Monitoring Localized Elevations of PM

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Workshop organizers and participants

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Motivation and background
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Knowledge deficits in air pollution epidemiology

- Lack of support in “mid range” of IER models
- Approx 50 – 5,000 $\mu g \cdot m^{-3}$ PM$_{2.5}$

Exposure burdens co-incident with substantial person-time

- Global: indoor cookstoves, …
- California: transportation corridors, …

Uncertainties inhibiting planning and policymaking

- Faster, cheaper, more agile evaluations needed
Motivation and background

Figure 1: Burnett et al (2014) *Environ Health Persp*
Motivation and background

Figure 2: Chulha stove and traffic congestion. [Wikimedia]
Study 1
Study 1: commodity hardware

Figure 3: Prototype incorporating PPD42NS sensor.
Study 1: colocation at Oakland BAAQMD site

Figure 4: Holstius D, Pillarisetti A, Smith KR, Seto E. Field calibrations of a low-cost aerosol sensor at a regulatory monitoring site in California. *Atmos Meas Tech* 7, 1121–1131, 2014.
Study 1: $R^2 = 0.72$ vs. 24 h FEM PM$_{2.5}$

Figure 5: Holstius D, Pillarisetti A, Smith KR, Seto E. Field calibrations of a low-cost aerosol sensor at a regulatory monitoring site in California. *Atmos Meas Tech* 7, 1121–1131, 2014.
Study 2
Study 2: larger-scale evaluation \((n = 48)\)

Figure 6: Holstius D. *Monitoring PM w/Commodity Hardware*, 2014.
Study 2: exchange near-road ↔ background sites

Figure 7: Holstius D. *Monitoring PM w/Commodity Hardware*, 2014.
Study 2: single-parameter calibrations

Figure 8: Holstius D. *Monitoring PM w/Commodity Hardware*, 2014.
Study 2: near-road site

Figure 9: Laney College site, looking southeast along I-880
Study 2: localized elevations at < 1 h scale

Figure 10: Sensor data, 30 min scale (near-road, background, background). Black steps = 1 h PM$_{2.5\text{-FEM}}$ (reference).
Study 2: localized elevations at < 1 h scale

Figure 11: Sensor data, 10 min scale (near-road, background, background). Black steps = 1 h PM$_{2.5}$-FEM (reference).
Study 2: localized elevations at < 1 h scale

Figure 12: Sensor data, 3 min scale (near-road, background, background). Black steps = 1 h PM$_{2.5}$-FEM (reference).
Study 2: localized elevations at < 1 h scale

Figure 13: Sensor data, 1 min scale (near-road, background, background). Black steps = 1 h PM\textsubscript{2.5-FEM} (reference).
Study 2: localized elevations at < 1 h scale

Figure 14: Sensor data, 1 min scale (near-road, background, background). Black steps = 1 h PM$_{2.5}$-FEM (reference).
Study 2: “remote” calibration

1. Assume one reference group \((m = 12)\) operated by AQMD.
2. For the other three, just cross-calibrate gains \textit{within} groups.
3. Expect group-level \(\hat{\beta}_1\)s to converge for “big enough” \(m\).

- Costs & limitations
  - \(\pm 10\%\) error in \(\beta_1\) for \(m = 12\)
  - usual threats to validity (extrapolation)

- Benefits to good-faith collaborations
  - faster than colocation if \(\tau < 1\ h\)
  - \textit{no need to travel to regulatory sites}\)
Summary and conclusion
Summary of findings

**Reliability.** In our field studies, PPD42NS optical aerosol sensors have exhibited acceptable performance:

- No failures of $n = 48$ sensors in 10+ weeks
- Very good precision (inter-sensor agreement)

**Fidelity.** Good agreement with FEM reference (BAM-1020). Measurand is not is exactly PM$_{2.5}$!

- 24 h scale: $R^2 = 0.72$
- 1 h scale: $R^2 \approx 0.6$
  - comparable to GRIMM, DustTrak, or 2$^{\text{nd}}$ BAM
  - $\sigma$ for BAM is $2 - 2.4 \, \mu g \cdot m^{-3}$ at 1 h scale
Summary of findings

**Utility.** Simple model has reasonable fit:

- $\beta_0$ very close to zero
- modest variation in $\beta_1$
- 10 % error in $\beta_1$ if “remotely” calibrated

**Relevance.** Can observe localized PM elevations:

- consistently, with multiple PPD42NS sensors
- can resolve structure at timescales $< 1$ h

*Further assessments under varying conditions are warranted. Independent replications are needed to substantiate or refute these findings.*
Conclusion

Contributes to prospects for monitoring localized PM elevations

- Good-enough assessments in absence of viable alternatives
- Supplement/complement to established monitoring
- Meeting the challenges of new geographies

Large $n$ can support more than just increased density/coverage

- Calibrate remotely with good-faith partners
- Degrade, don’t fail: triplicate sensors per device
Future directions

Figure 15: Sharp DN7C3JA001 with impactor, claimed to attenuate 98% of response to \( d_p = 5.0 \mu m \) (vs GP2Y1010AU0F).


Additional slides
Study 1: colocation

West Oakland, 15 – 23 Apr 2013

Figure 16: PPD42NS vs BAM at 1 h scale. ($R^2 \approx 0.6$)
Study 1: colocation

Figure 17: BAM vs BAM at 1 h scale. ($R^2 \approx 0.6$)