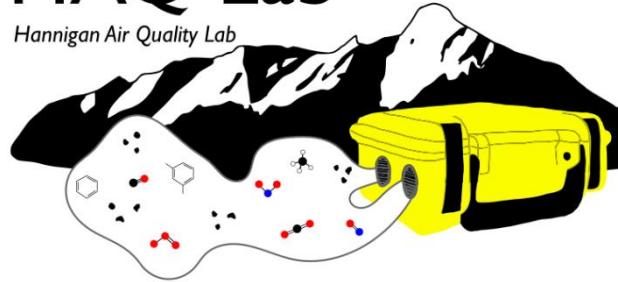# Application-specific quality assurance of low-cost VOC sensing technology

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University of Colorado **Boulder**

My work

- Community-based, low-cost air quality monitoring, especially of VOCs (volatile organic compounds), in oil and gas communities
  - Los Angeles, CA
  - Pascagoula, MS

Overview

1. Introduction: Low-cost VOC sensors

2. Key elements of resource-intensive quality assurance

3. Key elements of resource-limited quality assurance

4. Comparison & conclusion

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Introduction:
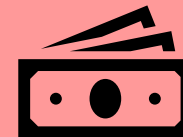## Low-cost VOC sensors

The good news!

- Low-cost VOC sensors can provide community access to important environmental data
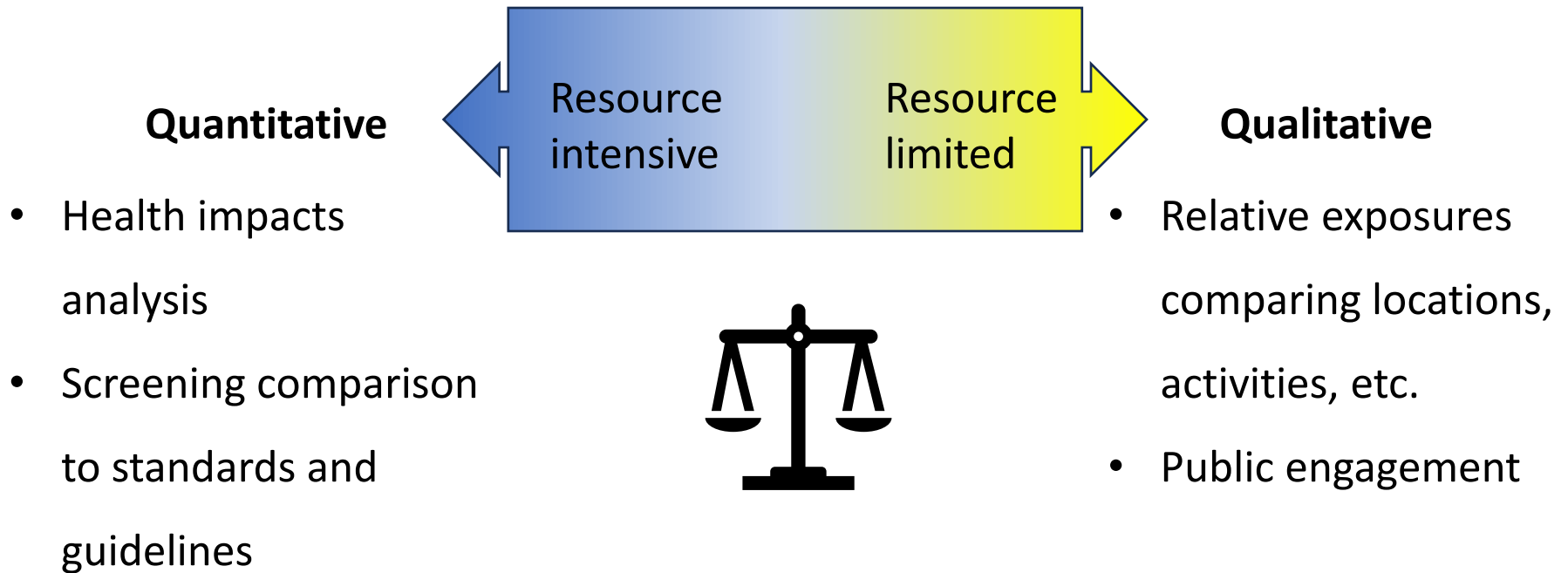
The bad (?) news!

- QA must account for:
  - Cross-sensitivity
  - Sensor drift, noisy data, etc.
- Quality assurance can take varying levels of resources

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Introduction:
Low-cost Sensor Quality Assurance

Quantitative

- Health impacts analysis
- Screening comparison to standards and guidelines

Resource intensive   Resource limited

Qualitative

- Relative exposures comparing locations, activities, etc.
- Public engagement

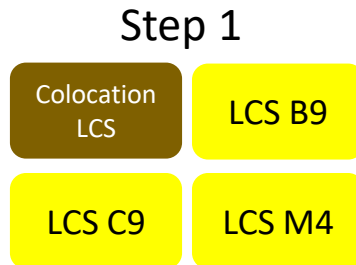# Resource-intensive quality assurance

Resource-intensive determinants: Access to reference-grade monitors and more extensive data analysis capacity
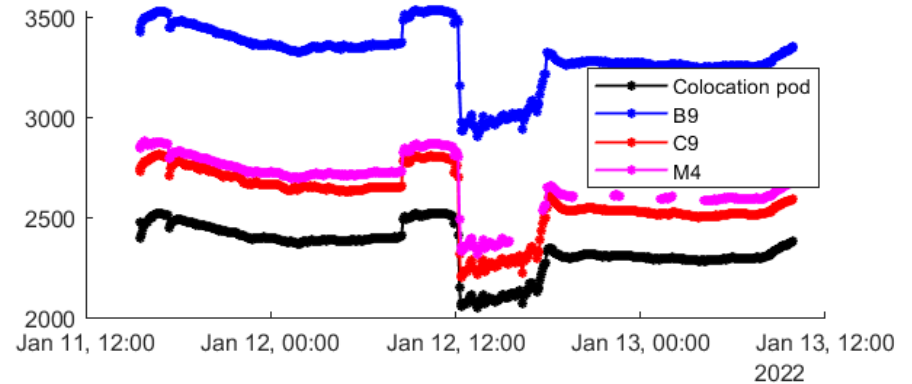
Key quality assurance element:

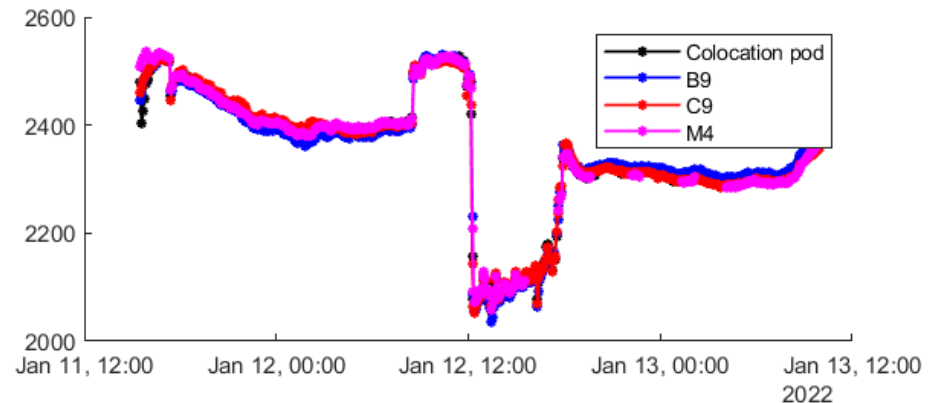1. Sensor normalization using a two-step colocation

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Resource-intensive quality assurance
Step 1: Normalize between pods

Step 1

Colocation LCS	LCS B9
LCS C9	LCS M4

- Simple, linear correction for shifted baselines between individual low-cost sensors

Linear model

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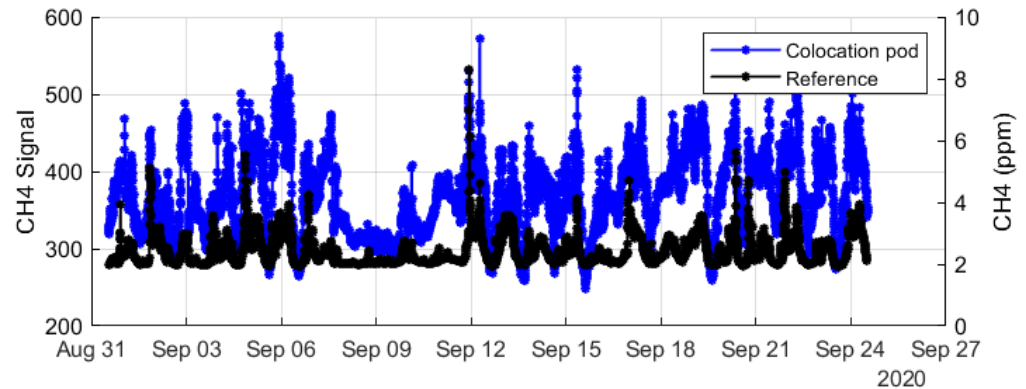# Resource-intensive quality assurance
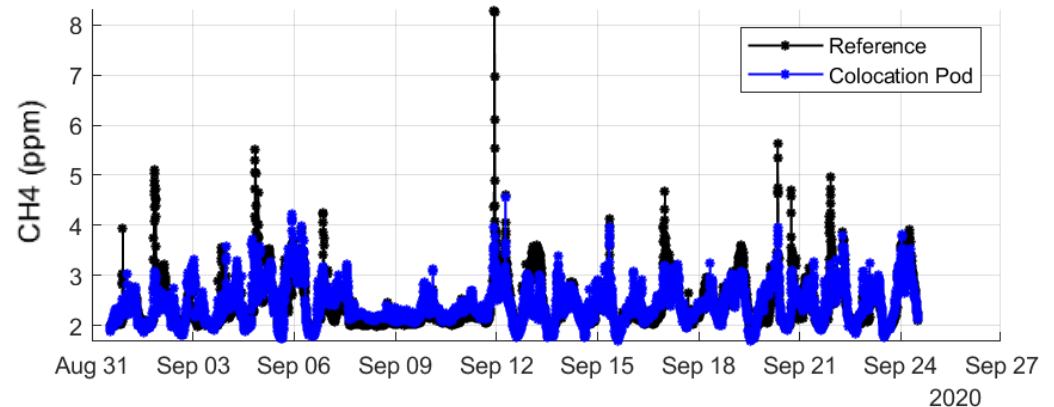## Step 2: Normalize one

Step 2

Colocation
LCS

Reference

- Complex, typically non-linear model to account for cross-sensitivities
  - Neural networks
  - Temp, humidity, and co-contaminants are included in model

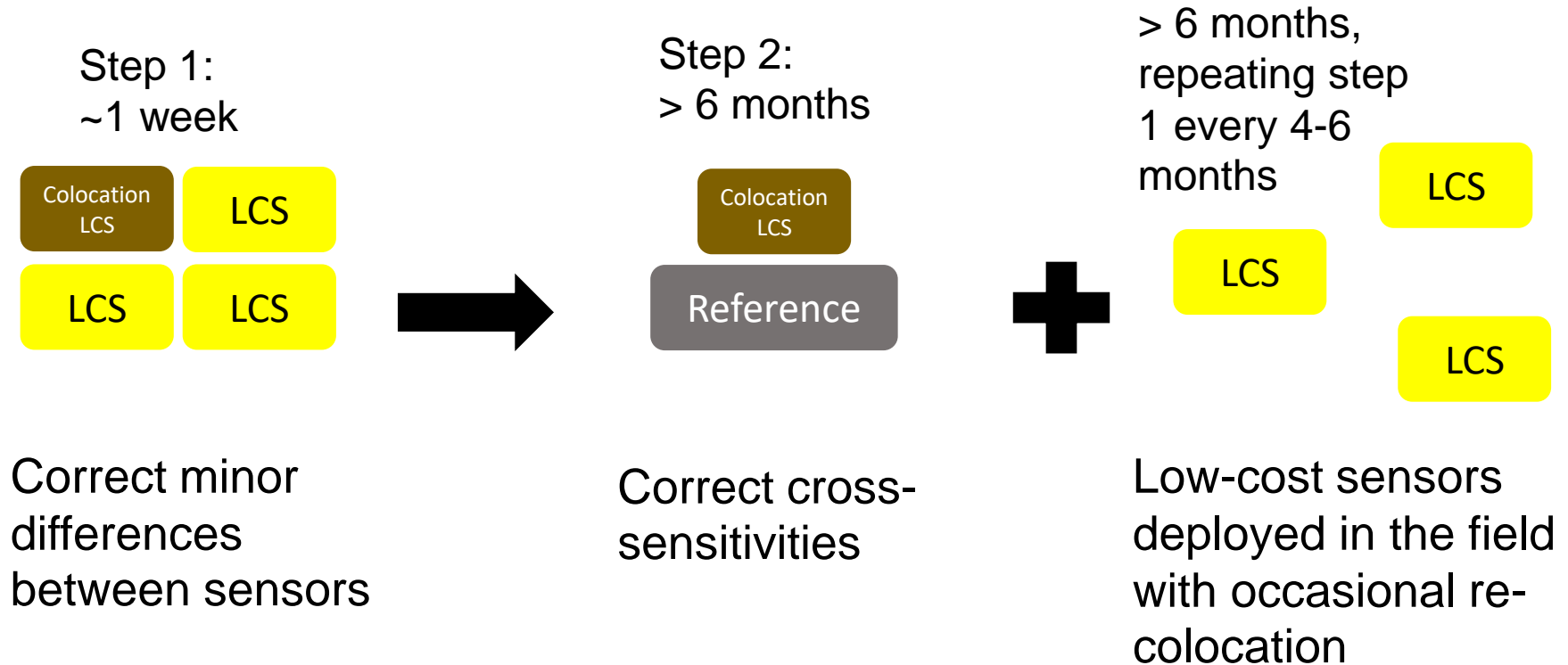- Requires more data than step 1 to avoid overfitting

Complex
model

Resource-intensive quality assurance
Two-step colocation

Step 1:
~1 week

Colocation LCS	LCS
LCS	LCS

Correct minor differences between sensors

Step 2:
> 6 months

Colocation LCS

Reference

Correct cross-sensitivities

+

> 6 months, repeating step 1 every 4-6 months

LCS

LCS

LCS

Low-cost sensors deployed in the field with occasional re-colocation

Okorn, K., et. al., 2021, Atmosphere, **12**, 645.

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Resource-limited quality assurance

Resource-limited determinants: No access to reference equipment and/or limited capacity for data analysis

Key elements:

1. Data quality checks

2. Context documentation

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Resource-limited quality assurance
1. Data quality check #1

"Step 1" Colocation

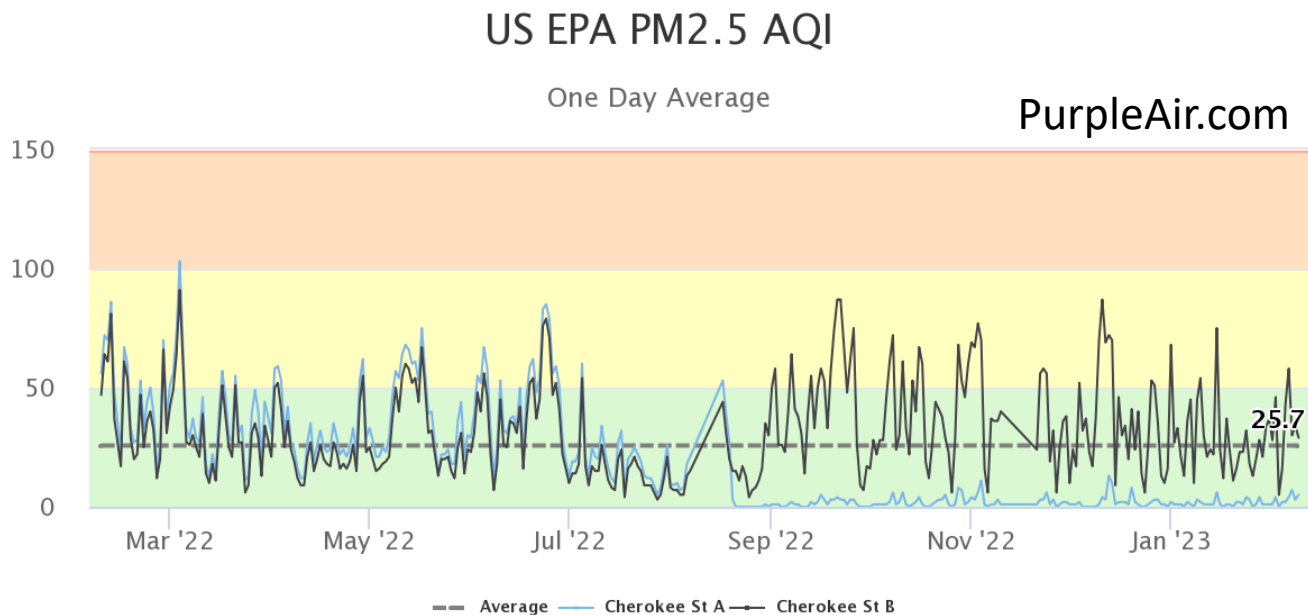• Is the data flatlined even

  with known exposures?

LCS	LCS
LCS	LCS

Sensor test using a lit match to check for PM, CO_2, VOC sensor response

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Resource-limited quality assurance
1. Data quality check #2

"Step 1" Colocation

- Are the sensor readings similar across pods?

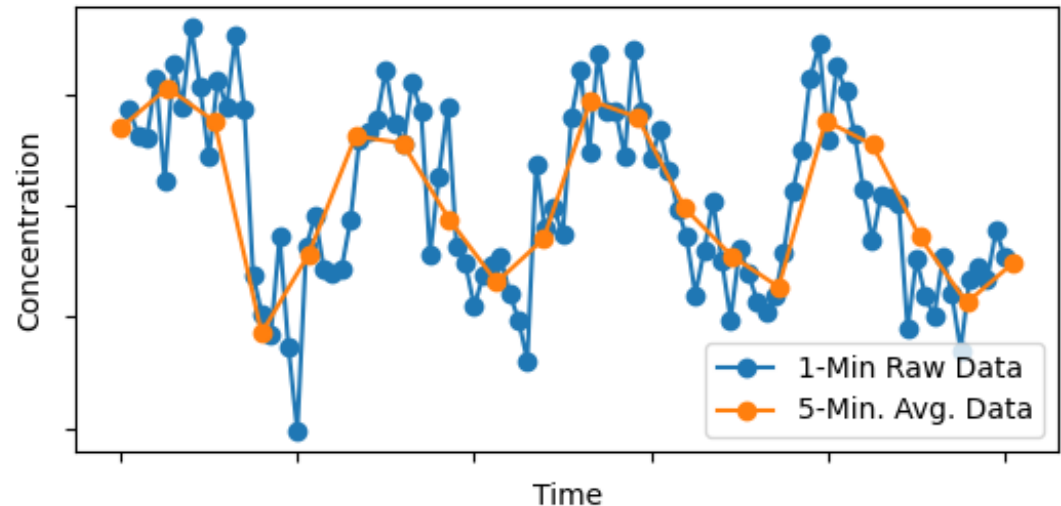 - *Visual check or correlation statistic*

| LCS | LCS |
| LCS | LCS |

US EPA PM2.5 AQI

One Day Average

PurpleAir.com

25.7

- - Average — Cherokee St A — Cherokee St B

PurpleAir.com

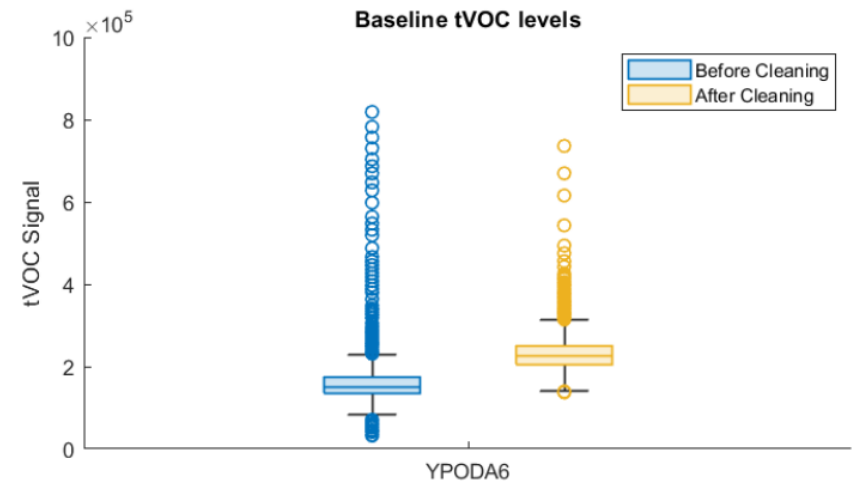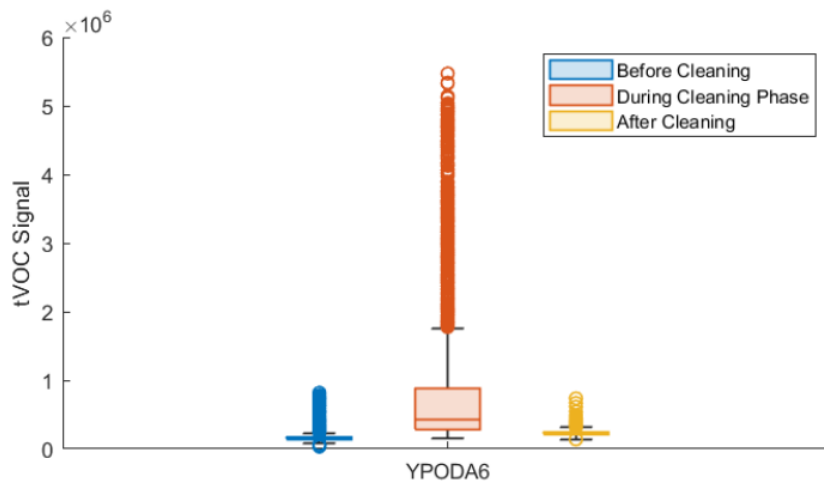# Resource-limited quality assurance
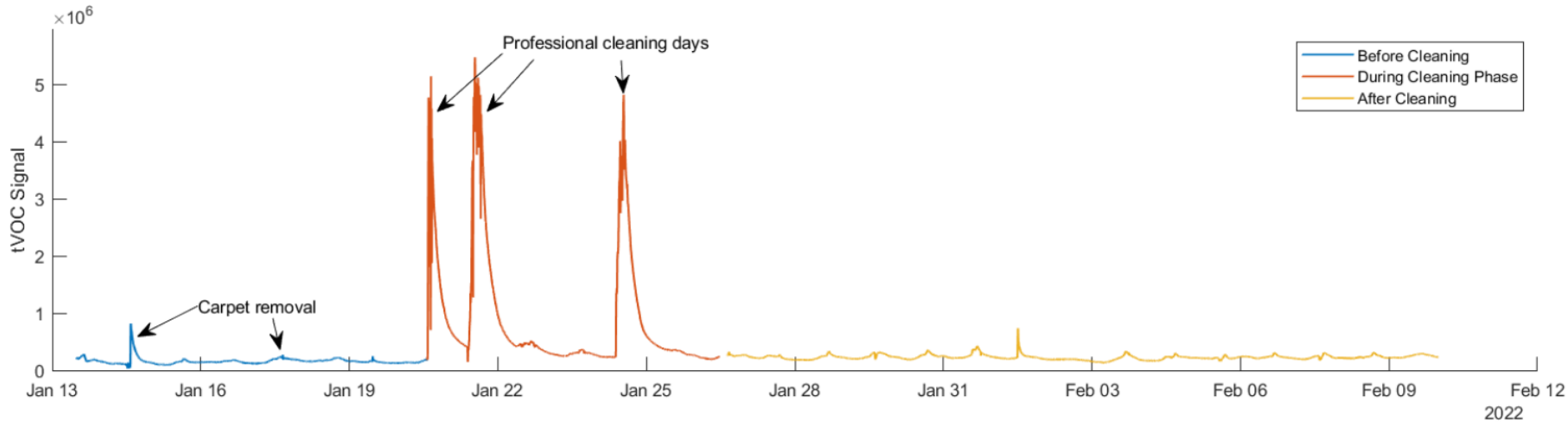## 1. Data quality check #3

"Step 1" Colocation

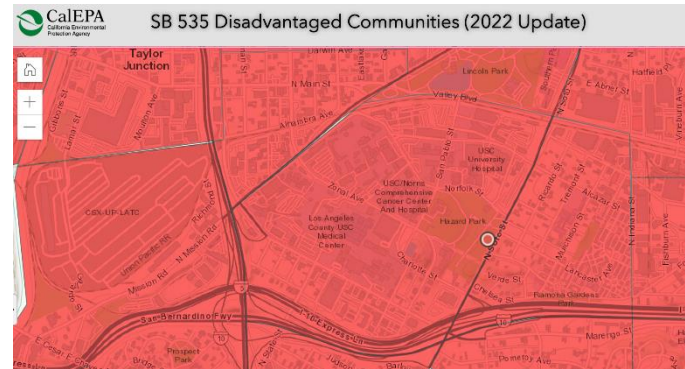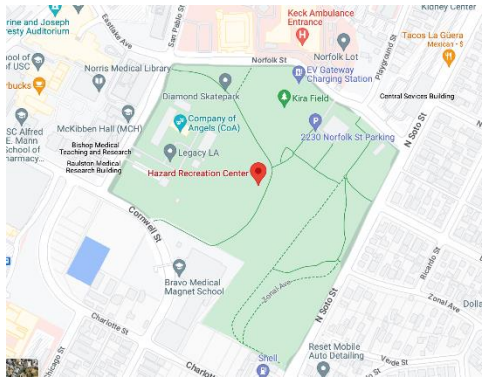• Is the data noisy or changing too

quickly to be realistic?

Resource-limited quality assurance
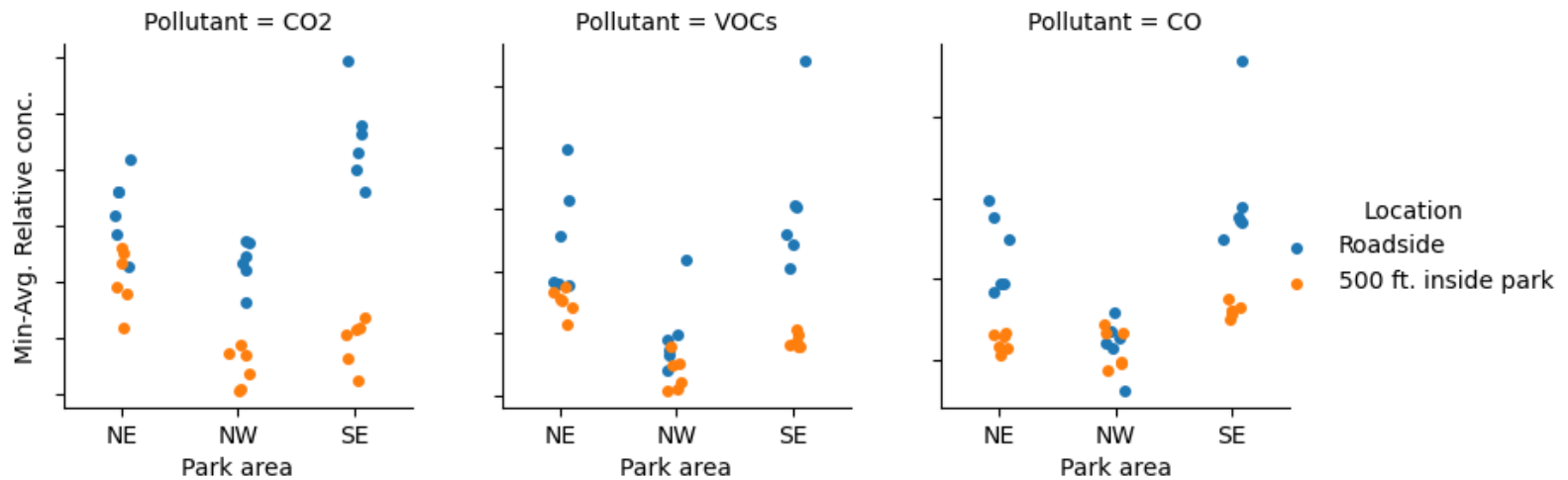## 2. Context documentation (ex. 1)

Resource-limited quality assurance
2. Context documentation (ex. 2)

A measure of cumulative impacts faced by a community

Comparison

Resource-intensive quality assurance

- Pros: Concentrations and species information possible, better for health impacts screening

- Cons: Requires access to reference instrument and ability to run complex normalization algorithms

Resource-limited quality assurance

- Pros: Does not require access to expensive instruments or complex algorithms, great for relative comparisons

- Cons: Does not provide concentrations, so data cannot be compared to health guidance values. Data also cannot be compared to different sensor types

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Low-cost VOC sensors can provide insightful data across a range of applications and resource levels.

Quality assurance plans should be adjusted accordingly.

Thank you!

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colorado.edu/lab/hannigan