Monitoring Localized Elevations of PM

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Acknowledgments

Workshop organizers and participants

- CAPCOA and SCAQMD
- Andrea Polidori, Eric Stevenson, Barbara Lee, Annie Boyd, ...
- Presenters and attendees

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- Phil Martien, Virginia Lau, Henry Hilken, ...
- Prof Ron Cohen and the UC Berkeley BEACON project
- Profs Kirk Smith and Edmund Seto

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

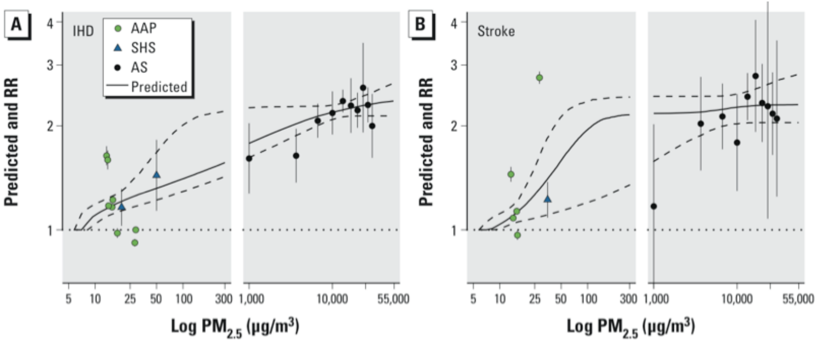

Figure 1: Burnett et al (2014) *Environ Health Persp*

Motivation and background

Figure 2: Chulha stove and traffic congestion. [*Wikimedia*]

Study 1

Study 1: commodity hardware

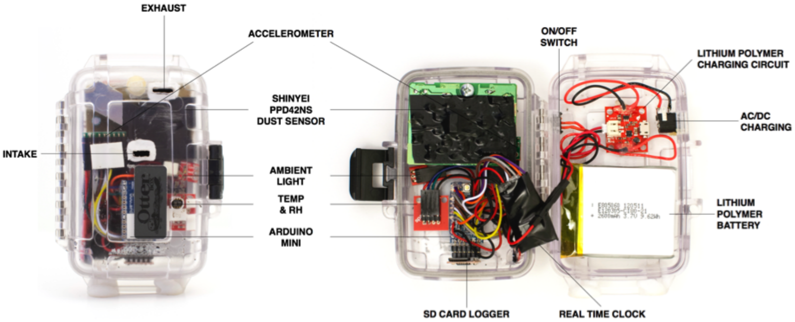

Figure 3: Prototype incorporating PPD42NS sensor.

Study 1: colocation at Oakland BAAQMD site

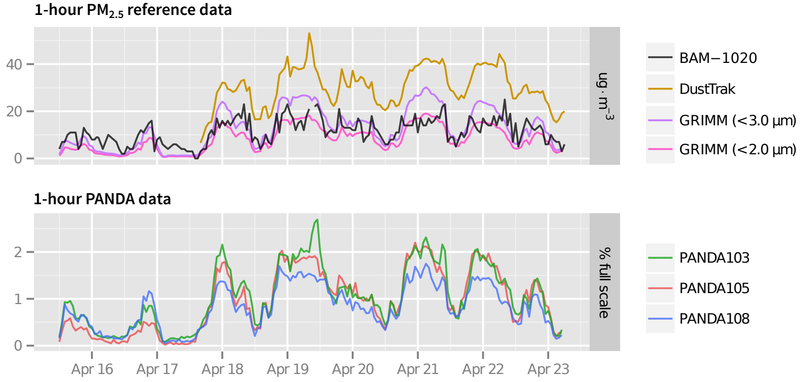

Figure 4: Holstius D, Pillarisetti A, Smith KR, Seto E. Field calibrations of a low-cost aerosol sensor at a regulatory monitoring site in California. *Atmos Meas Tech* 7, 1121–1131, 2014.

Study 1: $R^2 = 0.72$ vs. 24 h FEM $PM_{2.5}$

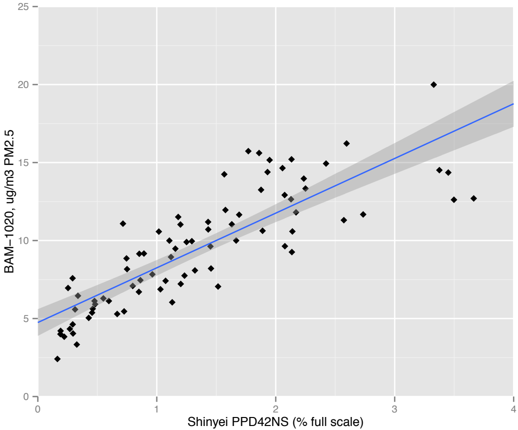

Figure 5: Holstius D, Pillarisetti A, Smith KR, Seto E. Field calibrations of a low-cost aerosol sensor at a regulatory monitoring site in California. *Atmos Meas Tech* 7, 1121–1131, 2014.

Study 2

Study 2: larger-scale evaluation ($n = 48$)

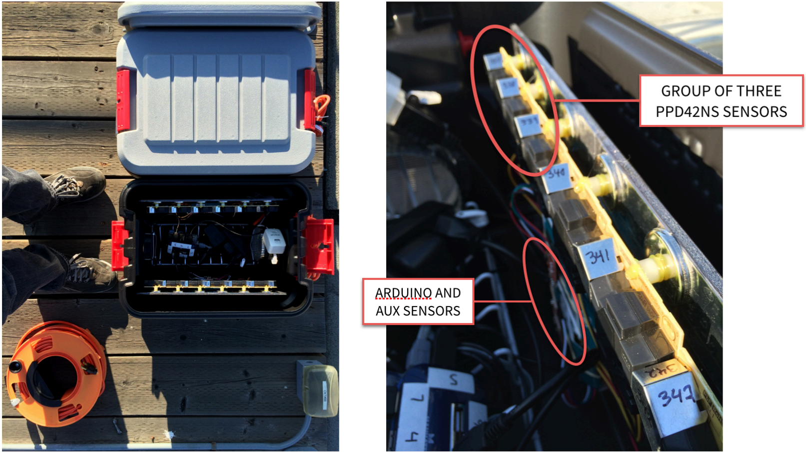

Figure 6: Holstius D. *Monitoring PM w/Commodity Hardware*, 2014.

Study 2: exchange near-road ↔ background sites

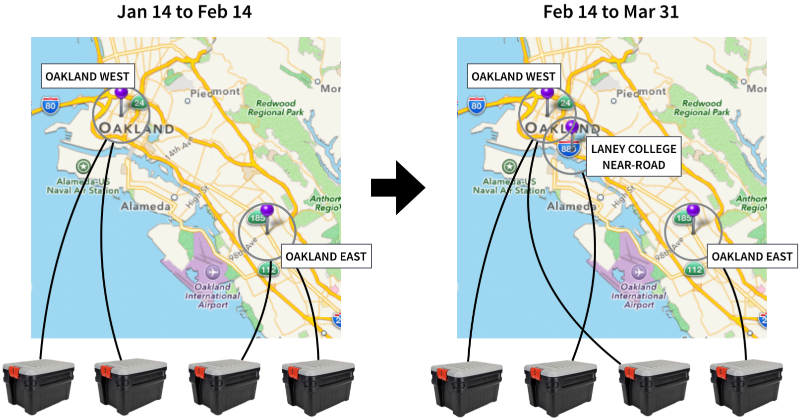

Figure 7: Holstius D. *Monitoring PM w/Commodity Hardware*, 2014.

Study 2: single-parameter calibrations

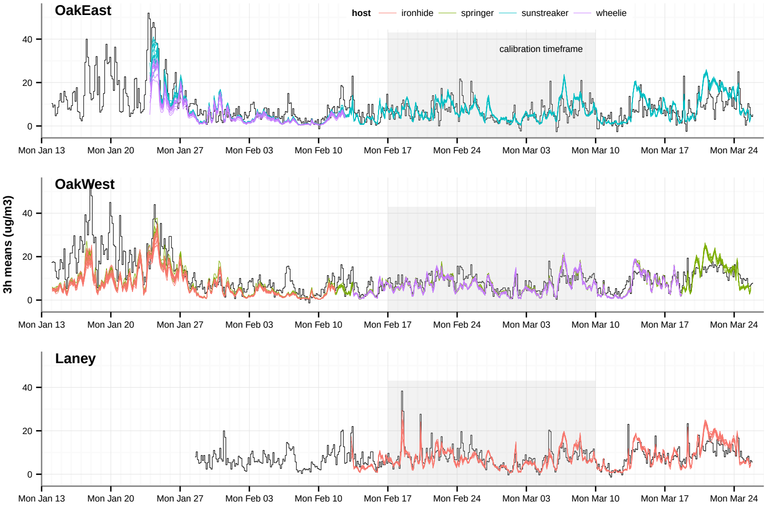

Figure 8: Holstius D. *Monitoring PM w/Commodity Hardware*, 2014.

Study 2: near-road site

Figure 9: Laney College site, looking southeast along I-880

Study 2: localized elevations at < 1 h scale

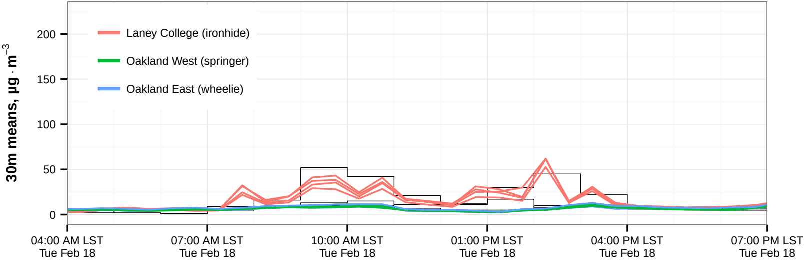

Figure 10: Sensor data, 30 min scale (near-road, background, background). Black steps = 1 h $PM_{2.5\text{-FEM}}$ (reference).

Study 2: localized elevations at < 1 h scale

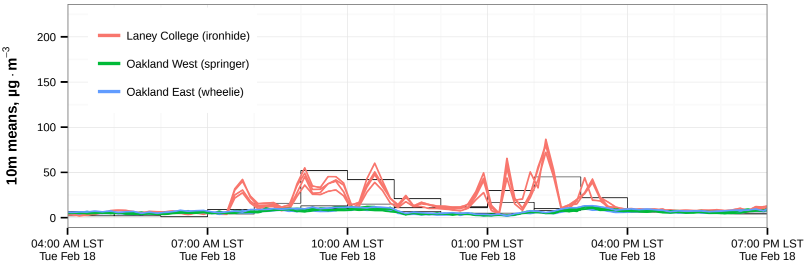

Figure 11: Sensor data, 10 min scale (near-road, background, background). Black steps = 1 h $PM_{2.5\text{-FEM}}$ (reference).

Study 2: localized elevations at < 1 h scale

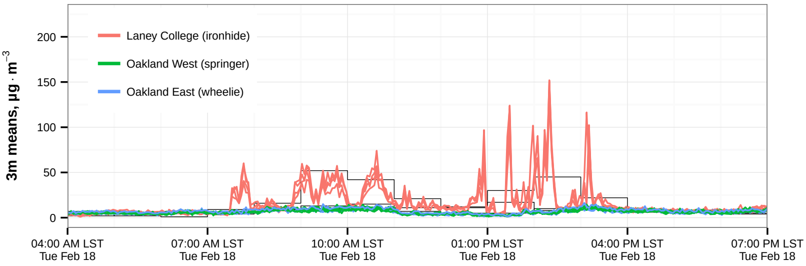

Figure 12: Sensor data, 3 min scale (near-road, background, background). Black steps = 1 h $PM_{2.5\text{-FEM}}$ (reference).

Study 2: localized elevations at < 1 h scale

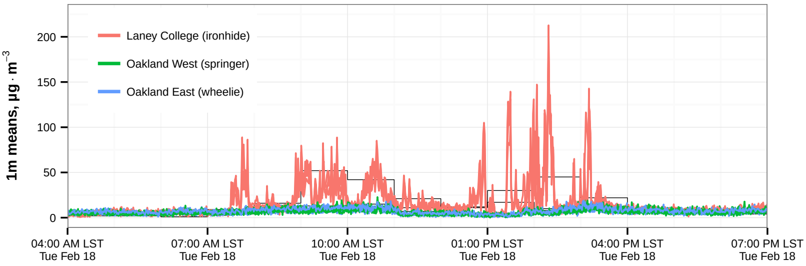

Figure 13: Sensor data, 1 min scale (near-road, background, background). Black steps = 1 h $PM_{2.5\text{-FEM}}$ (reference).

Study 2: localized elevations at < 1 h scale

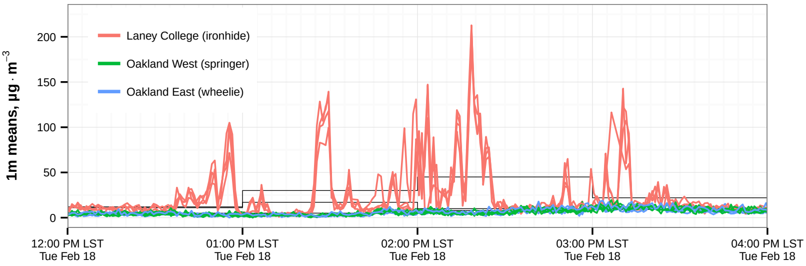

Figure 14: Sensor data, 1 min scale (near-road, background, background). Black steps = 1 h $PM_{2.5\text{-FEM}}$ (reference).

Study 2: "remote" calibration

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

- Costs & limitations
  - $\pm$ **10 % error in** $\boldsymbol{\beta_1}$ for $m = 12$
  - usual threats to validity (extrapolation)
- Benefits to good-faith collaborations
  - faster than colocation if $\tau < 1$ h
  - **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 2nd BAM
  - σ for BAM is 2 – 2.4 $\mu g \cdot m^{-3}$ at 1 h scale

Summary of findings

Utility. Simple model has reasonable fit:

- β_0 very close to zero
- modest variation in β_1
- 10 % error in β_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 absense 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).

Selected references

Burnett R et al. An Integrated Risk Function for Estimating the Global Burden of Disease Attributable to Ambient Fine Particulate Matter Exposure. *Environ Health Perspect* 112(4), 2014.

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.

Holstius D. Monitoring Particulate Matter with Commodity Hardware. Ph.D. thesis, University of California, Berkeley. 2014.

Snyder E et al. The Changing Paradigm of Air Pollution Monitoring. *Environ Sci Technol*, 2013, 47 (20), 11369–11377.

Additional slides

Study 1: colocation

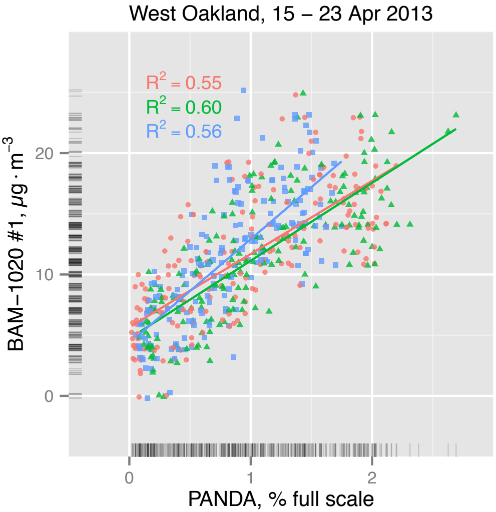

Figure 16: PPD42NS vs BAM at 1 h scale. ($R^2 \approx 0.6$)

Study 1: colocation

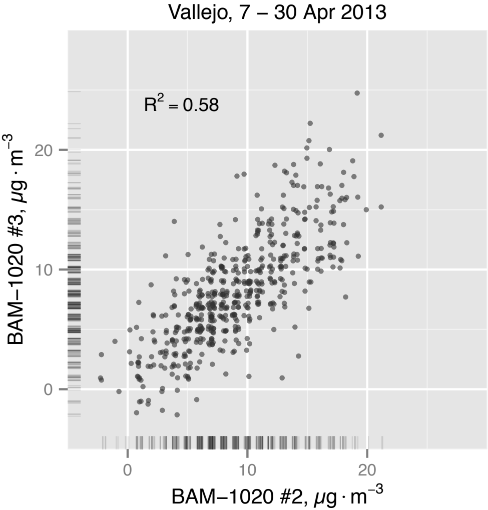

Figure 17: BAM vs BAM at 1 h scale. ($R^2 \approx 0.6$)