Remotely calibrating gas sensor devices in the field

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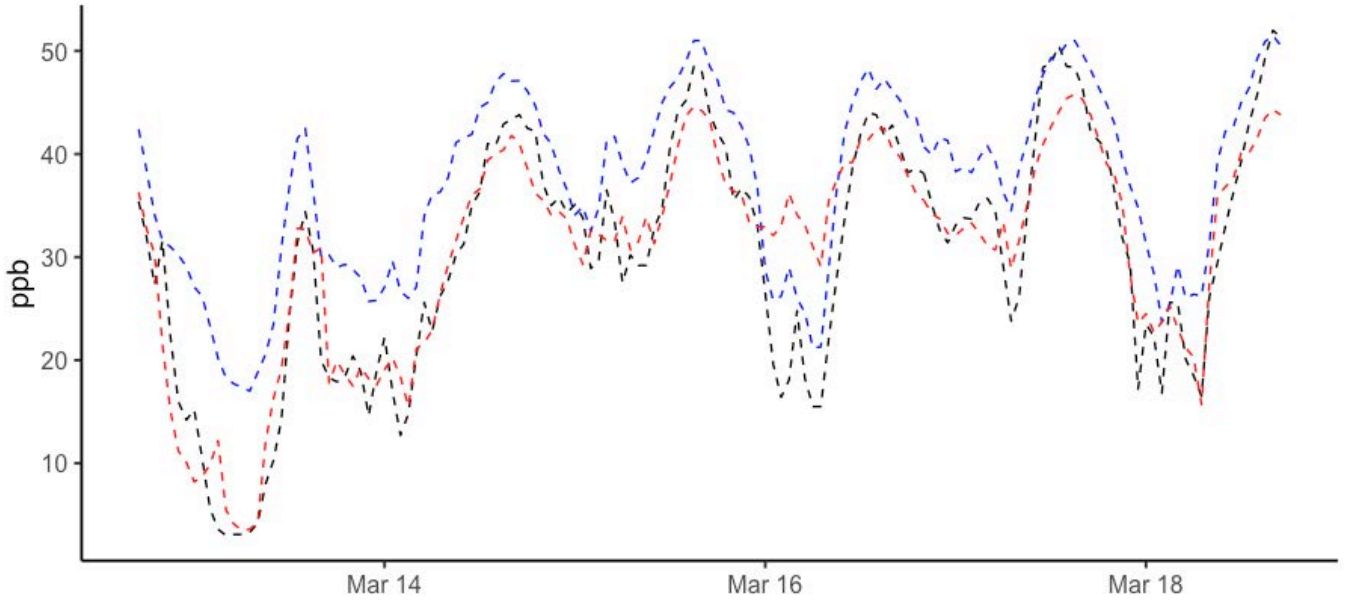
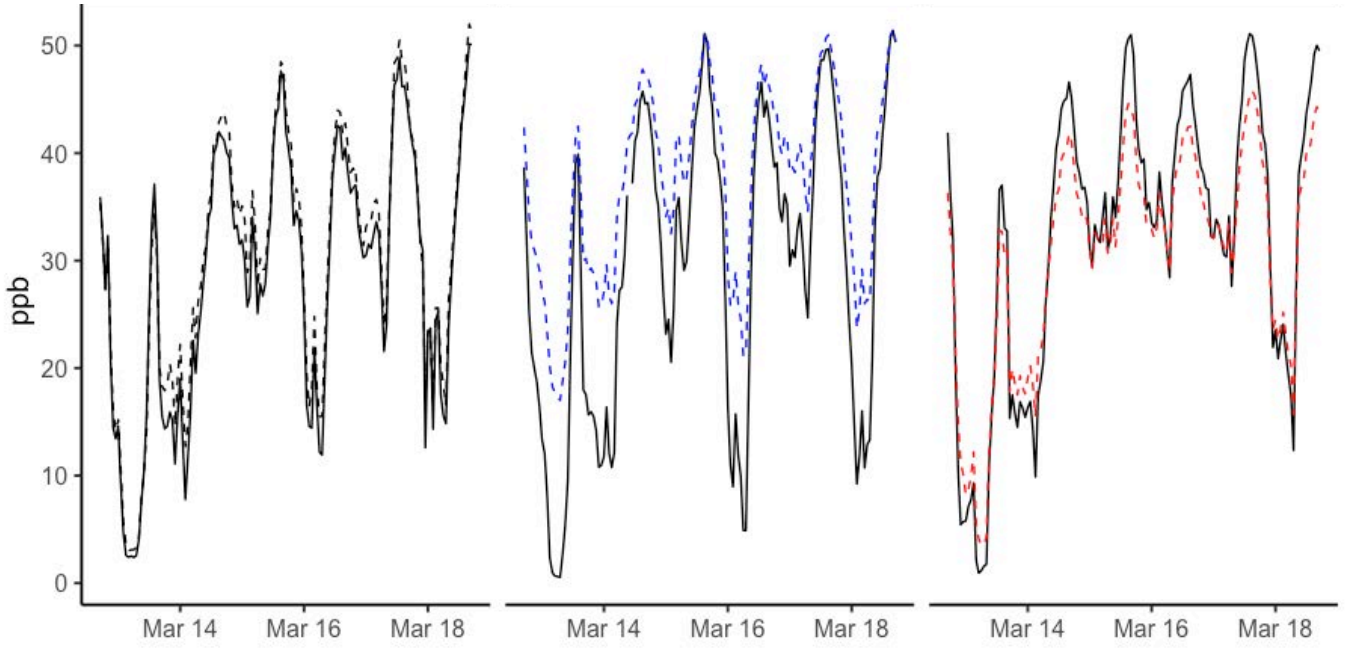
Calibrating Sensor Devices



- Sensors show reduced sensitivity over time when not regularly calibrated.
- Calibration often done using field co-location.
- Can be difficult to characterise changes in the data.

Calibrating Sensor Devices



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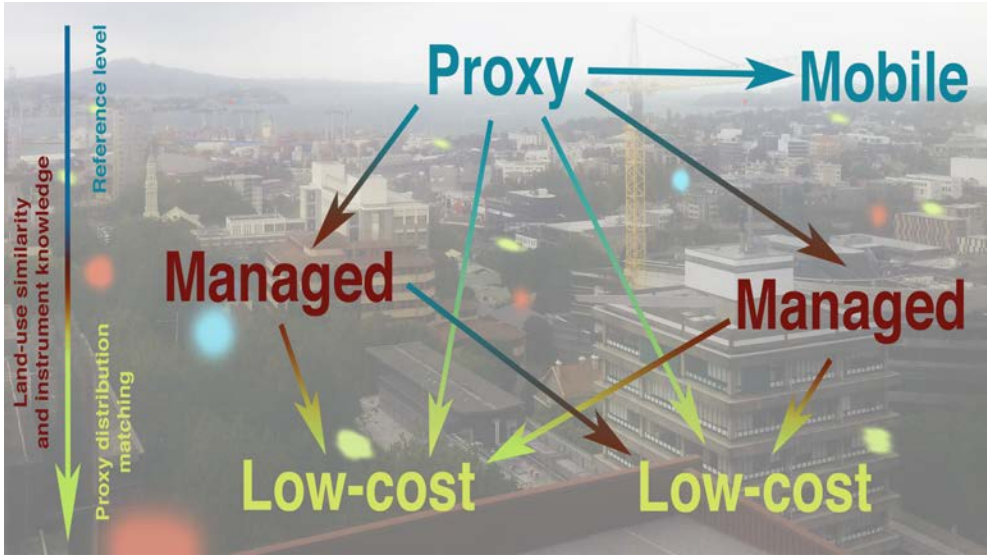
- Calibration often done using field co-location.
- Can be difficult to characterise changes in the data.

Remote Calibration

- Field visits can be time consuming and are unable to update continuously.
- Remote calibration – where coefficients are found without co-location – would resolve both these points.
- Need a method that is proven to find reliable coefficients.

Calibration Method

- Data as running three-day samples.
- High quality measurements provide ground-truth information – "proxies".
- Use land use similarity to improve the proxy sample.
- Verify calibration by co-located regulatory measurements.



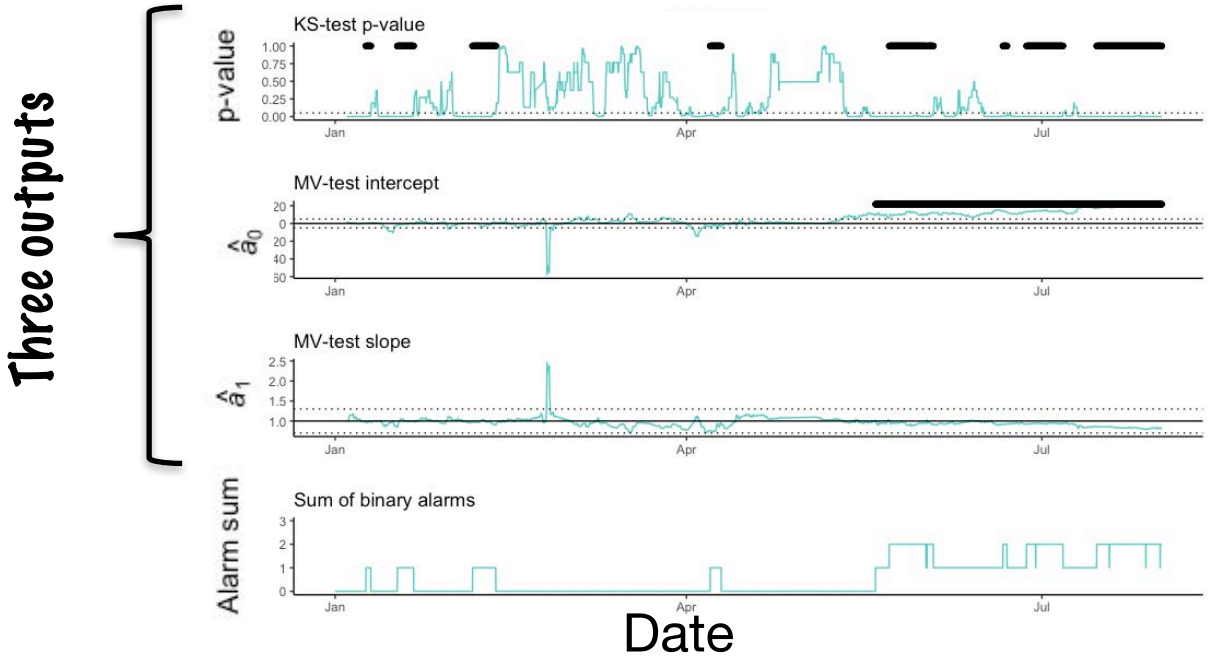
Calibration Method

- Assumption One: Sensor data (Y) is linearly related to 'true' concentration (X) over a sample of data.
- Assumption Two: Selected remote proxy data (Z) ~ X.
- Reworking assumptions gives the remote calibration coefficients:

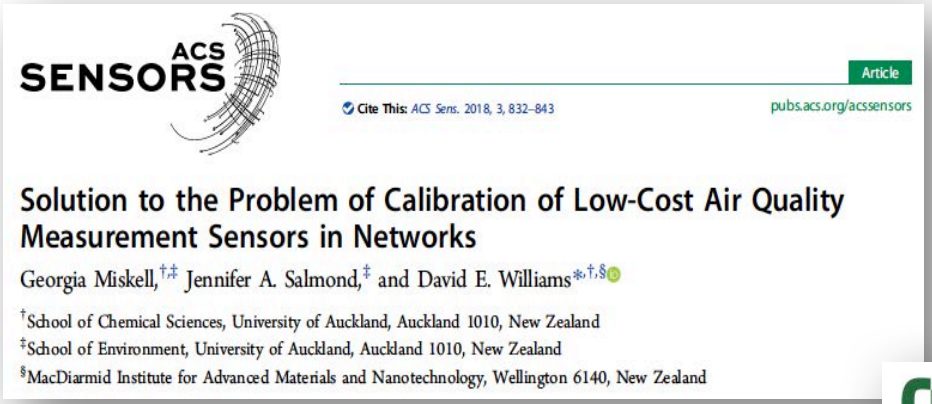
$$\hat{a}_1 = \sqrt{\sigma^2 < Z(t) > \Big/ \sigma^2 < Y(t) >}$$

$$\hat{a}_0 = \mu < Z(t) > - \hat{a}_1 \mu < Y(t) >$$

Calibration Method



- Two tests with three outputs to check sensor data.
- Thresholds defined where alarm signalled.
- Consistent signalling less likely from natural variability.
- If >1 outputs with consistent alarms, the calibration used.



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Solution to the Problem of Calibration of Low-Cost Air Quality Measurement Sensors in Networks

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Data Verification Tools for Minimizing Management Costs of Dense Air-Quality Monitoring Networks

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Miskell et al. *Env. Sci. & Technol.* 2016, 50(2), 835-846

Data

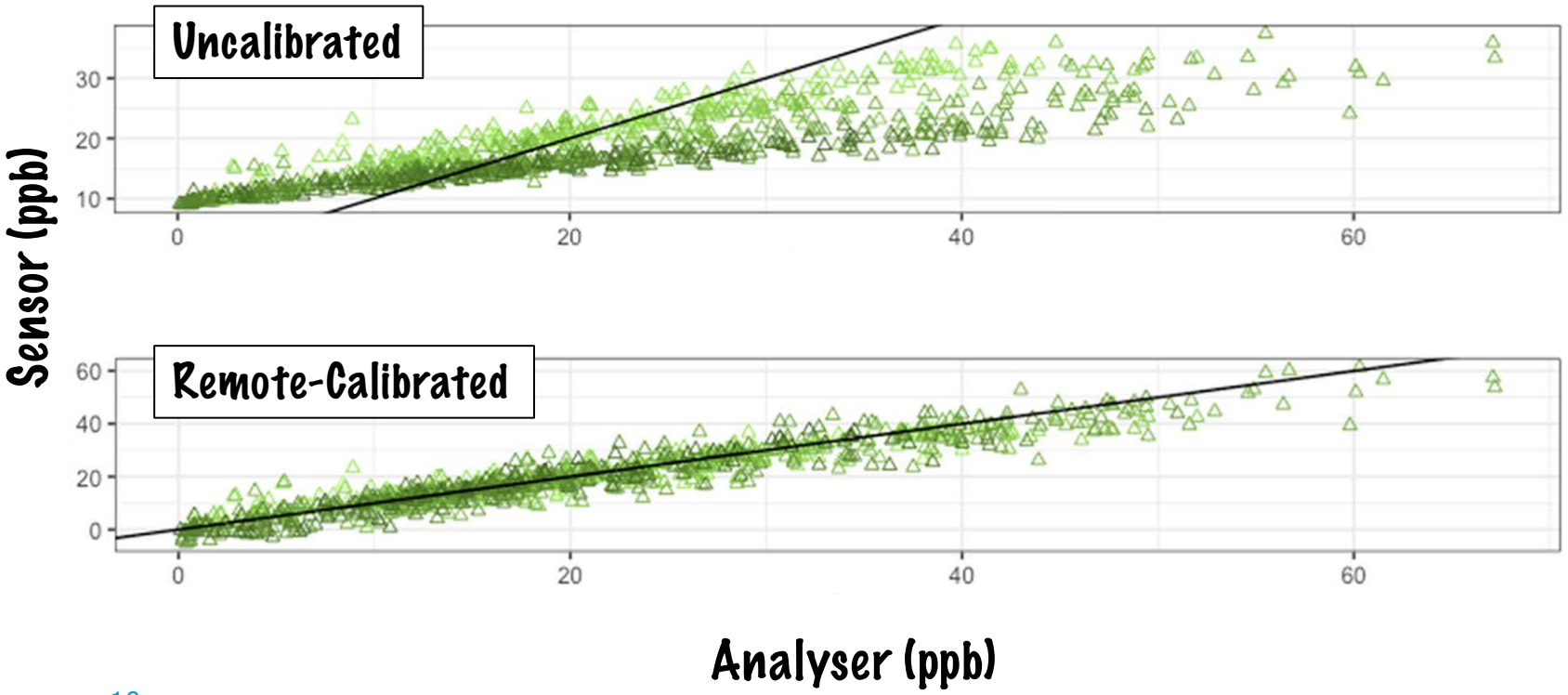
Data from two networks measuring ozone (ppb) by gas-sensitive semiconducting sensors manufactured by Aeroqual.

Network 1: Vancouver, Canada

Network 2: Los Angeles, California

Vancouver

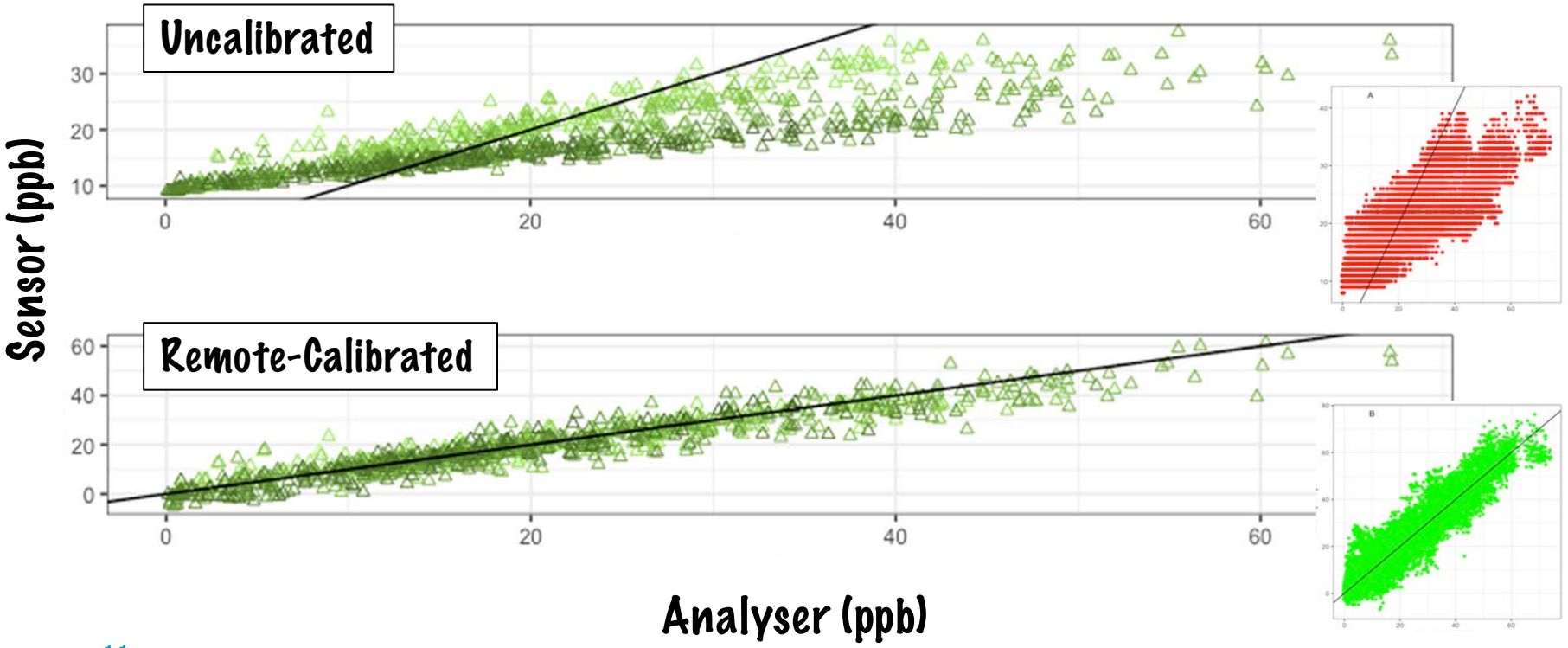
1-hour data.



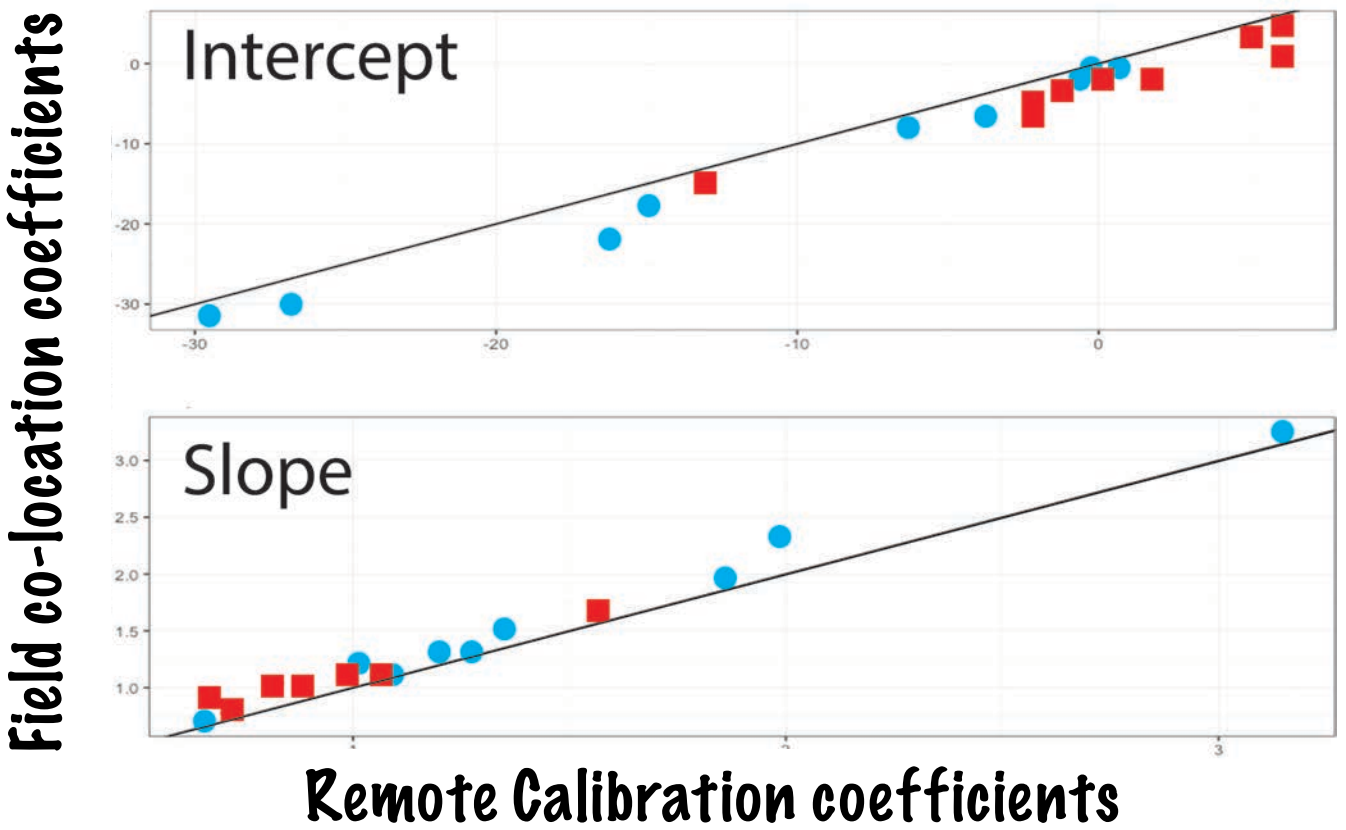
Vancouver

1-hour data.

1-min data.



Vancouver

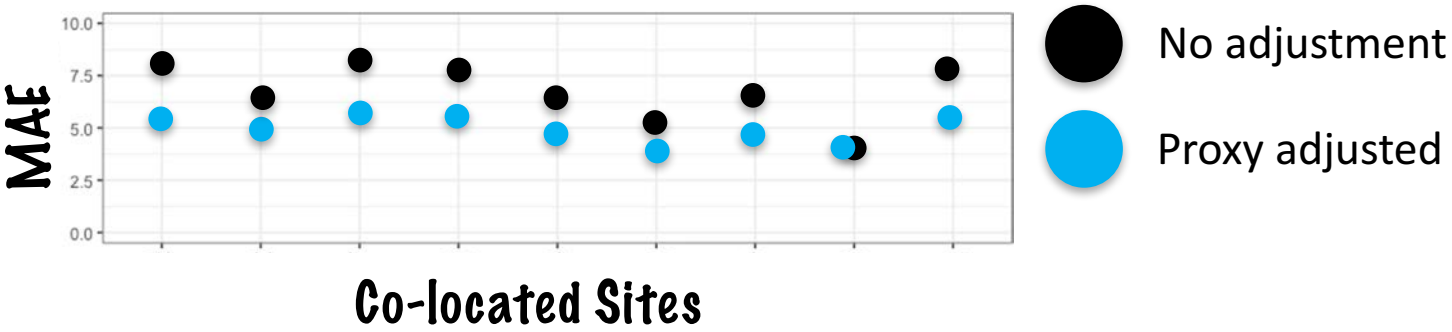


First week of monitoring

Last week of monitoring

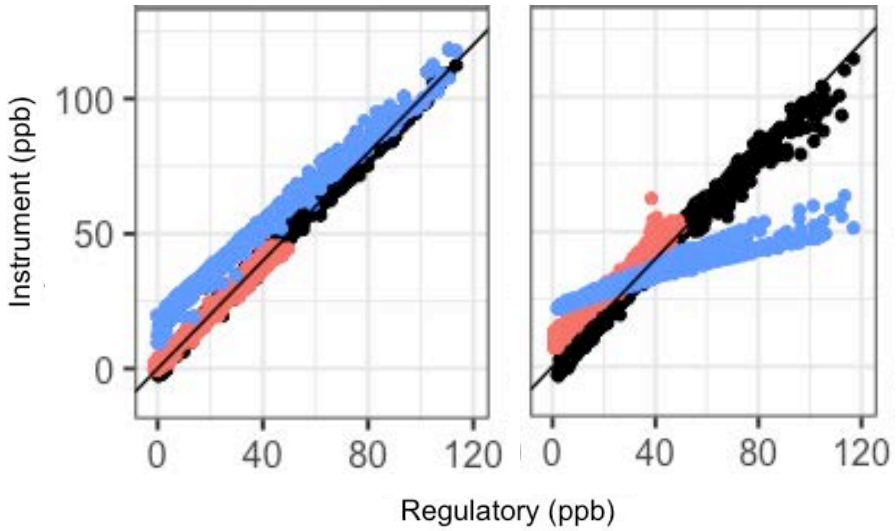
Vancouver

Sensor land use	Proxy land use		
	Urban	Suburban	Rural
Urban	1	0.76	0.68
Suburban	1.23	1	0.87
Rural	1.28	1.03	1



Land use adjustments improved the proxy when it was a poor fit.

Los Angeles



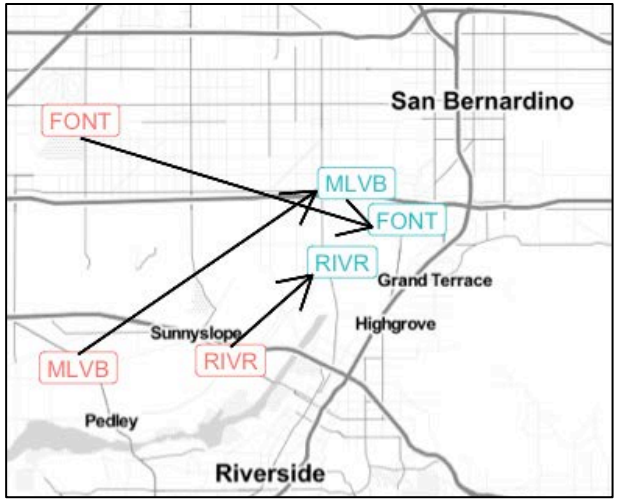
First month, uncalibrated

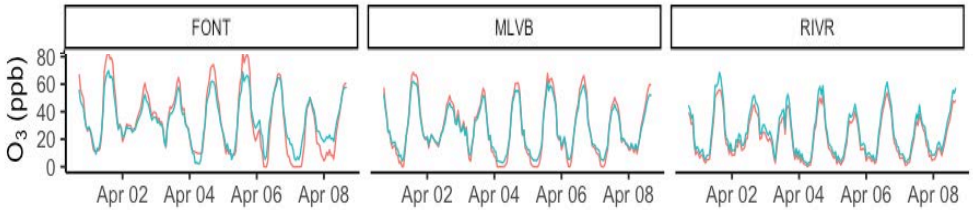
Last month, uncalibrated

Last month, remote calibrated

- Network of ~ 100 sensor devices.
- Remote calibration improved accuracy of data (O_3).

Los Angeles





- Field-calibrated sensors moved to non-co-located sensor devices calibrated by the remote method.
- Time-series showed good agreement between the two devices.

Summary

Remote calibration:

- Cost-effective.
- Check and update any time.
- Do not require regular access to sites.
- Shown to work for ozone sensor devices in two networks.

- Finding appropriate proxies a challenge.
- Unknown level of uncertainty added to the measurement.

Thanks for listening!

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