Kansas City TRansportation and local-scale Air Quality Study (KC-TRAQS): Examining Local Air Quality with a Network of Low-cost Sensors

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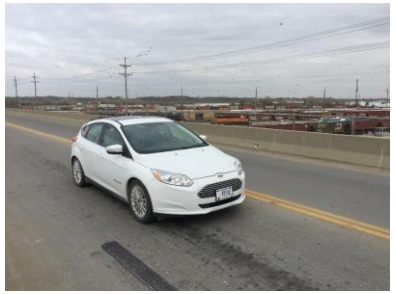
Summary

- Pollutants of Interest: **$PM_{2.5}$**, BC, EC/OC
  - Other parameters: wind speed (WS), wind direction (WD), temperature, relative humidity (RH), barometric pressure
- Project started mid-Oct 2017
- Planned completion Oct 31, 2018
- End-of-study collocation 1st week Nov 2018
- **Fixed Site Measurements ongoing**
- Geospatial Measurement of Air Pollution (GMAP; mobile measurement intensives)
  - Fall intensive completed Oct/Nov 2017
  - Spring intensive completed Feb/Mar 2018
- AirMapper (citizen science ongoing)
- Plan to deploy additional lower-cost sensors Summer – Fall 2018 (evaluate new technologies)



AirMapper -- – an integrated portable sensor unit that includes an OPC-N2 particle sensor (measuring PM_1, $PM_{2.5}$, PM_{10}), CO_2 sensor, GPS, accelerometer, noise sensor, temperature and humidity sensor.

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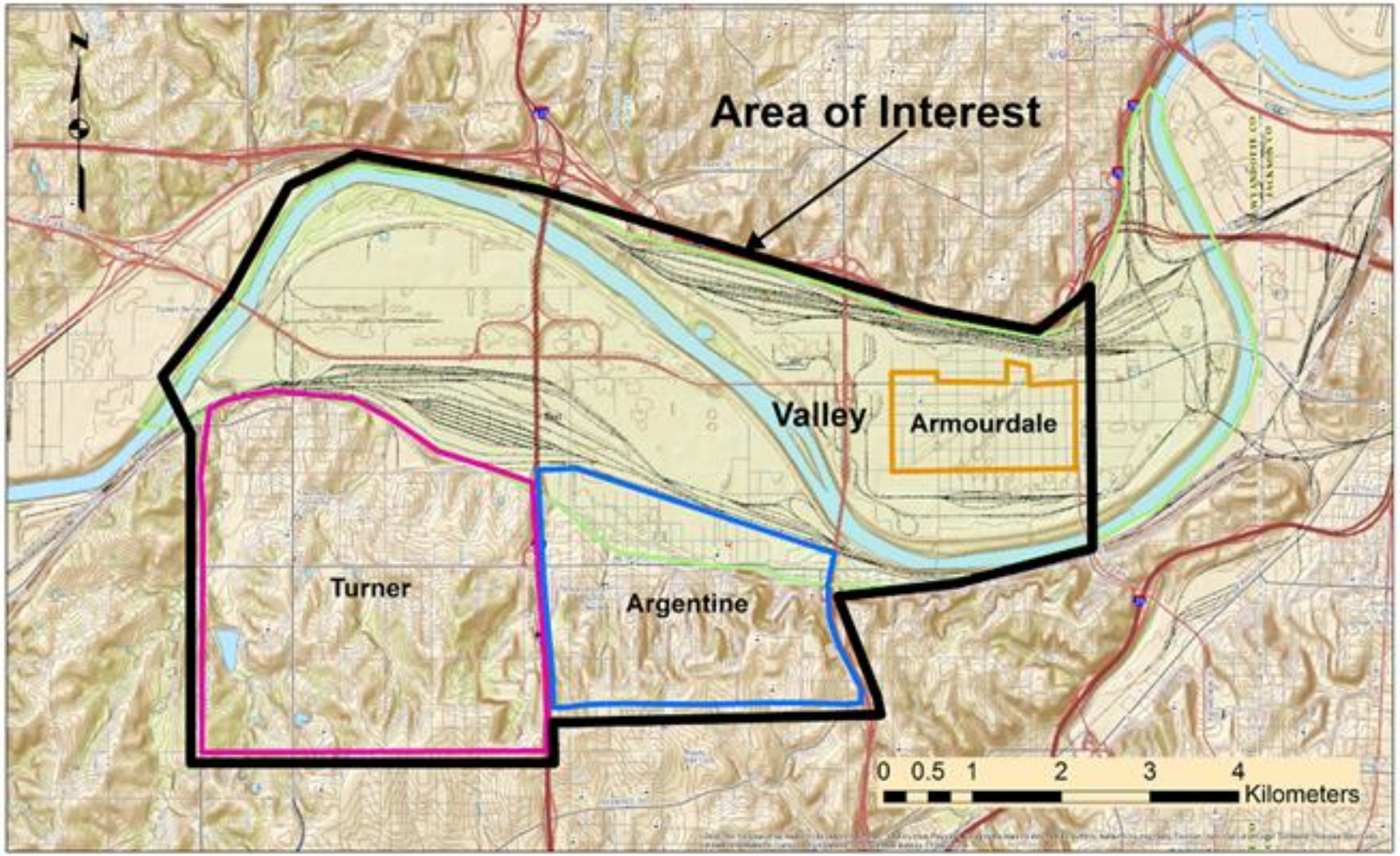
Study Area



Science Questions & Drivers

- **What is the spatial and temporal extent of local air pollution sources in and around the Argentine (KS) neighborhood?**

- Can the impact of local air pollution sources on the Argentine and surrounding neighborhoods' air quality be identified and quantified?

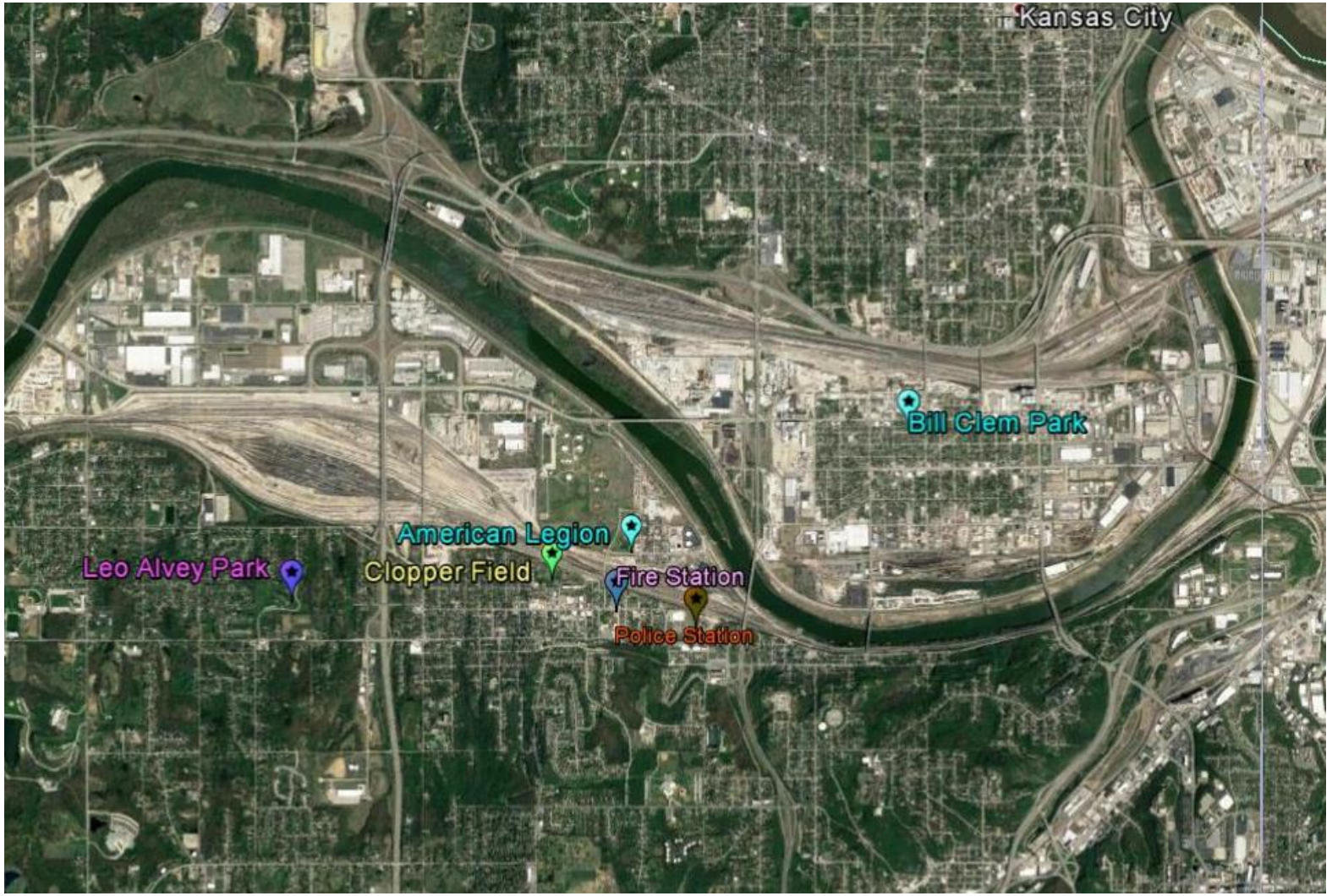
  - ✓ What is the spatial and temporal variability of rail-yard air pollution impacts and other nearby sources, under different meteorological conditions and source activities?

  - ✓ Can the effectiveness of a self-driven community measurement project be quantified? What is the suitability of a sensor instrument package (e.g., AirMapper) to support real-time mapping of particulate matter by citizens?

  - ✓ What is the added value of citizen science in the research process and can this value added be quantified?

  - ✓ What is the suitability and effectiveness of modeling tools to support citizen science in the research process and can this value added be quantified?

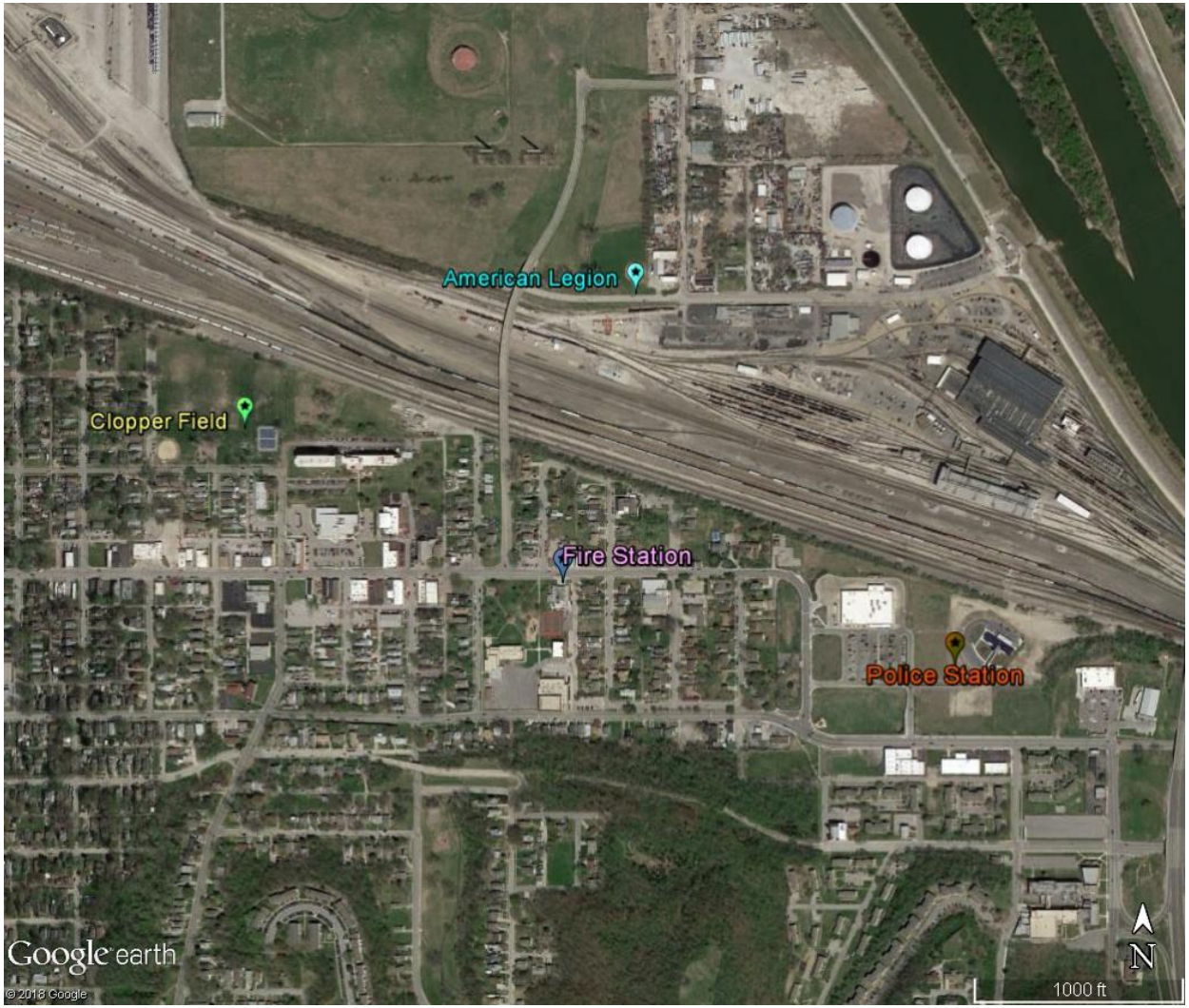
Monitoring Locations



Preliminary Data Analysis

- Focus on four Sensor Pods located near the railyard
  - $PM_{2.5}$ measured by Alphasense OPC-N2
  - WS and WD measured by RM Young 2-D Sonic Anemometer
- Data collected between October 2017 and May 2018 (approximately 300k minutes of data per pod
- Limited Data Screening
  - Remove negative values for $PM_{2.5}$, WS, RH, Temp
  - Require 45 minutes of valid data for hourly averages
  - Require complete observations when pairing winds and $PM_{2.5}$ data
- Sensor data is “raw” – no post-processing or data transformation
- Final analysis will require more in depth QA screening and incorporation of collocation results

Focus Monitors - Argentine



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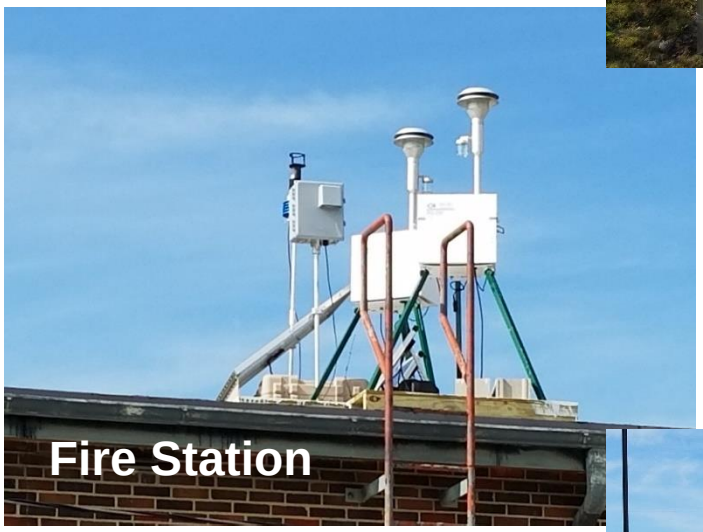
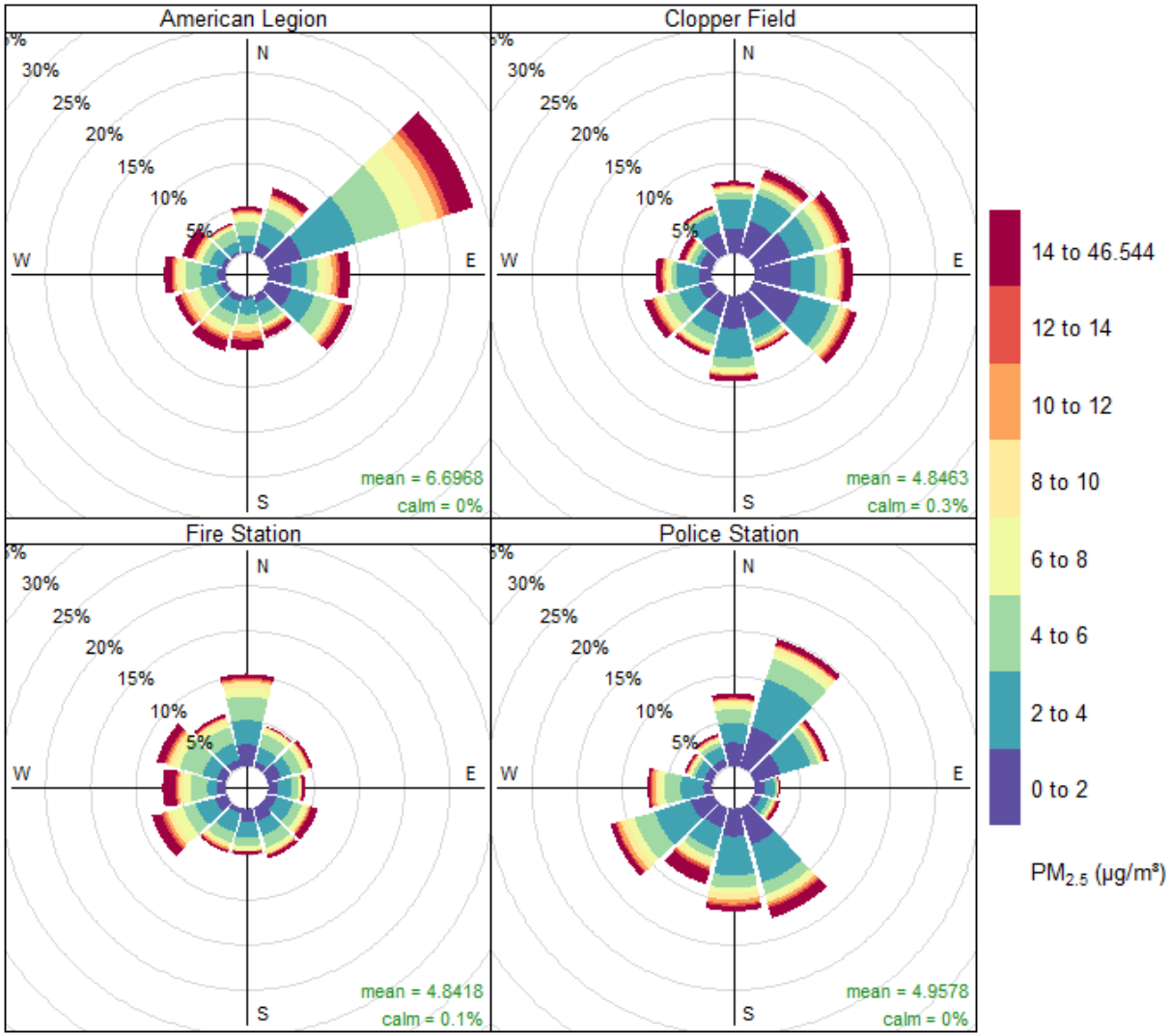
Priority Fixed Measurements
BC
$PM_{2.5}$
Met Data
- Barometric Pressure
- Relative Humidity
- Temperature
- Wind Speed
- Wind Direction



Traditional Pollution Roses

- Variability in measured winds
- Difficult to see concentration percentages within wind sectors
- Cannot combine results from different pods within the network



Nonparametric Trajectory Analysis

- The 1-minute data collected by the sensor pods allow for advanced data analysis techniques.
- One such technique is called Nonparametric Trajectory Analysis (NTA); Henry, R. C.; Vette, A.; Norris, G., *Environ. Sci. Technol.*, 2011, *45* (24), 10471-10476.).
- NTA calculates local wind back trajectories (in this case, 50 minute trajectories) with associated measured concentrations.
- The analysis then performs weighted averaging to calculate the statistically expected concentration at the monitoring site when the wind passes over a given point before reaching the monitor.

Nonparametric Trajectory Analysis

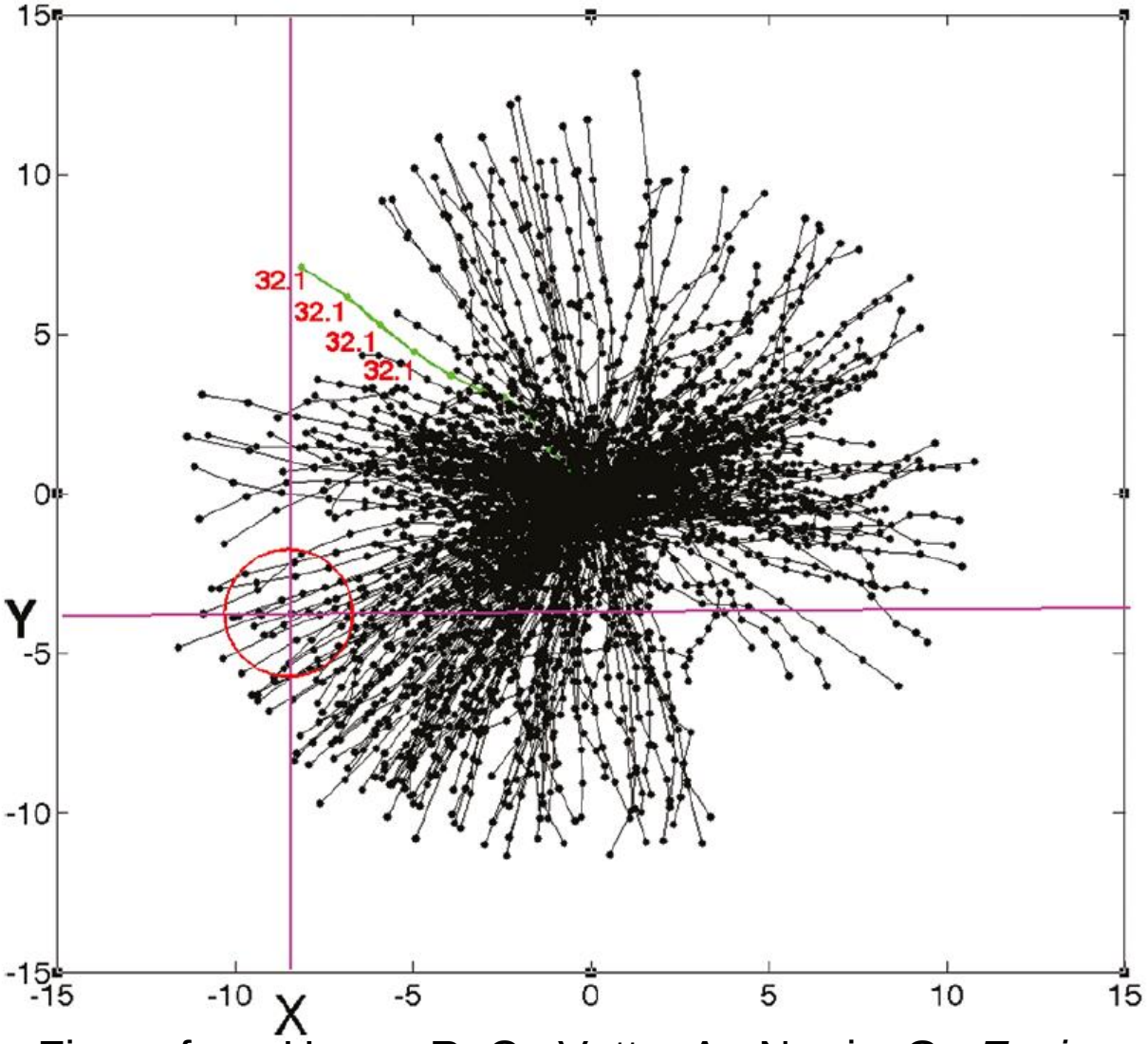


Figure from Henry, R. C.; Vette, A.; Norris, G., *Environ. Sci. Technol.*, 2011, *45* (24), 10471-10476.

NTA Result Example – American Legion

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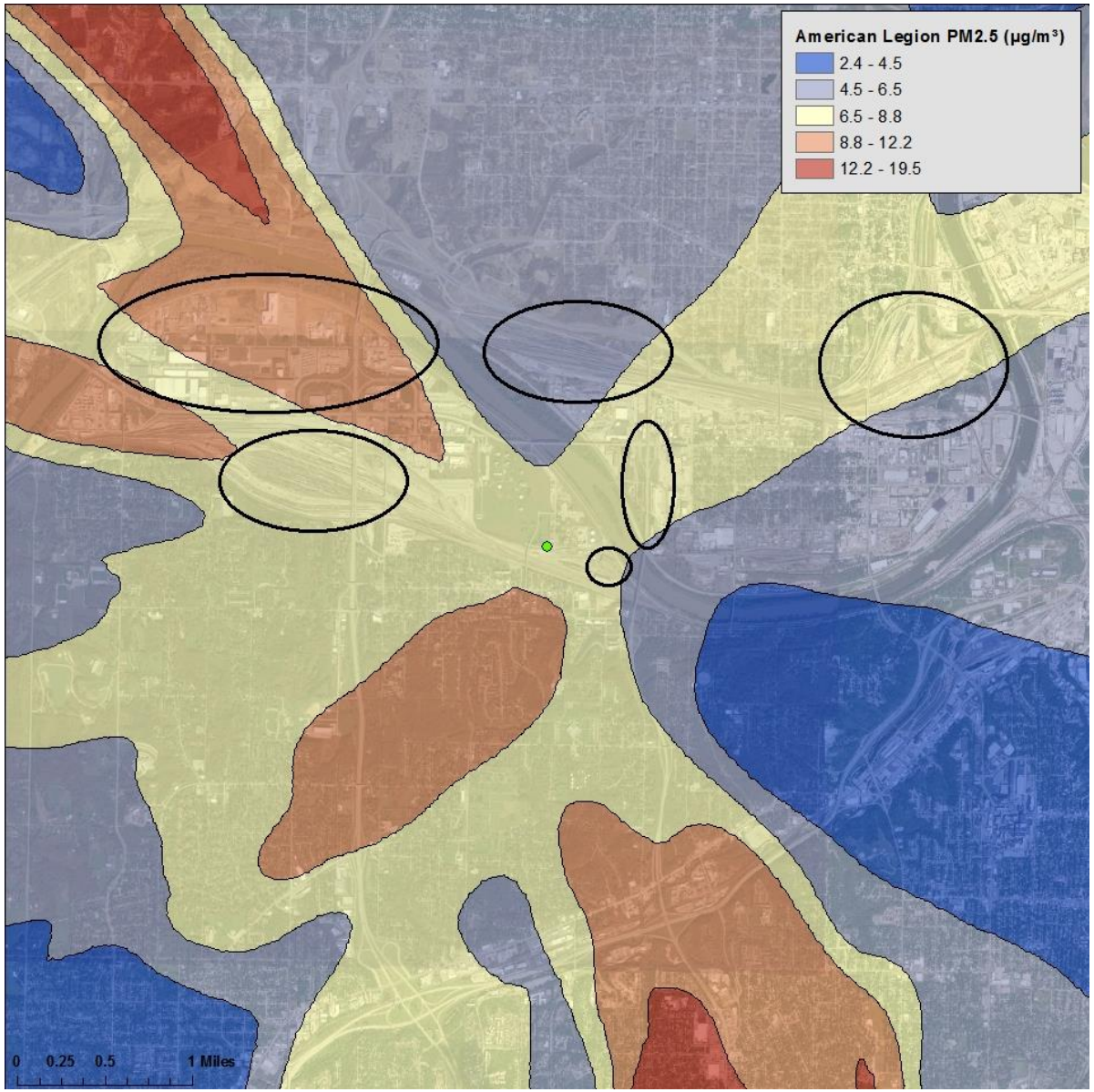
- Area has many sources that contribute to measured $PM_{2.5}$
- These results do not suggest individual sources, rather locations where multiple sources are nearby



NTA Results – All Four Sites

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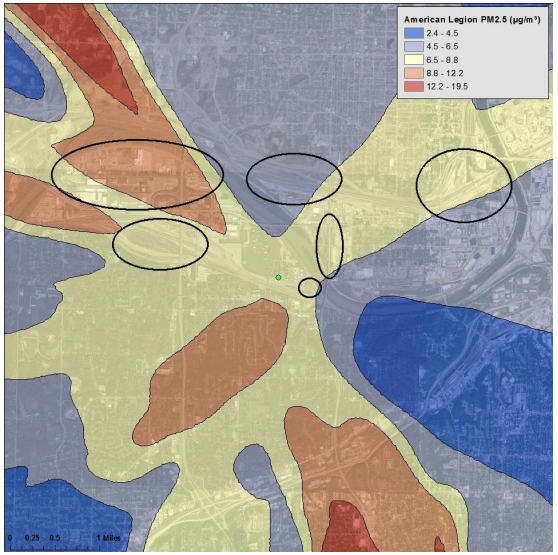
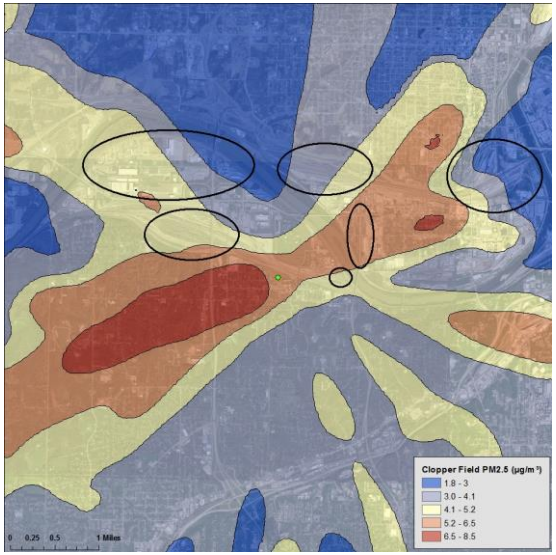
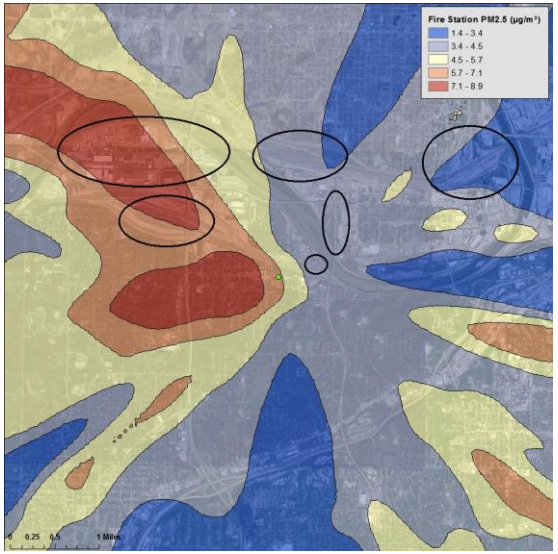
American Legion



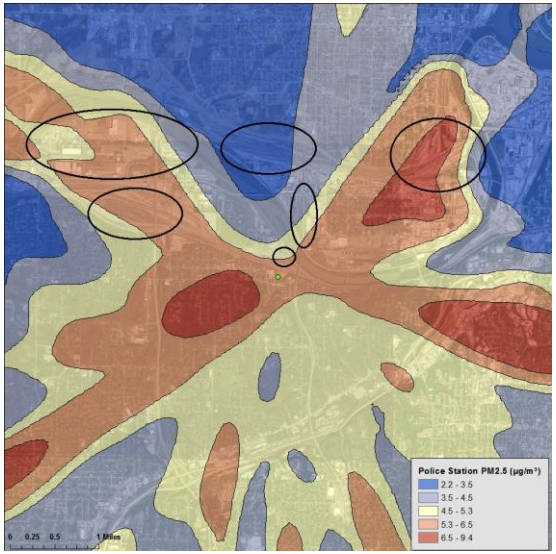
Clopper Field



Fire Station

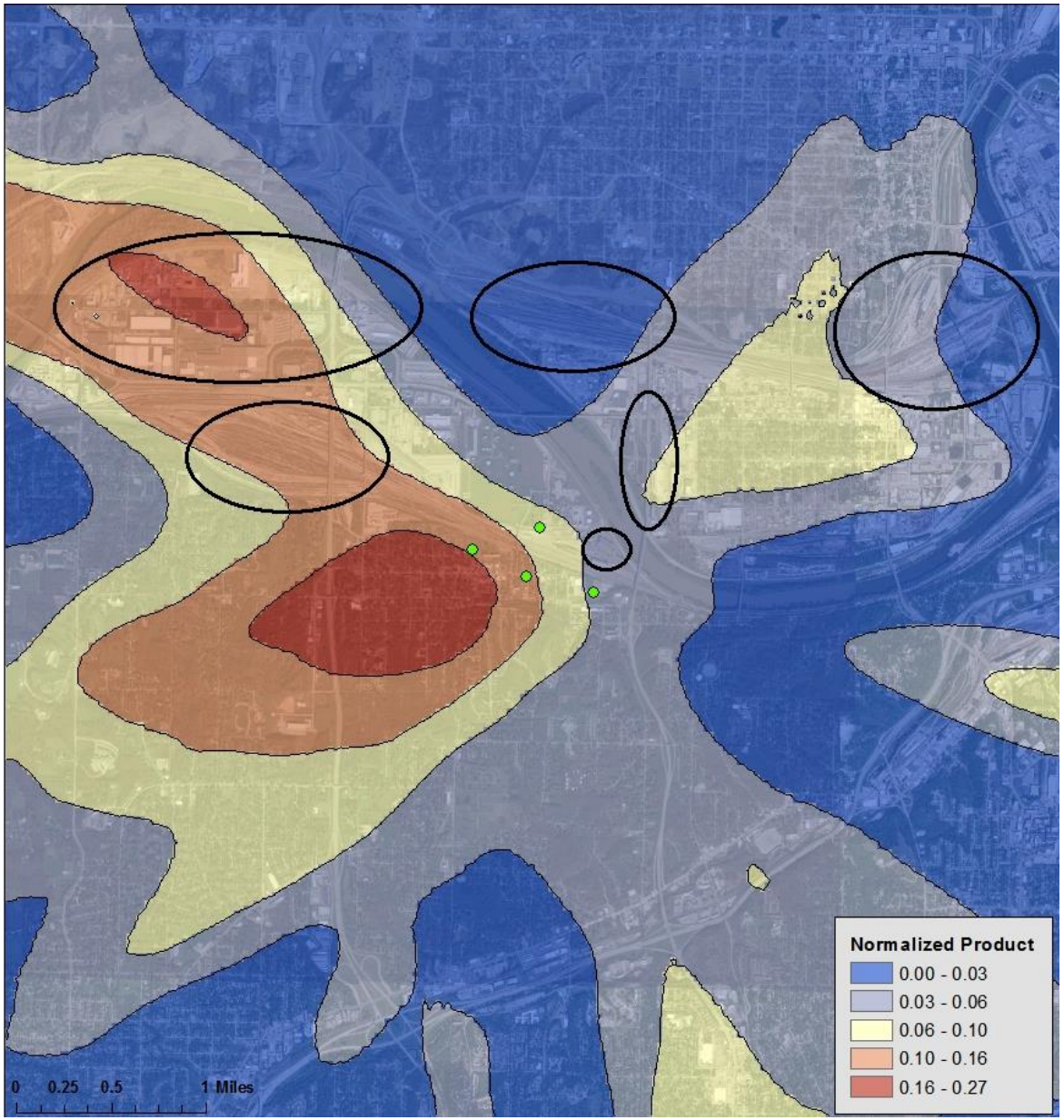


Police Station



NTA Results – Combined

- Combine NTA data by normalizing individual results and multiplying together
- Each site is impacted by similar regions with variable magnitude
- Results indicate that local $PM_{2.5}$ contributions come from a mix of sources, many nearby each other



Summary

- KC-TRAQS is a long term study to examine impacts of local sources of air pollution in Kansas City, KS
- Sensor Pods deployed in the area allow for advanced data analysis techniques
- NTA analysis shows that the local area is impacted by multiple nearby sectors, many with multiple types of sources

Next Steps

- Complete measurement campaign
- Collocate sensor pods with reference quality monitors
- Refine and apply quality assurance and data screening procedures
- Examine data from other sensors and pollutants
  - How do Met One E-BAM $PM_{2.5}$ measurements compare to Alphasense OPC-N2?
  - How similar are black carbon trends to $PM_{2.5}$ and what does this imply about local sources?
  - Do mobile monitoring and citizen science data agree with fixed sites?

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Questions?