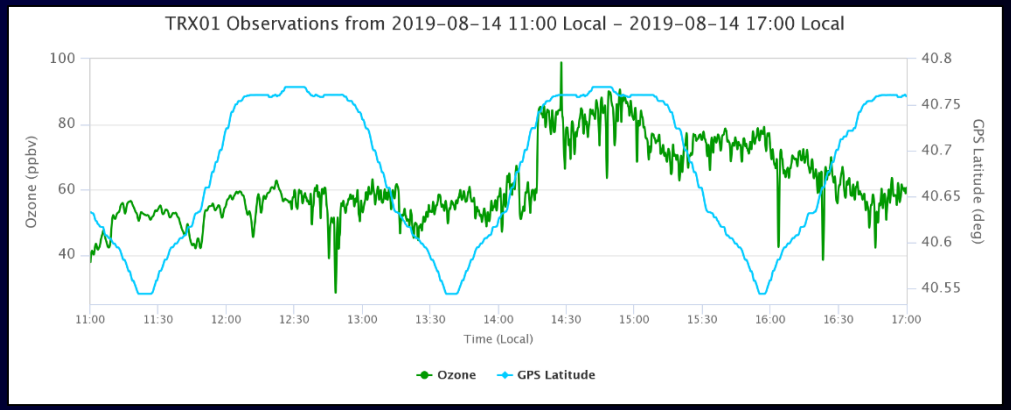
14 Aug 2019 High O_3 Event

- Higher concentrations observed for several hours in northeast corner of the valley in vicinity of downtown Salt Lake City

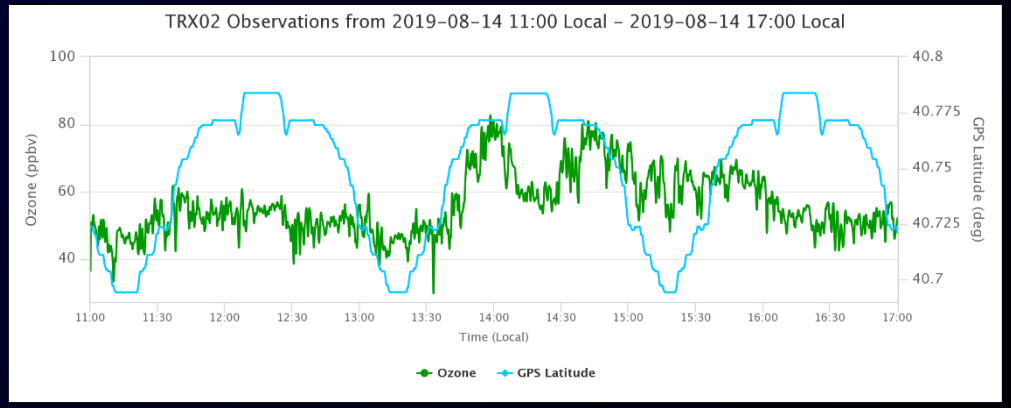
14 Aug 2019 3pm Local



TRX01 (Deployed on Red Line)



TRX02 (Deployed on Green Line)



Summary and Future Work

- $PM_{2.5}$ and O_3 monitors deployed operationally on 3 separate light rail vehicles that routinely transect the Salt Lake Valley
    - Equipment inspected monthly and repaired as needed
    - Fixed site deployments used as real-time validation points

- Real-time provisional observations accessible via online resources

- Future Analyses
    - QA/QC of collected data thus far
    - Further analysis of air quality episodes/events as they occur
    - Long-term spatial averaging as dataset temporal period continues to grow

- Development of an accessible, finalized dataset which will contain QA/QC information alongside the observations

Manuscripts and Acknowledgements

Mendoza, D. L., E. T. Crosman, L. E. Mitchell, A. A. Jacques, B. Fasoli, A. M. Park, J. C. Lin, and J. D. Horel, 2019: The TRAX Light-Rail Train Air Quality Observation Project. Urban Sci., **3**, 108, doi:10.3390/urbansci3040108

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