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High resolution pollutant measurements in complex urban environments using mobile monitoring

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Goal of this talk

- Talk about EPA's Office of Research and Development experiences – positives and negatives – with using mobile monitoring for near-source air pollution studies.
- Discuss mobile monitoring study design and data processing challenges, as well as tools to support future research.

Mobile monitoring in the spectrum of air measurement technologies

Higher cost systems

Desirable direction

Lower cost systems

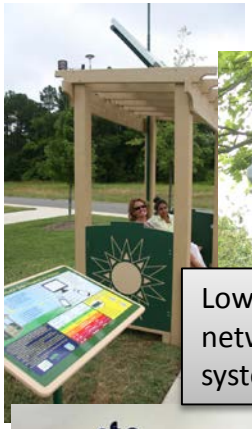
Traditional air monitoring shelter

Moveable mobile laboratory

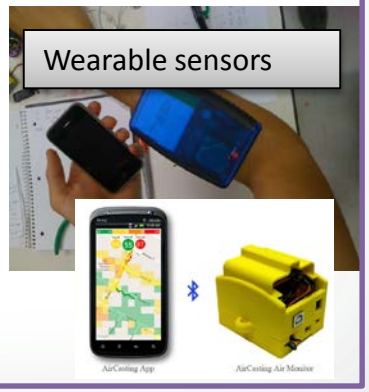
Lofted measurement platforms

Today's focus

Vehicle air pollution mapping systems



Low-profile network systems



Wearable sensors

Lower spatial resolution

Desirable direction

Higher spatial resolution

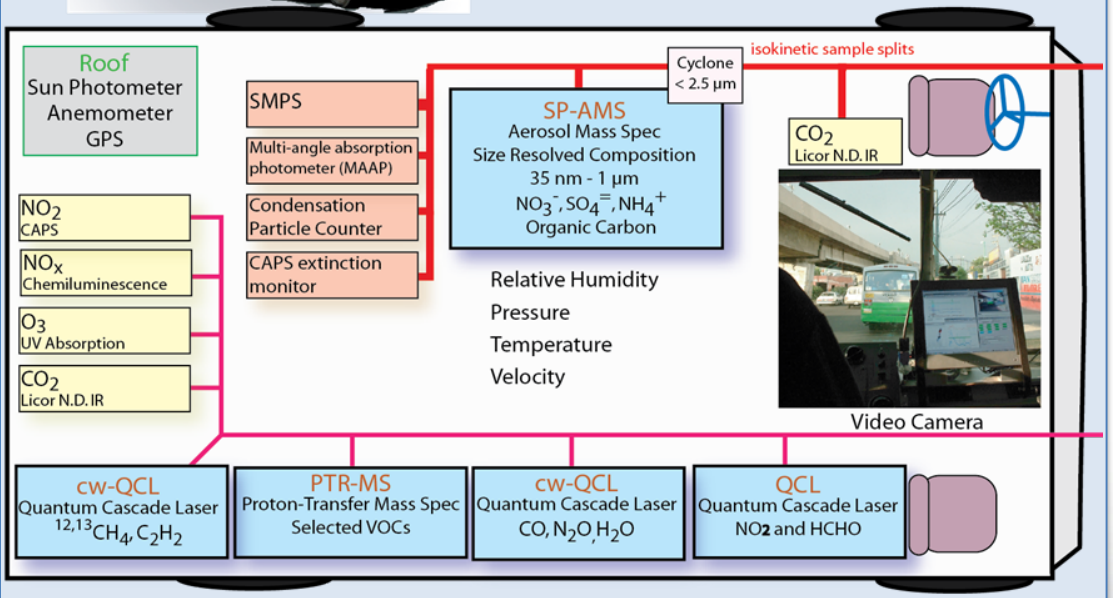
Mobile monitoring

- **Driving around with instruments is not the easiest way to measure air pollution**
  - Tough on instruments: vibration, unstable environmental conditions
  - Limited space and power
  - Labor-intensive
  - Few instruments able to resolve trends at a very fast sampling rate (seconds)
  - Complex monitoring and data analysis: monitoring limited to roadway access, potential confounding sources including self-contamination

Mobile monitoring

- Despite the challenges – this measurement approach provides unique and rare data collection opportunities
- Some example mobile monitoring vehicles applied to EPA studies in recent years:

Aerodyne mobile van:
Comprehensive approach:
three operators, extensive and advanced instrumentation



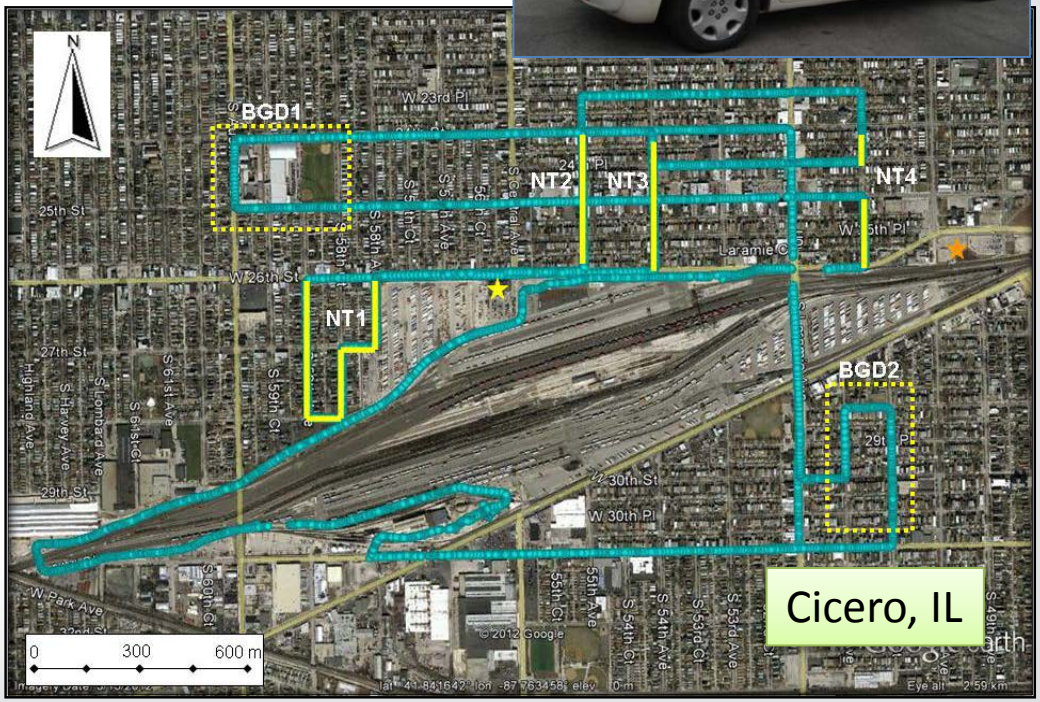
EPA electric car:
Nimble approach: single operator, fewer instruments

CO – quantum cascade laser
NO_2 – CAPs
Particle counts (ultrafine): EEPS
Particle counts (fine to coarse): APS
BC – Aethalometer (model 42)
CO_2 - Licor

Mobile monitoring

- A key tool in our research to understand spatial variation of air pollution

Measuring local air quality trends around large complex sources



Mobile monitoring

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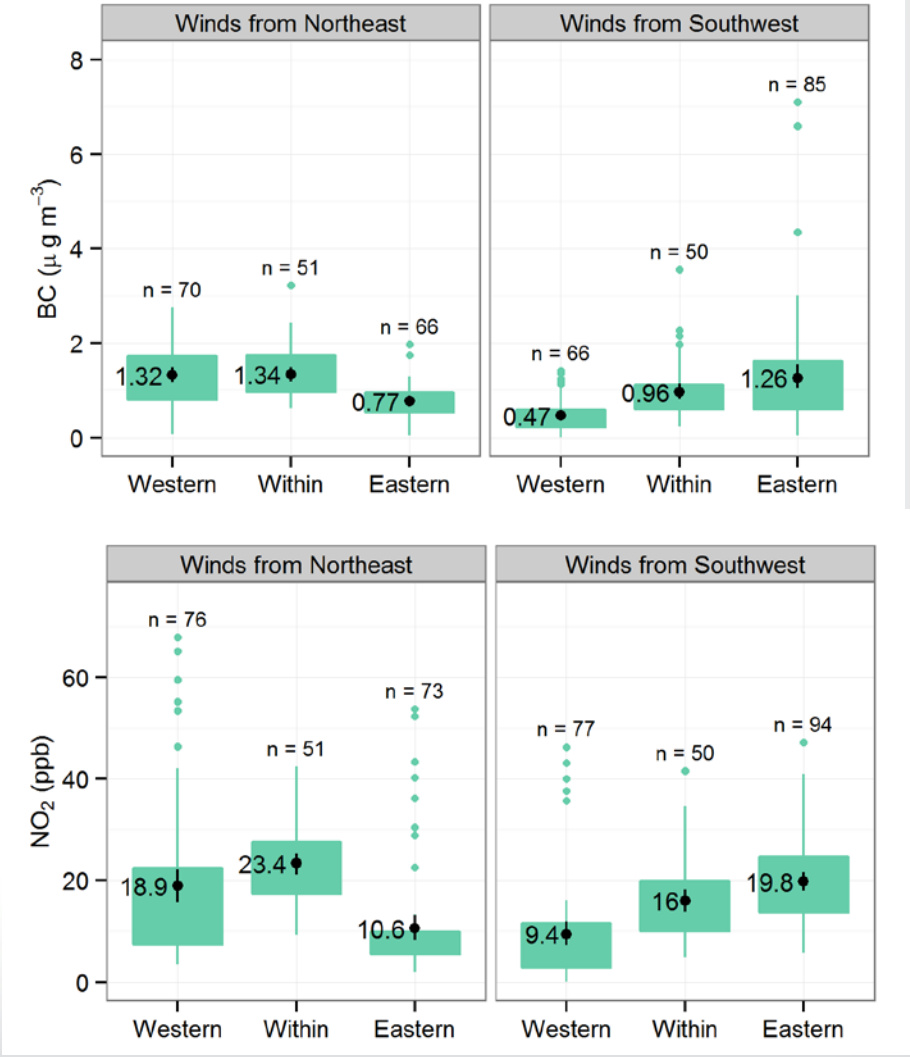
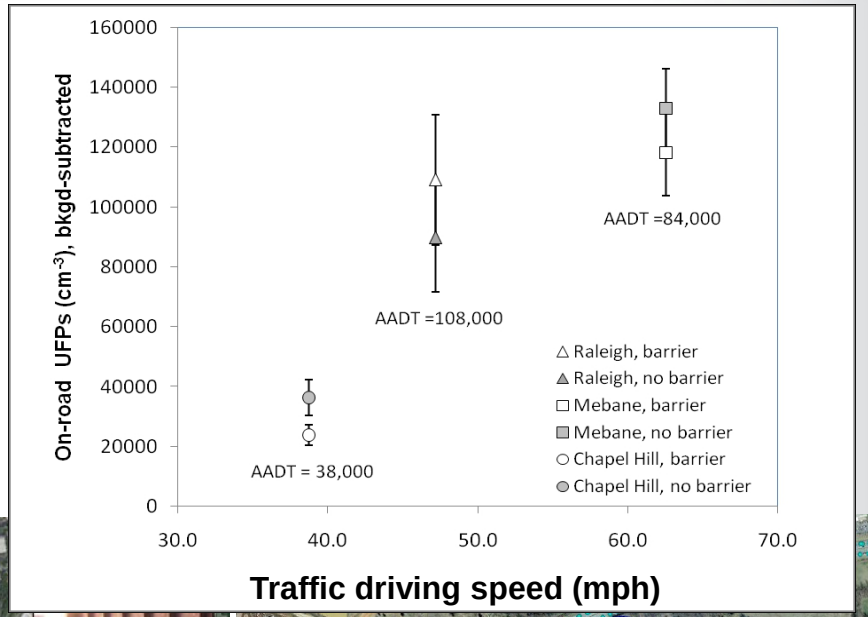


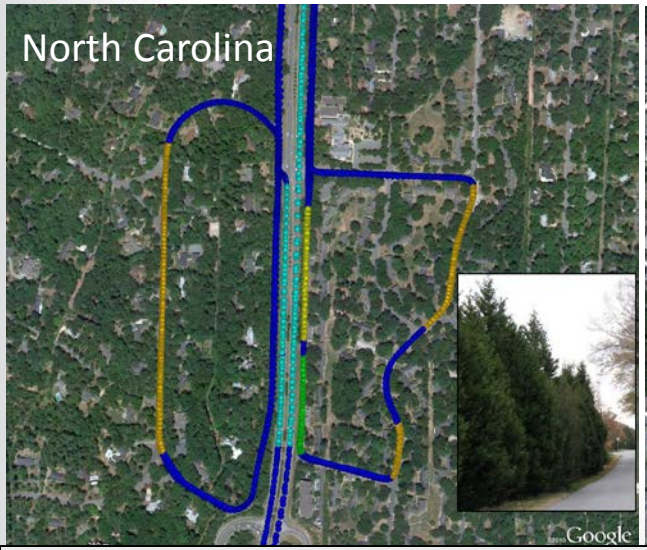
Mobile monitoring

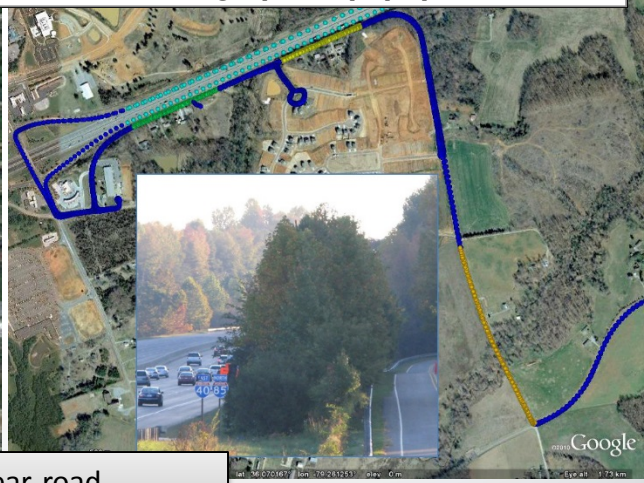
- Also, extremely useful in near-road studies

e.g., Does the presence of trees or a noise barrier increase on-road ultrafine particle concentrations?

e.g., Are near-road UFPs higher or lower in near-road areas with and without a tree stand or structural wall?





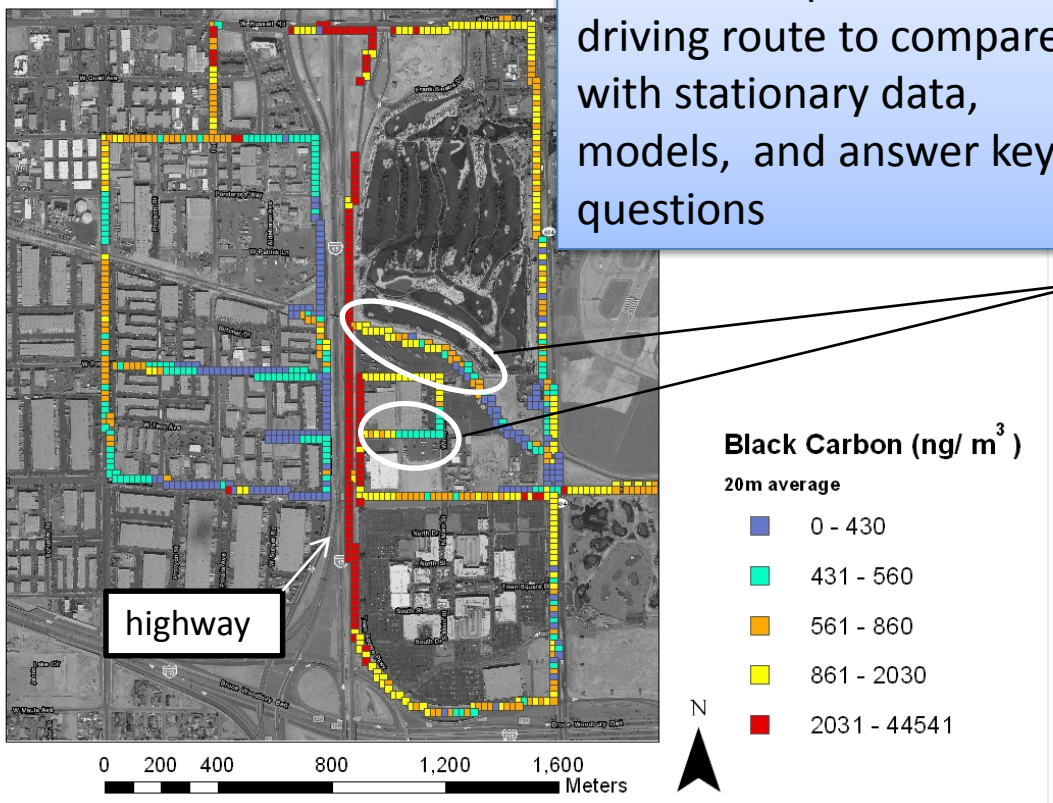


Hagler et al., (2012). Field investigation of roadside vegetative and structural barrier impact on near-road ultrafine particle concentrations under a variety of wind conditions. Science of the Total Environment, 419: 7-15.

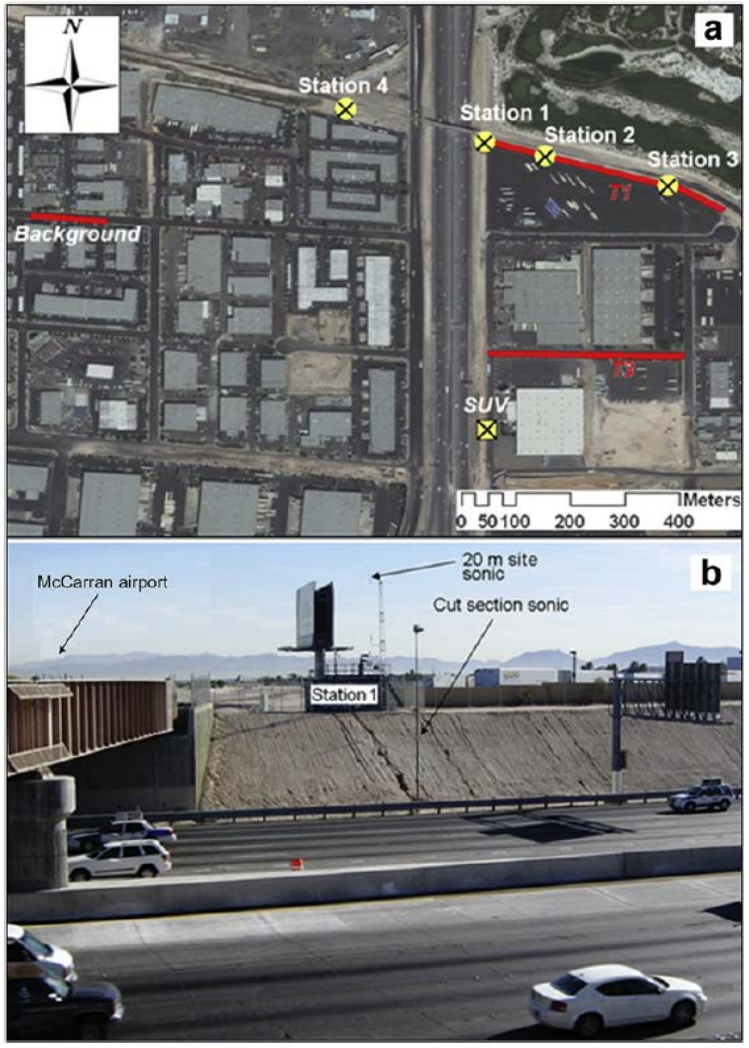
Mobile monitoring

- Also, extremely useful in near-road studies

Las Vegas, Nevada



Isolation of part of driving route to compare with stationary data, models, and answer key questions



Baldauf et al., (2013). Air quality variability near a highway in a complex urban environment. Atmospheric Environment. 64: 169-178.

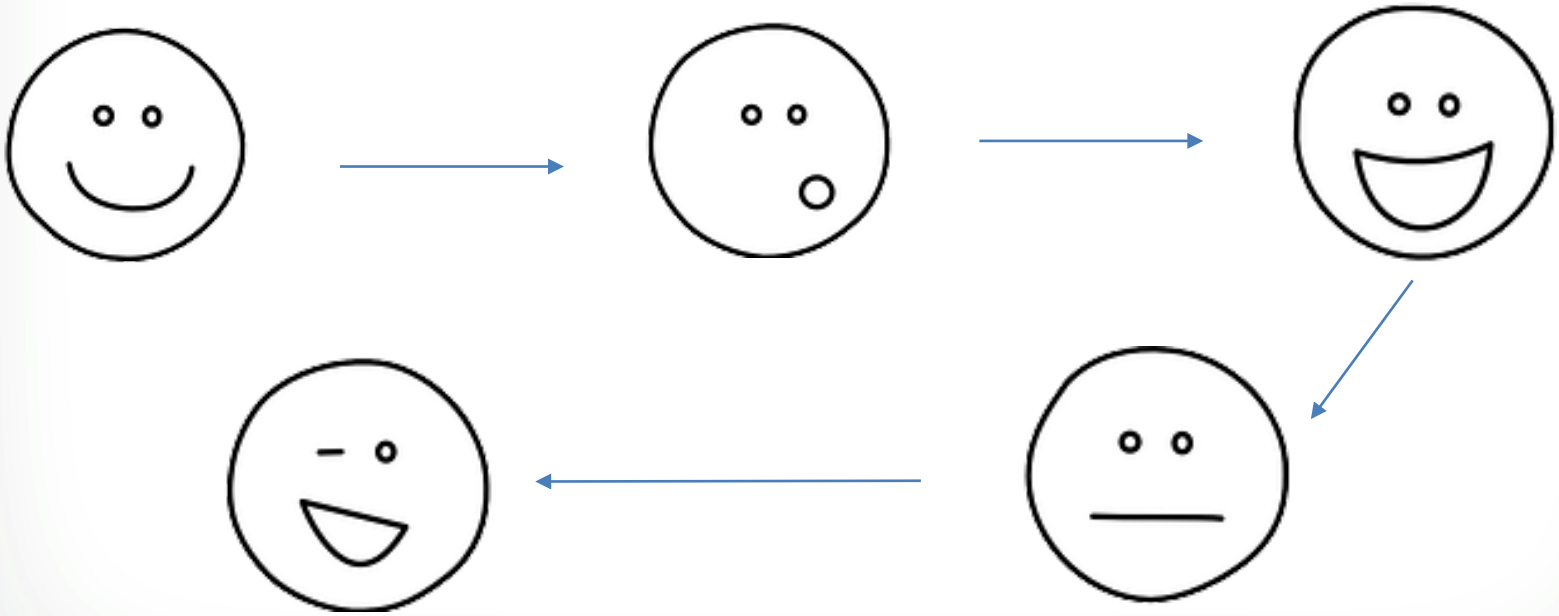
Dealing with data

- What happens behind the scenes

"We have this pretty cool air monitoring vehicle and a great study plan…"

"… we realized we need to do a lot of pre-testing to make sure we understand our data…"

"Finally executed our study plan and the instruments worked well!"



"Hey bright programming minds, cool project(s) over here!"

"Need to develop custom algorithms to handle this complex data…before we even get to answering research questions…"

Dealing with data

- What happens behind the scenes

"We have this pretty cool air monitoring vehicle and a great study plan…"

Elements to think about in designing a near-source mobile monitoring study:

- Desired geographic area coverage
- Available time / resources
- Variation in local wind direction/speed
- Time variation in source emissions
- Confounding sources

Example plan to balance available sampling days among multiple routes

Prevailing wind direction

	Minimum target # days	N	NE	E	SE	S	SW	W	NW
Route 1	6						Target: 3+		
Route 2	5		Target: 2+						
Route 3	4	Target: 2+							
Route 4	3	Target: 1+						Target: 1+	

Dealing with data

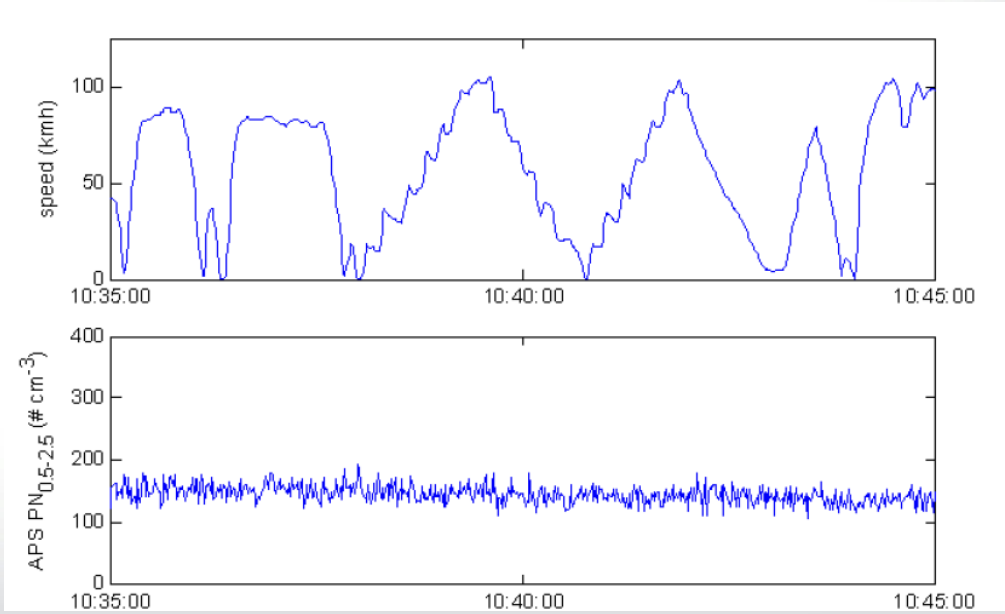
- Measurement evaluation

"… we realized we need to do a lot of testing to make sure we understand our data …"

Elements to think about in instrumentation selection and application:

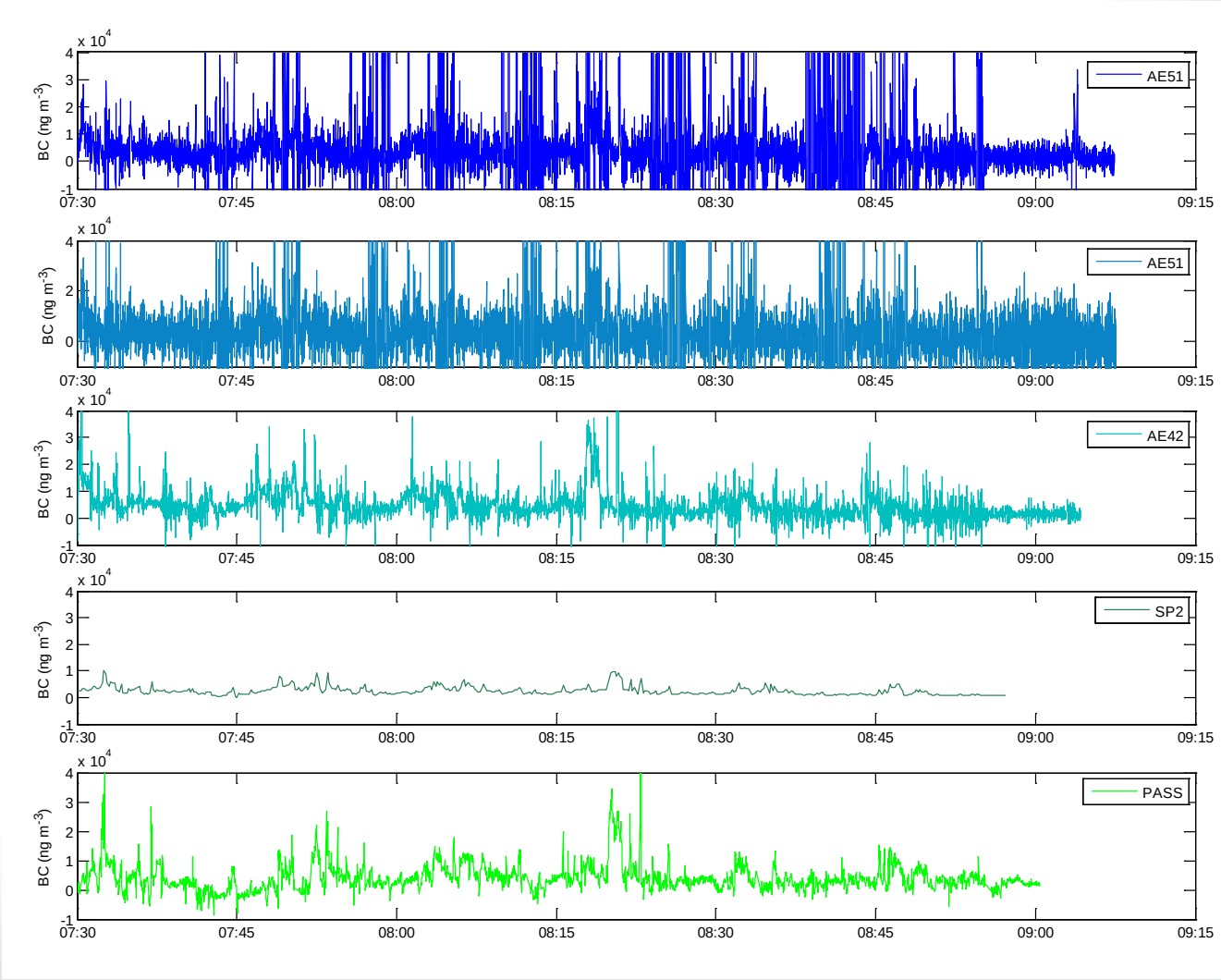
- Sampling inlet design
- Instrument response time
- Sampling lag time per instrument
- Measurement issues caused by instrument orientation or vibration

Testing on no-traffic road to see if varying vehicle driving speed leads to differences in instrument noise, artifact in larger particle sampling



Dealing with data

- Measurement evaluation



Testing of various BC sampling instruments – instrument orientation a potential issue for AE51s

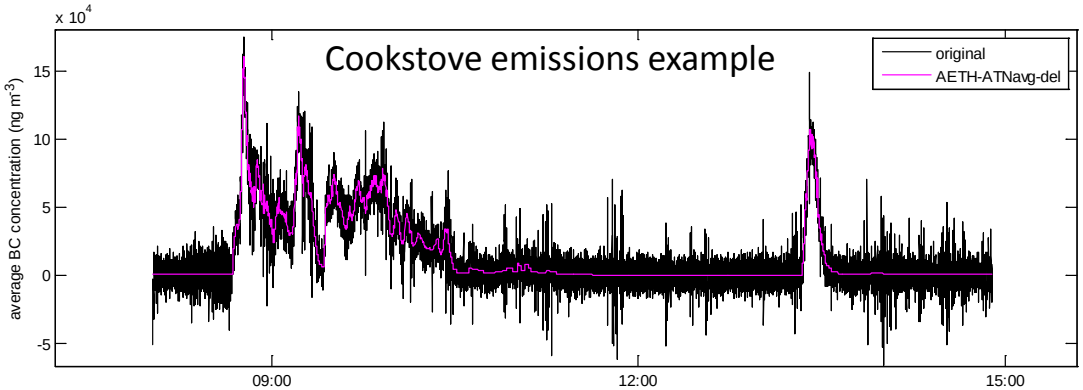
Holder et al., (2014). On-road black carbon instrument intercomparison and aerosol characteristics by driving environment. Atmospheric Environment. 88: 183-191.

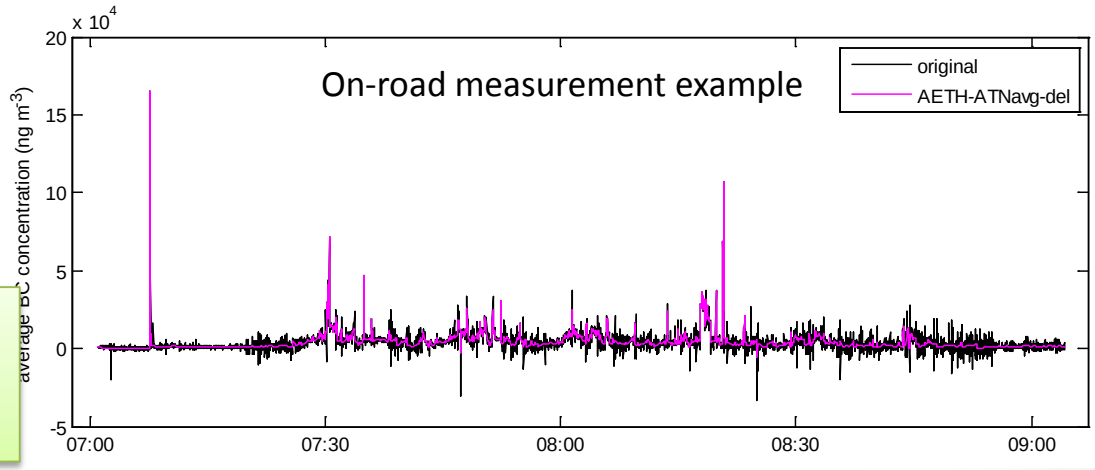
Dealing with data

- Data processing approaches

"Need to develop custom algorithms …"

Algorithm to maximize utility of real-time Aethalometer data





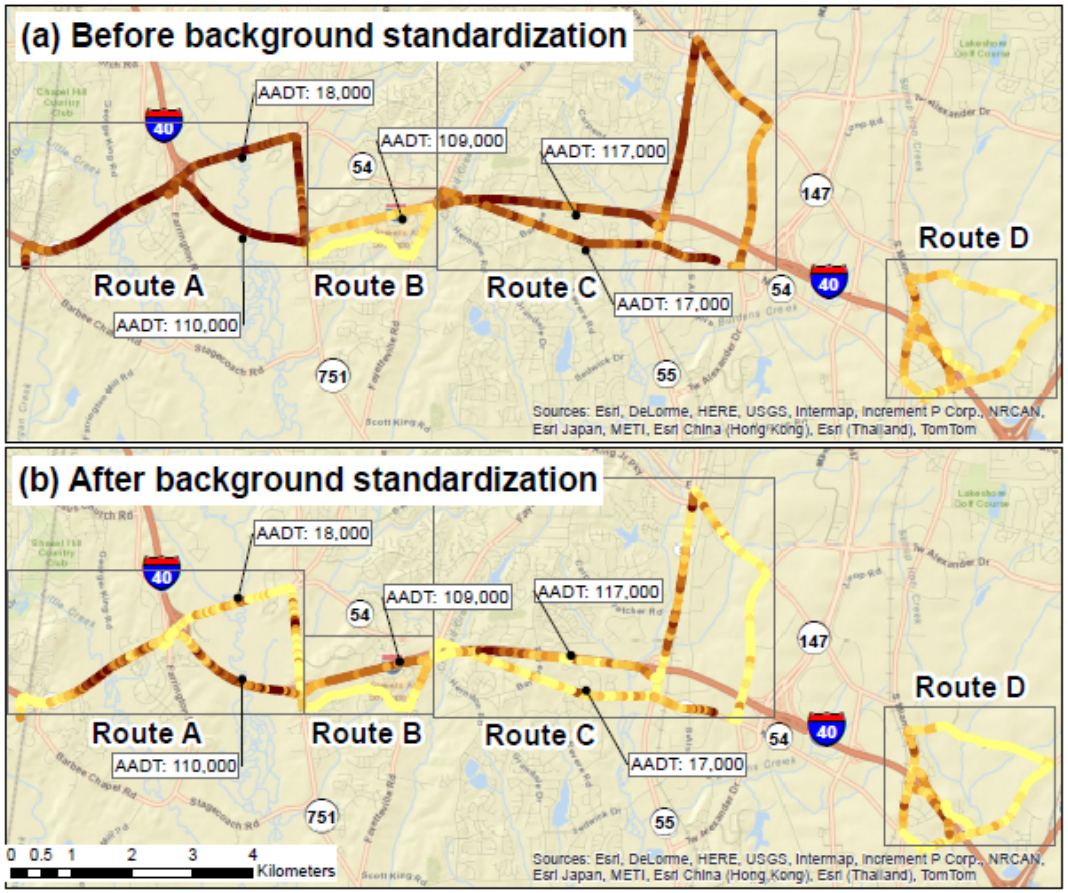
Code and executable available at: http://www.epa.gov/ordntrnt/ORD/NRMRL/appcd/mmd/ona.html

Hagler et al., (2011). Post-processing method to reduce noise while preserving high time resolution in Aethalometer real-time black carbon data. Aerosol and Air Quality Research. 11: 539-546.

Dealing with data

- Data processing approaches

Evaluating method to merge together and interpret data collected on different routes, on different days…with different regional background levels



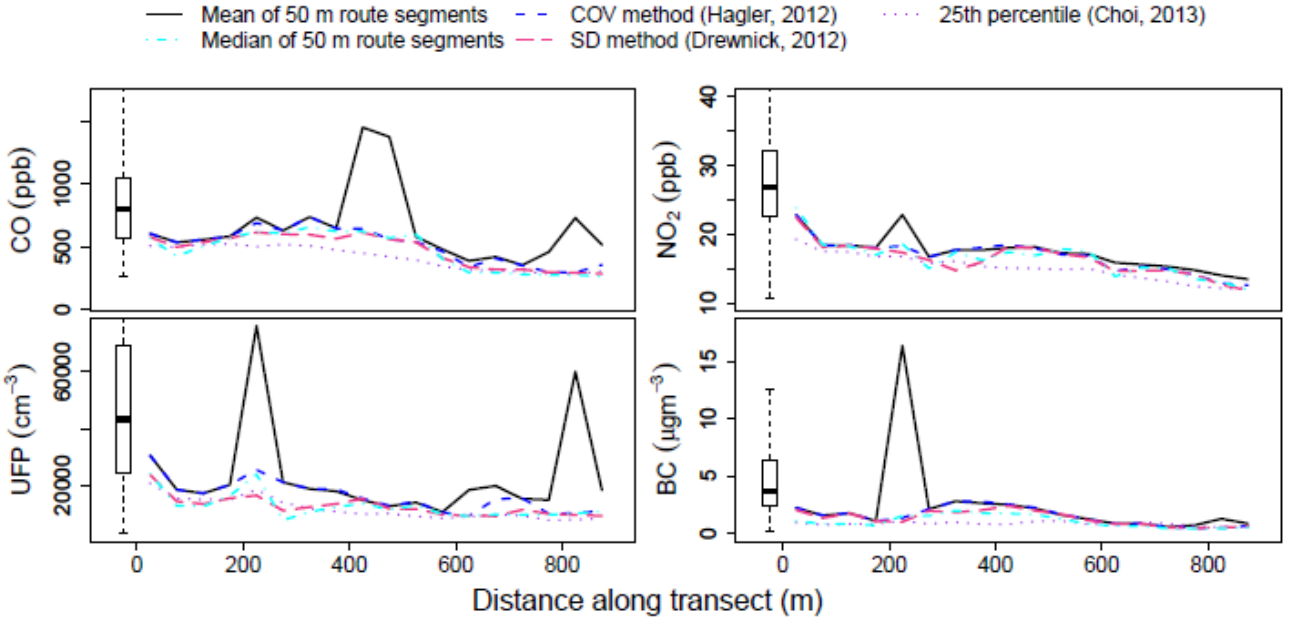
Brantley et al. (2014). Mobile air monitoring data-processing strategies and effects on spatial air pollution trends. Atmospheric Measurement Techniques. 7: 2169-2183.

Dealing with data

- Data processing approaches

Evaluating methods to merge together many laps of a near-road transect and isolate/remove brief proximate exhaust events

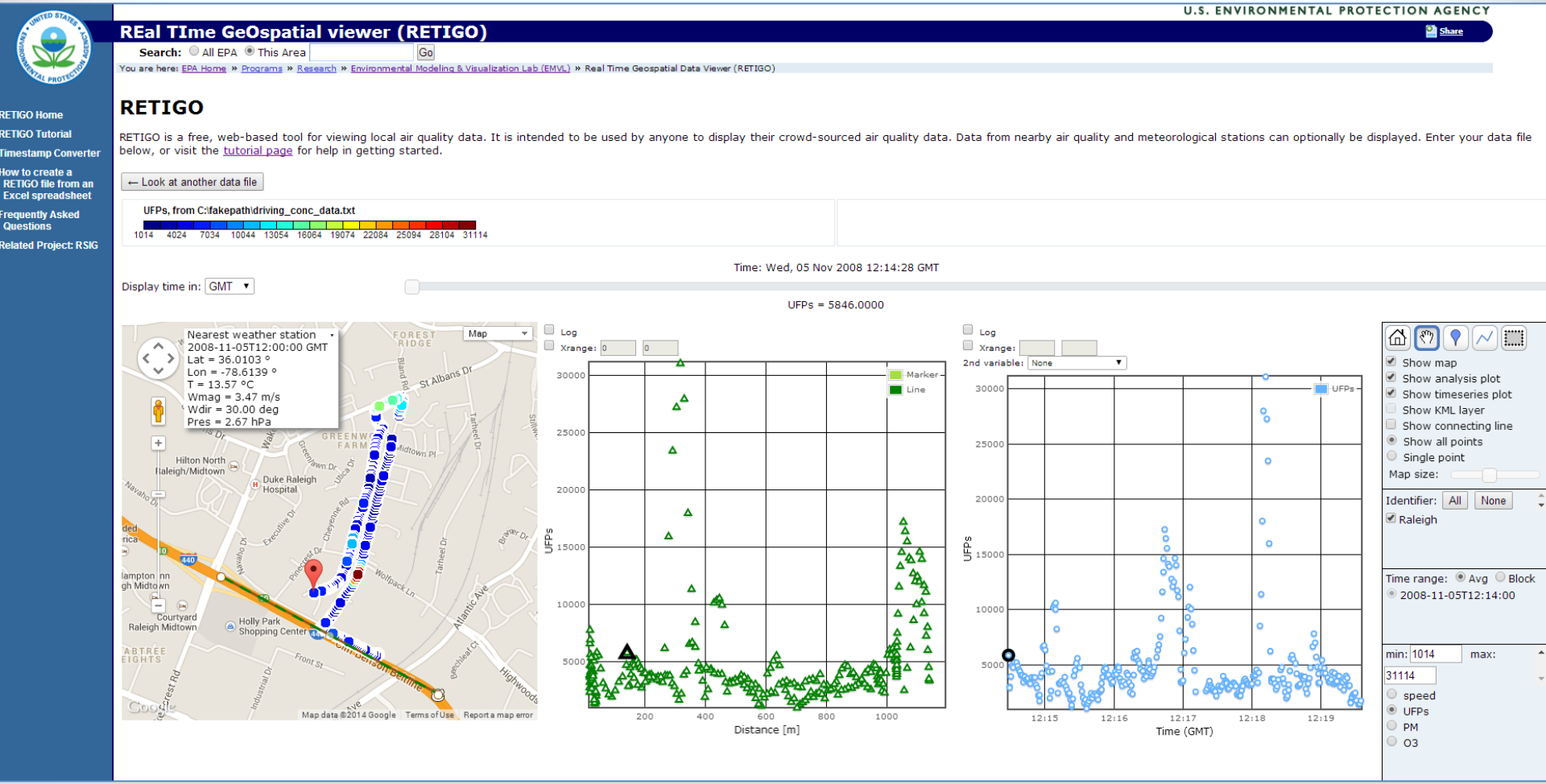
(simply taking a spatial median was comparable to more sophisticated techniques)



Brantley et al. (2014). Mobile air monitoring data-processing strategies and effects on spatial air pollution trends. Atmospheric Measurement Techniques. 7: 2169-2183.

One useful new tool

- RETIGO: free tool for a quick upload and exploration of geospatial air monitoring data.
- Email: hagler.gayle@epa.gov if you are interested in information on its pending availability and live webinar tutorials



Take-home thoughts

- Mobile monitoring is an extremely useful tool for near-source air quality characterization
- Successful data collection is highly labor and data-processing intensive – careful data interpretation required, taking into light instrumentation capability, route complexity, local meteorology.
- Emergence of new portable instrumentation is likely to increase the prevalence of mobile monitoring (bicycles, wearables, vehicles)

Acknowledgements

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