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Assessing and Using Low-Cost Sensors in a Community Stakeholder Context: Promises and Pitfalls

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It’s Not as Easy as it Looks

- Promises and pitfalls observed in community-based air monitoring projects
- Example of a low-cost sensor air monitoring project within the Rutgers community

Example of a Pilot Study with Low-Cost Sensors

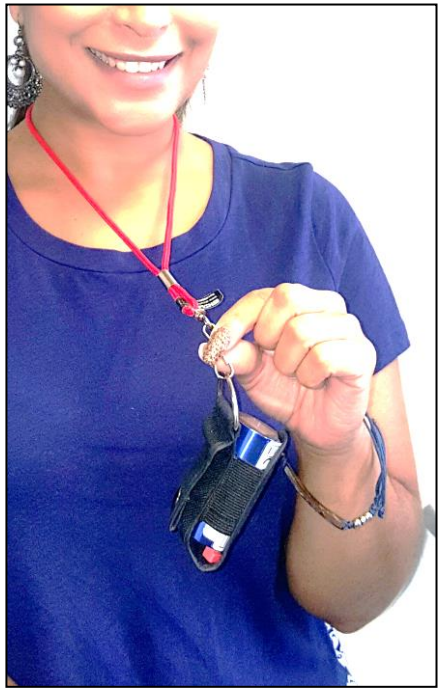
- Goals:
  - To assess feasibility of using a low-cost sensor to measure in-vehicle NO_2 exposure among NJ commuters
  - To characterize in-vehicle exposure to NO_2 during routine commutes to and from Rutgers Piscataway campus

Pilot Study: Exposure to NO_2 in Personal Vehicles

- **Rutgers Commuter Community Cohort (RC3)**
- 16 Rutgers faculty and staff in study
- Cairpol Cairclip oxidant gas (O_3/NO_2) monitor worn on a lanyard
- 1 week of regular commuting
- Daily time-activity log and GPS tracking
- Two focus groups

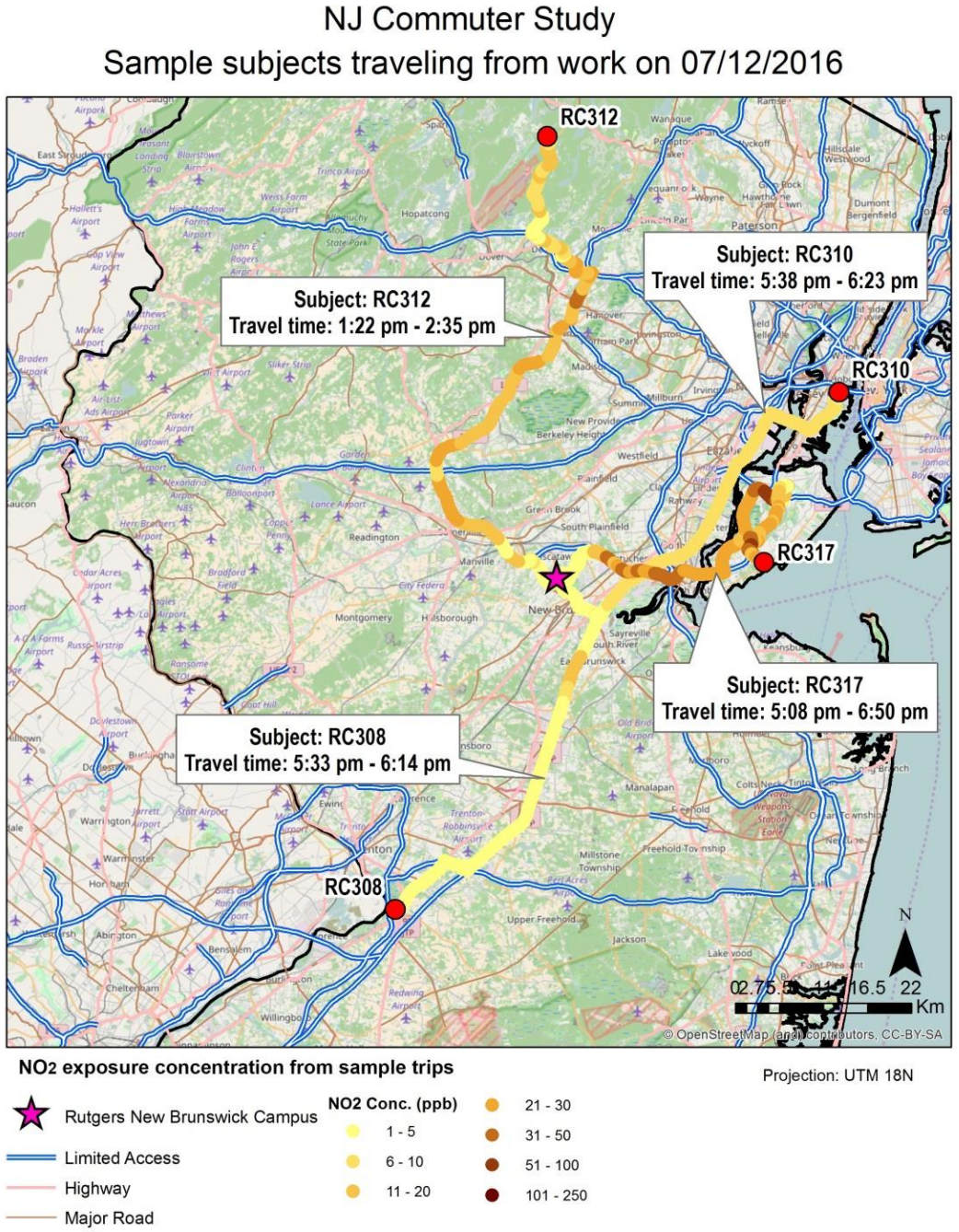
Measurement of NO_2 in Vehicles

- Cairpol CairClip® monitor
- USEPA found $R^2 > 0.99$ and precision within 9.3 ppb
- Measures NO_2, O_3 and "oxidant gases"
- Assumed readout was NO_2 in vehicles in traffic, even in summer



Mean concentrations of NO_2 during rides were relatively low (about 20 ppb)

Some **shorter time periods** over 100 ppb in traffic



Promise of low-cost sensors in the community context

- Capability and Feasibility:
  - Low-cost
  - Small
  - Portable
  - Easy-to-use
  - Continuous, real-time data
    - Combine with GPS data to place data in space and time
  - Data-logging

Promise of low-cost sensors in the community context

- Enabling:
  - Local scale, micro-environmental data
  - Finer-scale spatial arrays
  - Personal monitoring
    - Personal exposure
    - Personalized risk assessment
    - Personalized behavioral response
  - Crowd-sourced data

Pitfalls of low-cost sensors in the community context

- Too easy to obtain and use!
- Lack of accuracy and/or precision
- Lack of user background knowledge/perspective
- Lack of standards for shorter-term concentrations
- True cost may not be low-cost
- Frustration and distrust due to unmet expectations

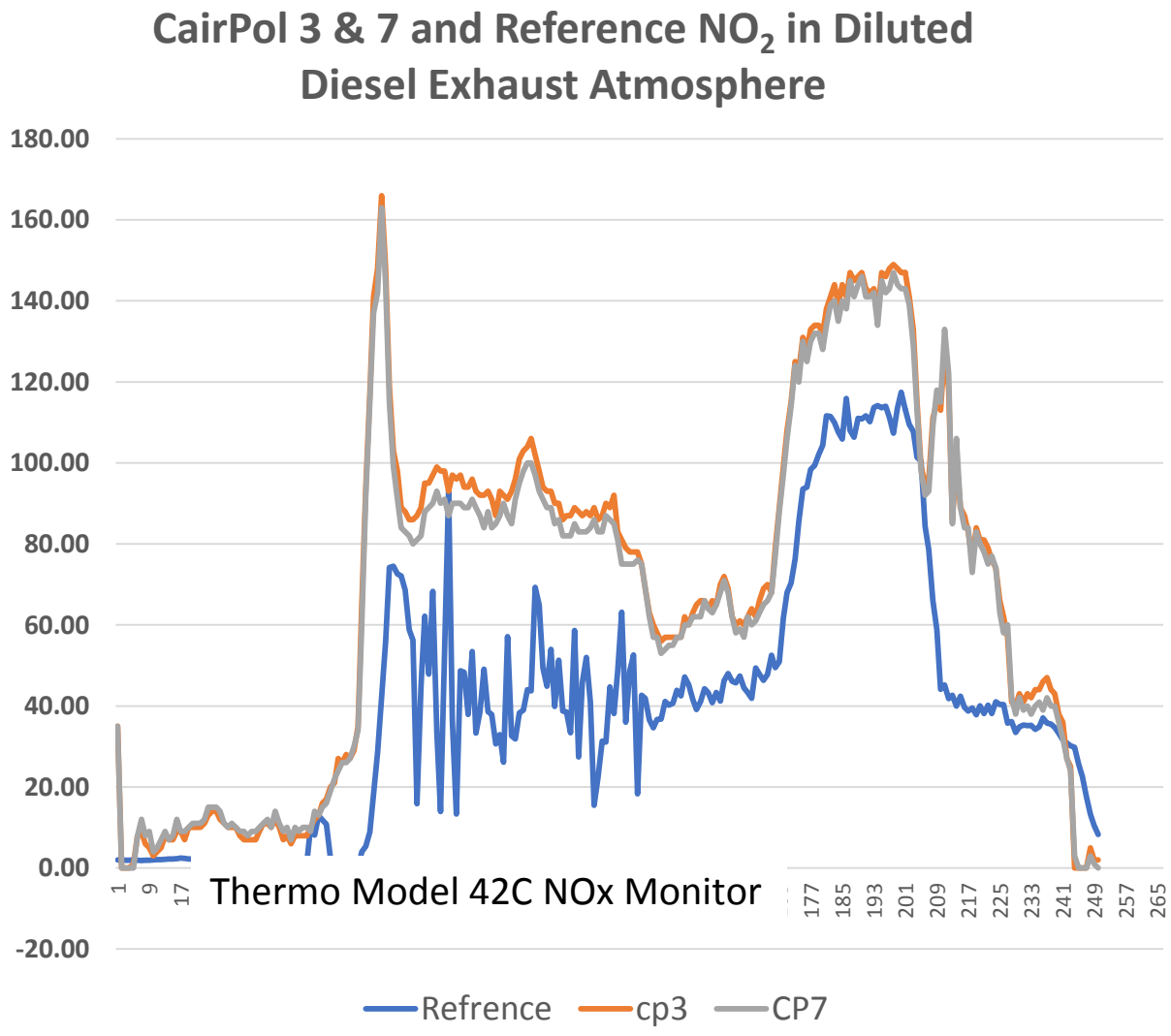
Critical Questions

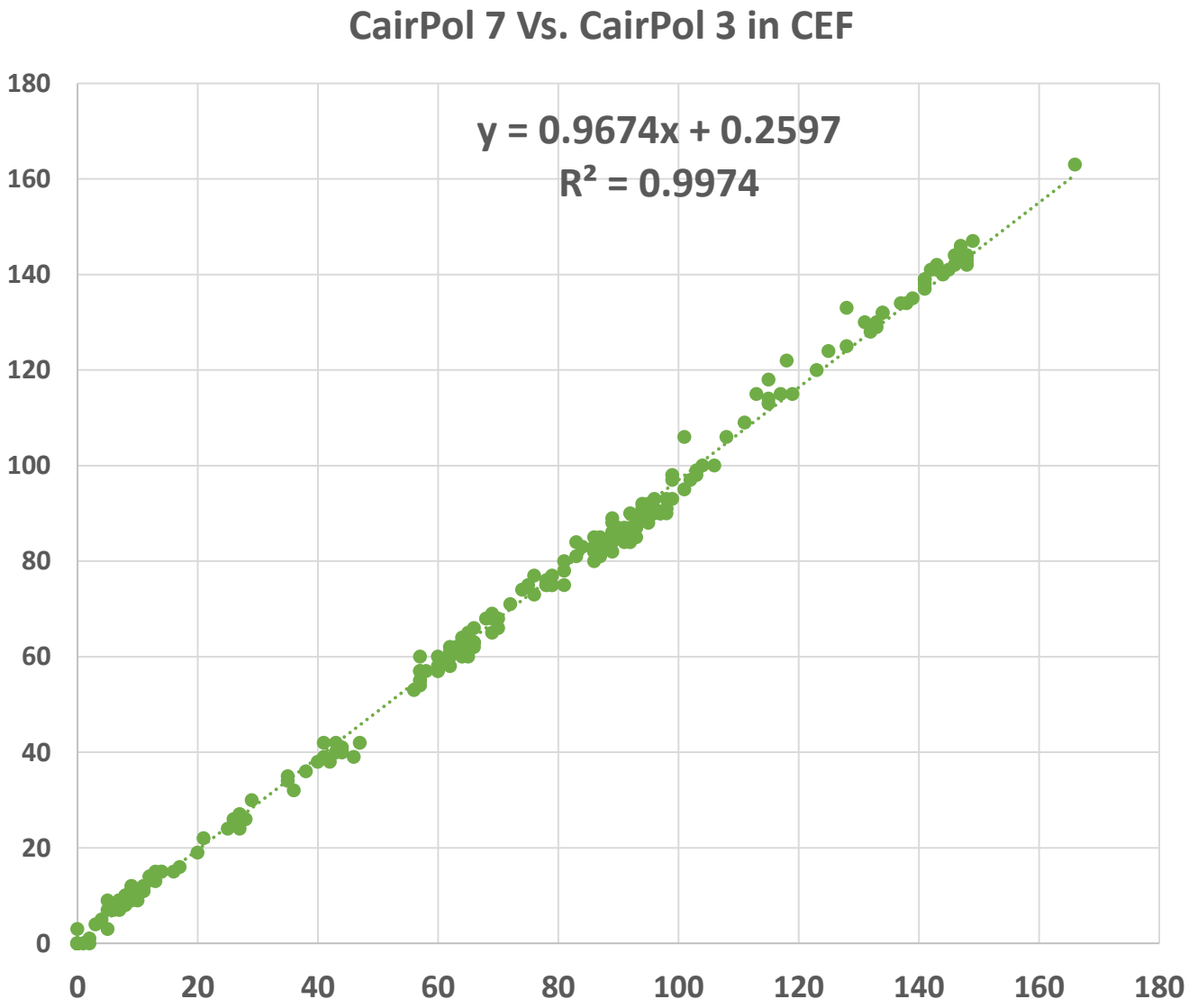
- What question are you trying to answer?
- What is the purpose of the monitoring?

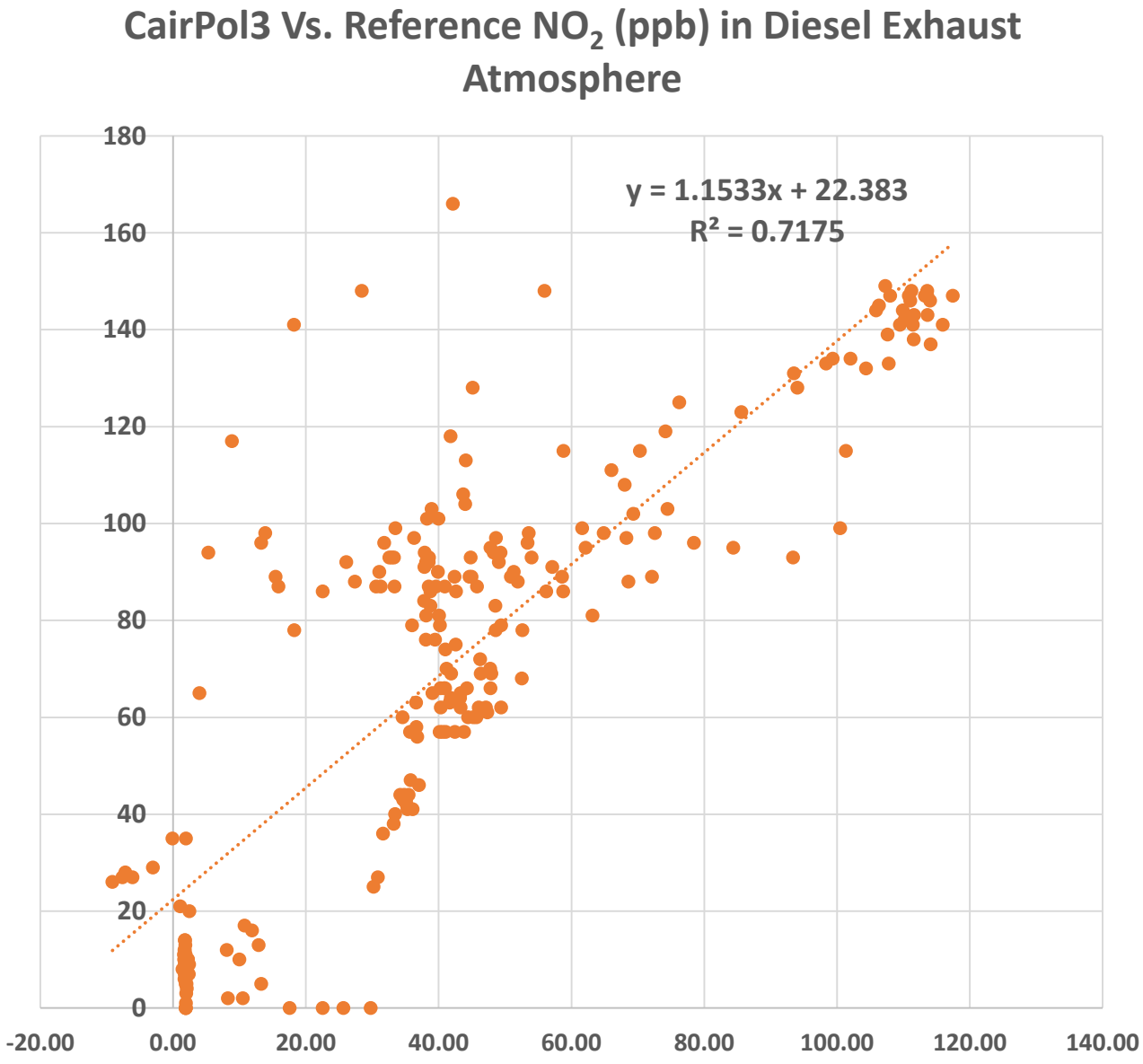
Accuracy and Precision

How much one needs depends on the purpose:

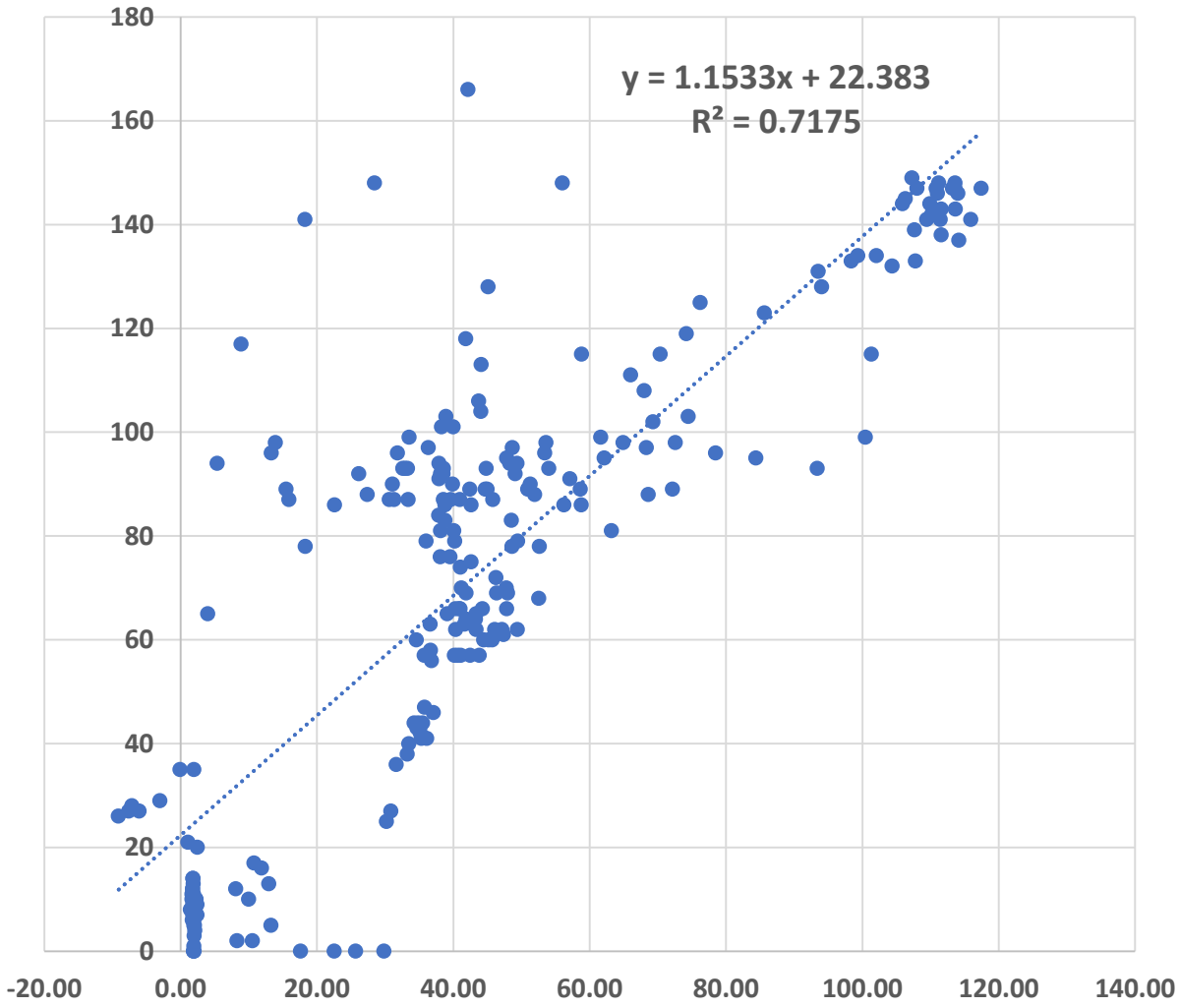
1. Awareness: making air pollution visible
2. Education, e.g. student citizen-science projects
3. Local-scale air quality: increasing geographic coverage
4. Personal exposure monitoring: eg. sensitive individuals
5. Research: associations between exposure and health outcomes


CairPol 3 & 7 and Reference NO_2 in Diluted Diesel Exhaust Atmosphere
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
1
9
17
177
185
193
201
209
217
225
233
241
249
257
265
Thermo Model 42C NOx Monitor
Refrence
cp3
CP7


CairPol 7 Vs. CairPol 3 in CEF
y = 0.9674x + 0.2597
R² = 0.9974
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180


CairPol3 Vs. Reference NO2 (ppb) in Diesel Exhaust Atmosphere
y = 1.1533x + 22.383
R² = 0.7175
180
160
140
120
100
80
60
40
20
0
-20.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00

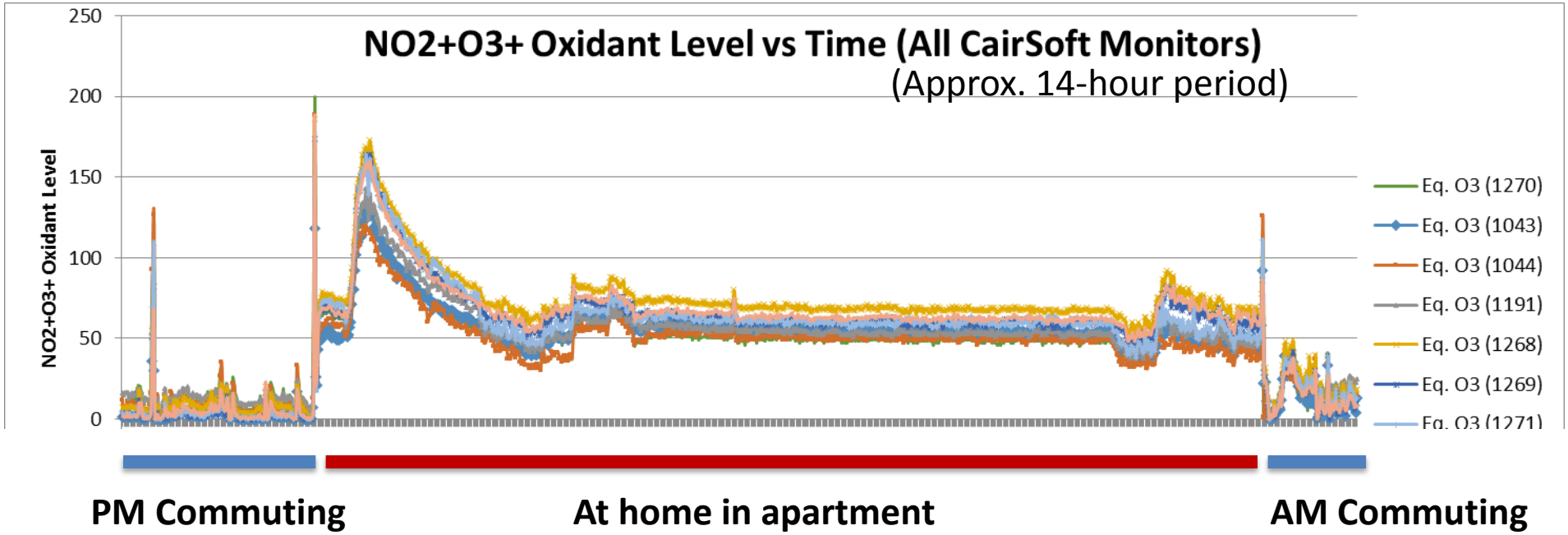
CairPol 7 Vs. Reference NO2 (ppb) in Diesel Exhaust Atmosphere



Managing Expectations

- Clear communication of purposes and limitations
- For regulators and researchers working with communities:
  - Define questions: is monitoring the right answer?
  - Define limitations
  - Define roles
  - Provide necessary background and context
  - Assist with analysis of data

One Unexpected Result



PM Commuting **At home in apartment** **AM Commuting**

Recommendation

- NJDEP should engage with communities in all phases of community-based projects using low-cost sensors
  - Encourage early engagement
  - Provide resources
  - Provide technical assistance

Questions