The Deployment of Low-Cost Dust Monitors in a Surface Mineral Processing Facility

Cody Wolfe

MINERALS COUNCIL
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Biography

Dr. Cody Wolfe is a data scientist working for the Pittsburgh Mining Research Division, of the National Institute for Occupational Safety and Health (NIOSH), in Pittsburgh Pennsylvania. Dr. Wolfe completed his Ph.D. in Environmental and Occupational Health in 2020 from the University of Pittsburgh and joined NIOSH shortly after graduating.

Dr. Wolfe's research at NIOSH primarily focuses on monitoring and predicting airborne levels of occupational aerosols present in the mining environment, specifically dust, silica, and elongated mineral particles. Dr. Wolfe's research involves the development and application of machine learning algorithms that can predict, in near real-time, air quality conditions based on historical data.

Dr. Wolfe is interested in visual storytelling and how to use high-dimensionality data to represent current data conditions accurately and efficiently to an audience with limited previous exposure to these types of data.

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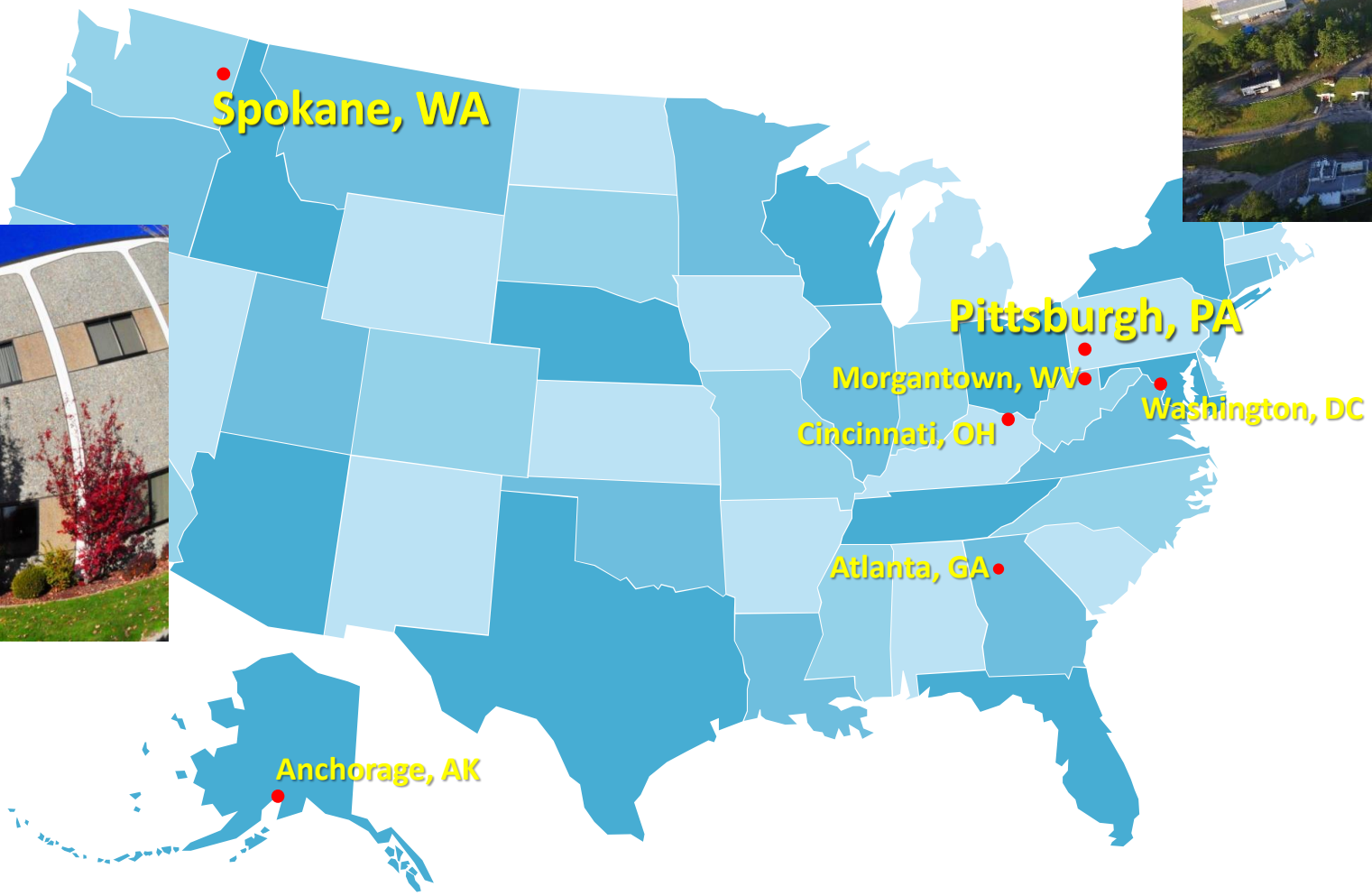
Most NIOSH Mining research comes from divisions based in Spokane, WA and Pittsburgh, PA



The NIOSH Mining Program has three strategic goals…

1. Reduce mine workers' risk of **occupational illness**

2. Reduce mine workers' risk of **traumatic injuries and fatalities**

3. Reduce the risk of **mine disasters** and **improve survivability** of mine workers

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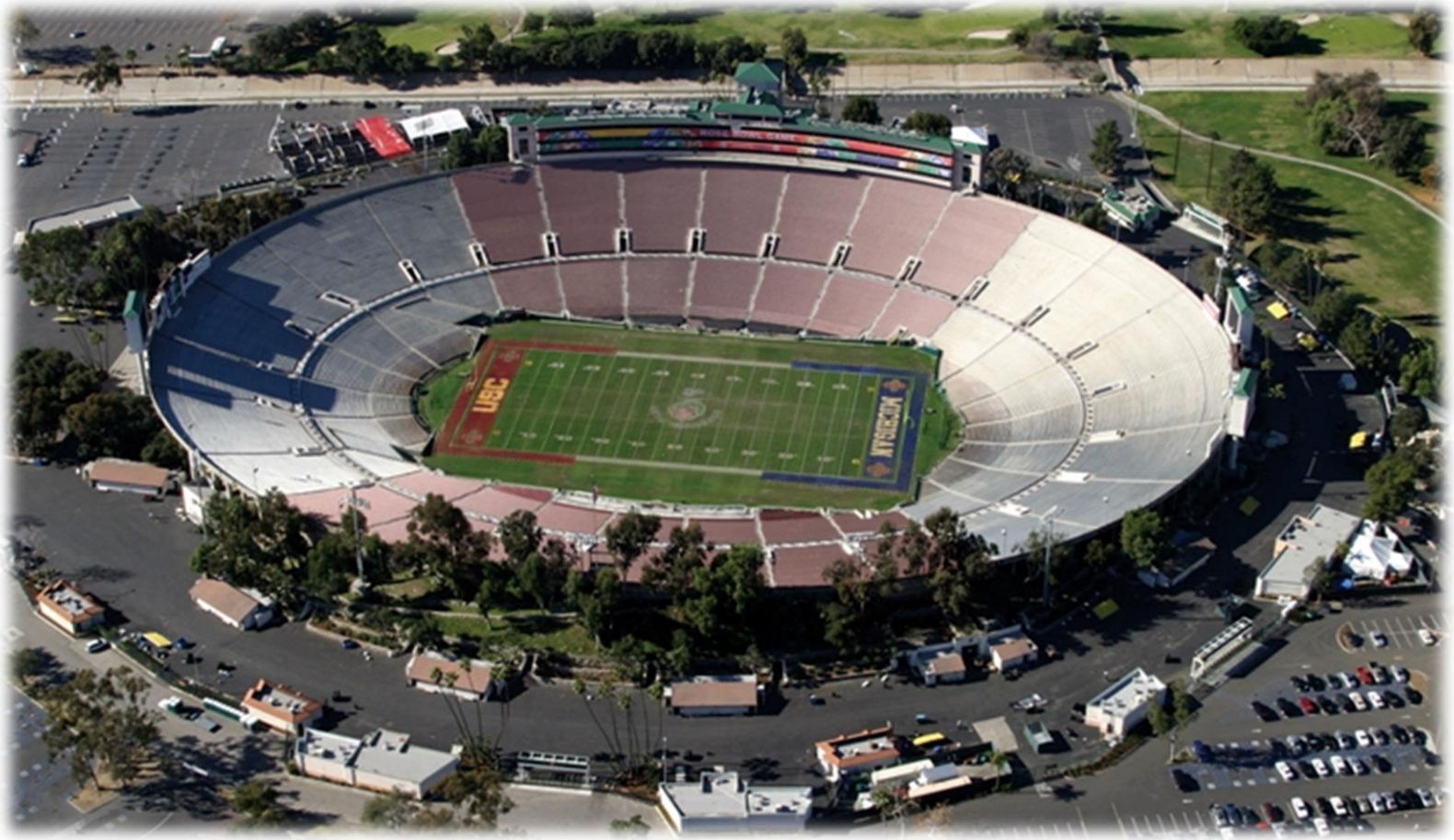
Respirable Crystalline Silica Dust Standards…

- **MSHA: PEL (mg/m3) for respirable dust = 50 µg/m^3**
- **NIOSH: Recommended Exposure Limit (REL): 50 µg/m^3**
- **Department of Labor – OSHA rule entitled "Occupational Exposure to Respirable Crystalline Silica" went into effect on June 23, 2016. Various enforcement dates:**
  - **Construction industry: June 23, 2017 (29 CFR Section 1926.1153(k)),**
  - **General and maritime industries: June 23, 2018 (29 CFR Section 1910.1153(l)(3)(i)).**
  - **Exceptions hydraulic fracturing operations within the oil and gas industry: June 23, 2020 (29 CFR Section 1910.153(l)(4))**
  - **Enforcement of engineering controls: June 23, 2021 (29 CFR Section 1910.1153(l)(3)(ii)).**

MSHA Silica Standard: at the old limit of 0.1 mg/m^3 or 100 µg/m^3

The nature of the problem…



Evenly distribute 5.6 grams respirable silica dust in the air volume of the Rose Bowl stadium would cause a worker breathing this air over 8 hours to be over-exposed

Mining fundamentally turns large rocks into small rocks

This creates dust (not quartz)

Dust may contain quartz


We can’t control quartz, but we can control dust that’s why we monitor dust.
NIOSH Mining Program

Emerging Respirable Dust Sensing and Control for M/NM Mining

Objectives

Low-Cost Dust Sensors

To determine the suitability of low-cost dust sensors for continual monitoring applications in the mining industry.

1. Lab testing

2. Field testing

FAST

Field Analysis of Silica Toolkit, brief overview and future directions.

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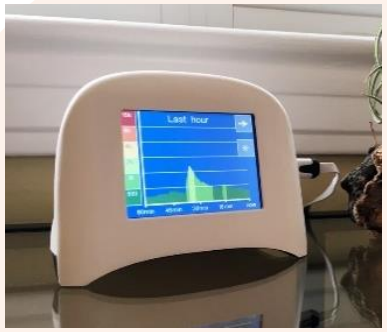
Area & Personal Dust Monitors Exist but are Cost-Prohibitive for More than a Few Areas or Units

What are low-cost pollution monitors?

(TSI) BlueSky™ Air Quality Monitor

Applied Particle Technology

IQAir



Dylos

Strong Aerosol Science background

(Quant-AQ)ModulAIR-PM

(SGS Galson)SMARTSense

Awair

Aircasting

Originally communities monitors

Integration with other sensors (gas/vapor)

Instruments Under Test in Lab Environment

1. Lab testing…

Not low cost

$~300 per unit

1

2

3

4

5

6

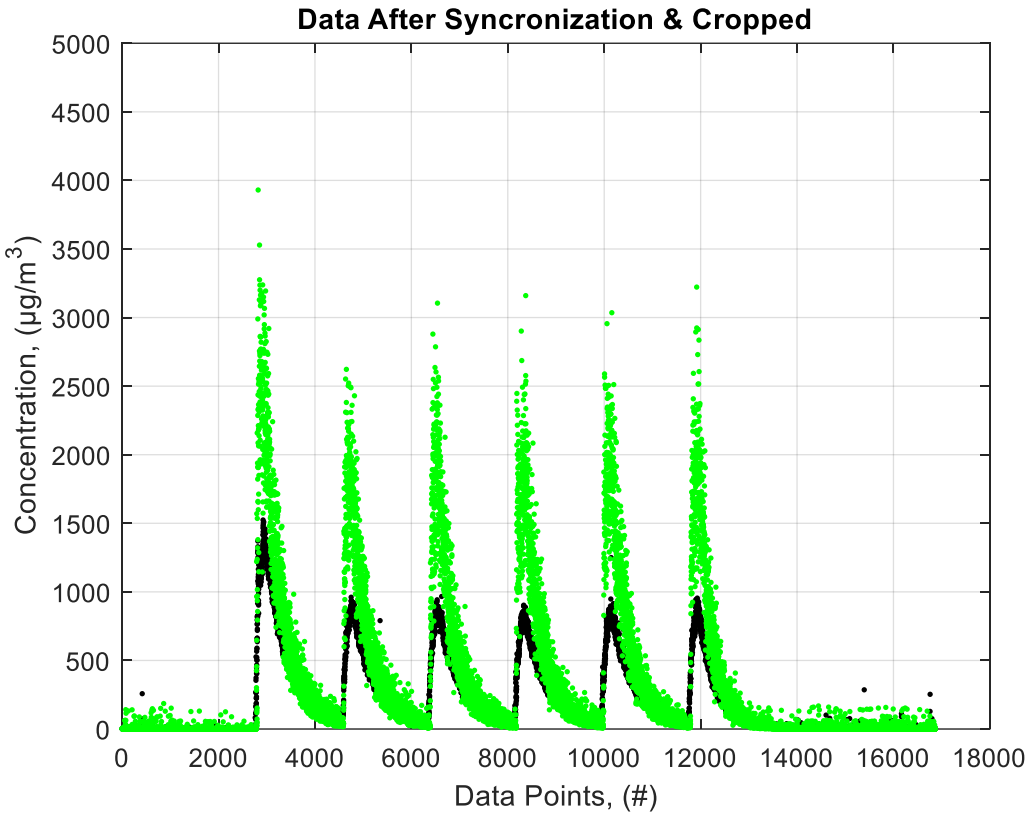
7

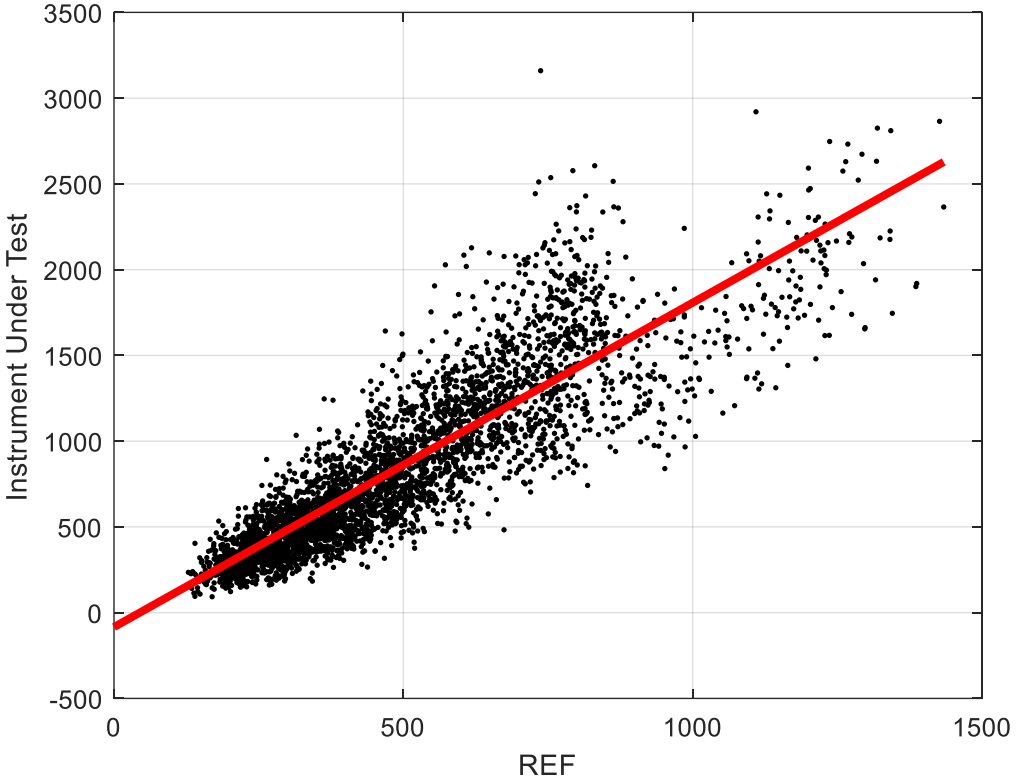
8

9

Lab Testing Compares LCDM to Reference Grade Instruments

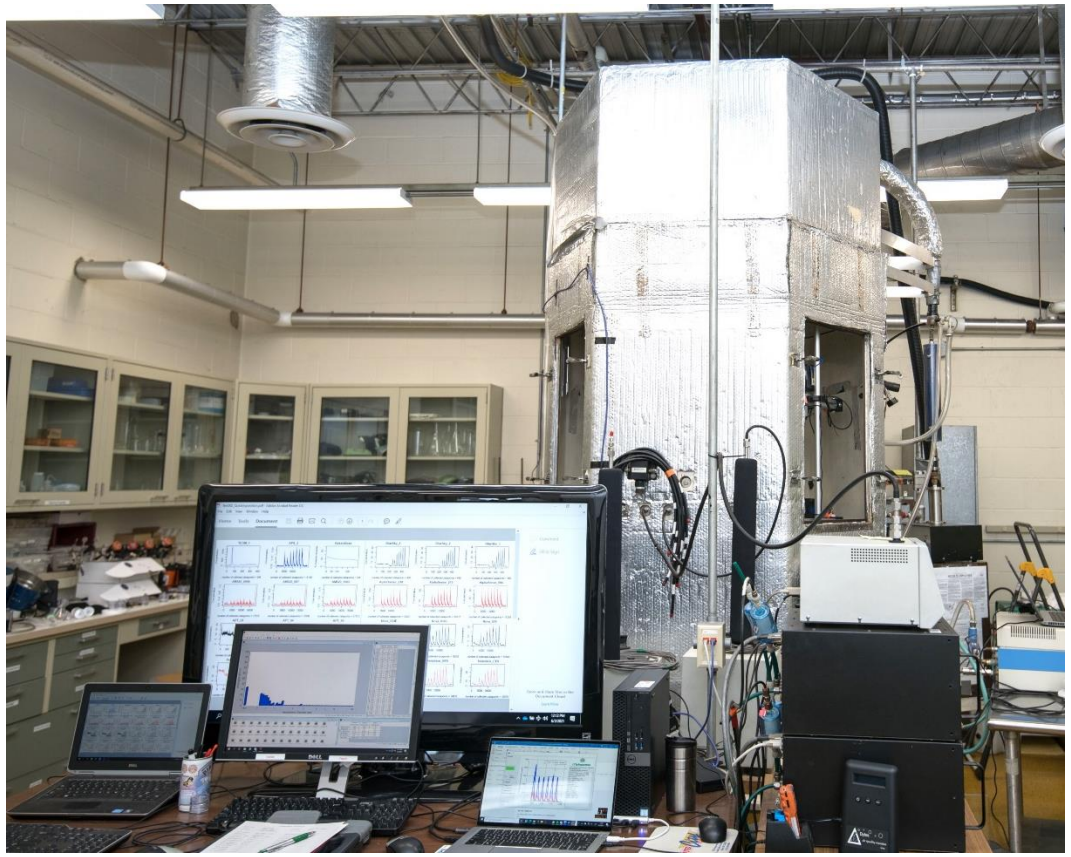
1. Lab testing…

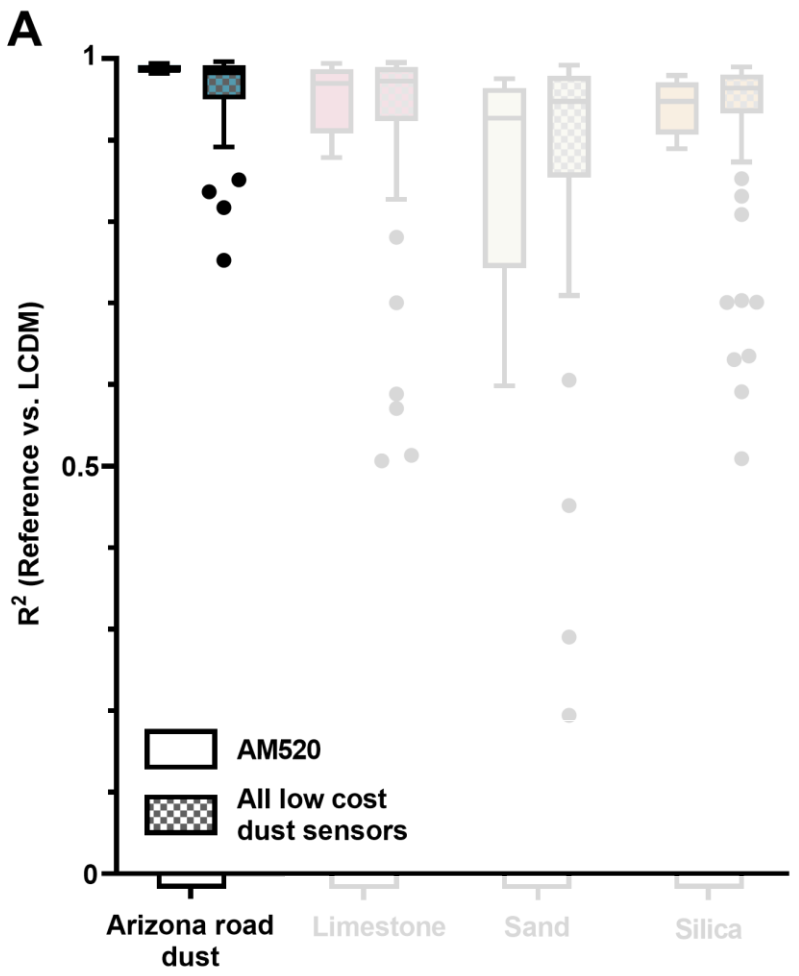


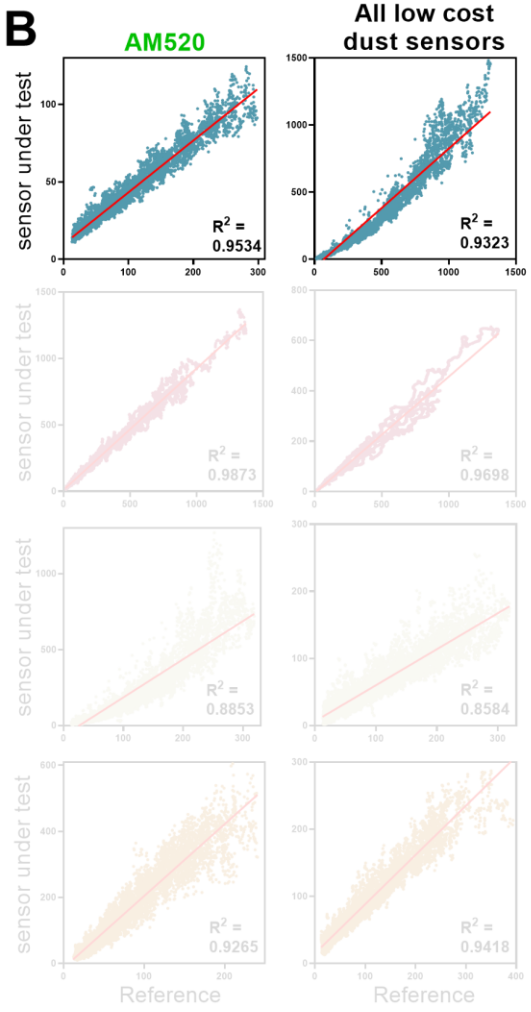


LCDM Laboratory Testing Completed, Performance is Compelling

1. Lab testing…







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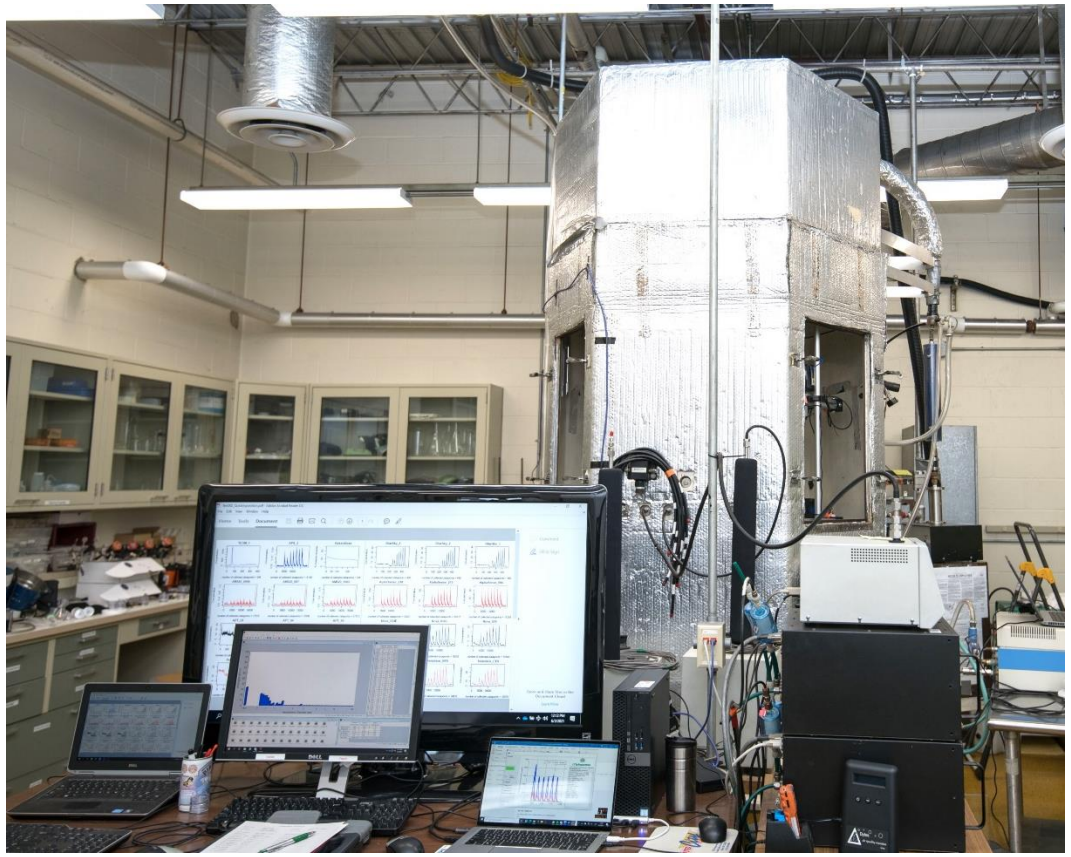
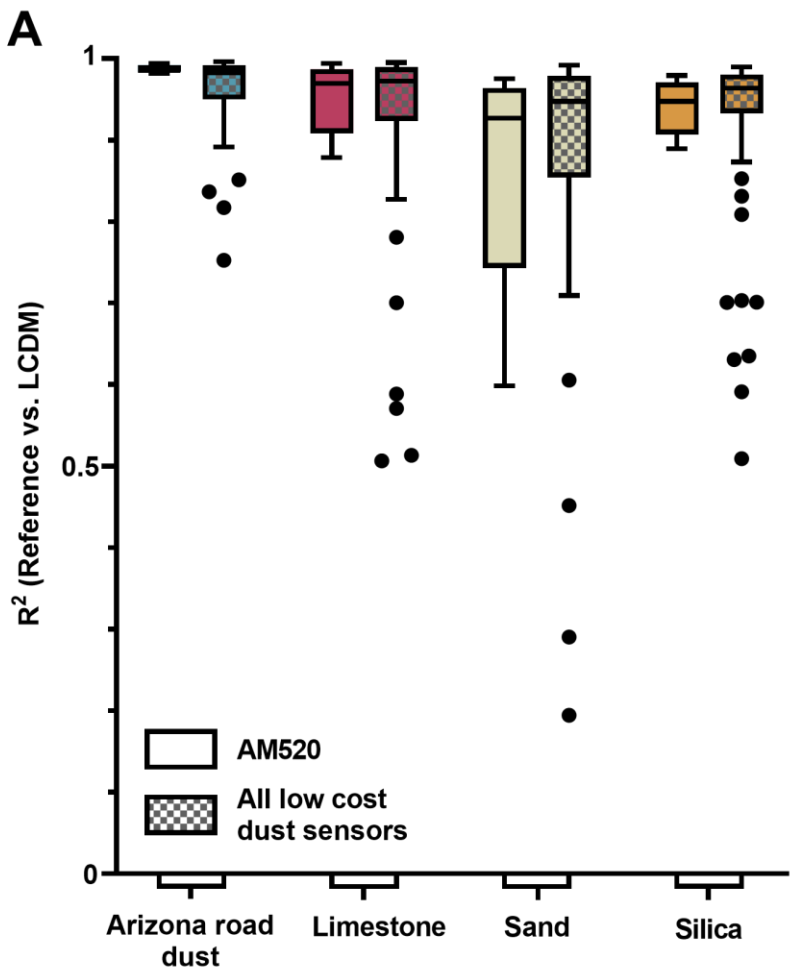
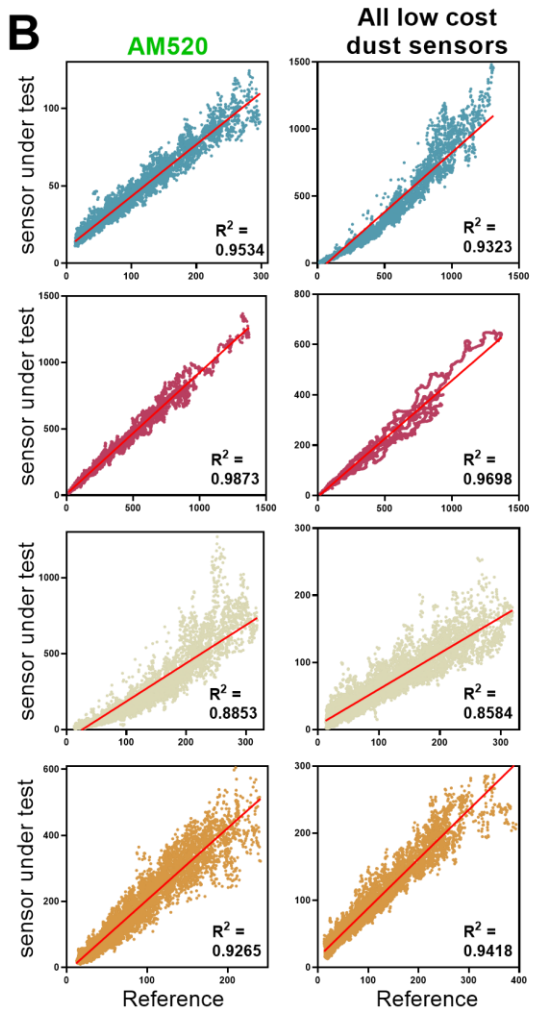
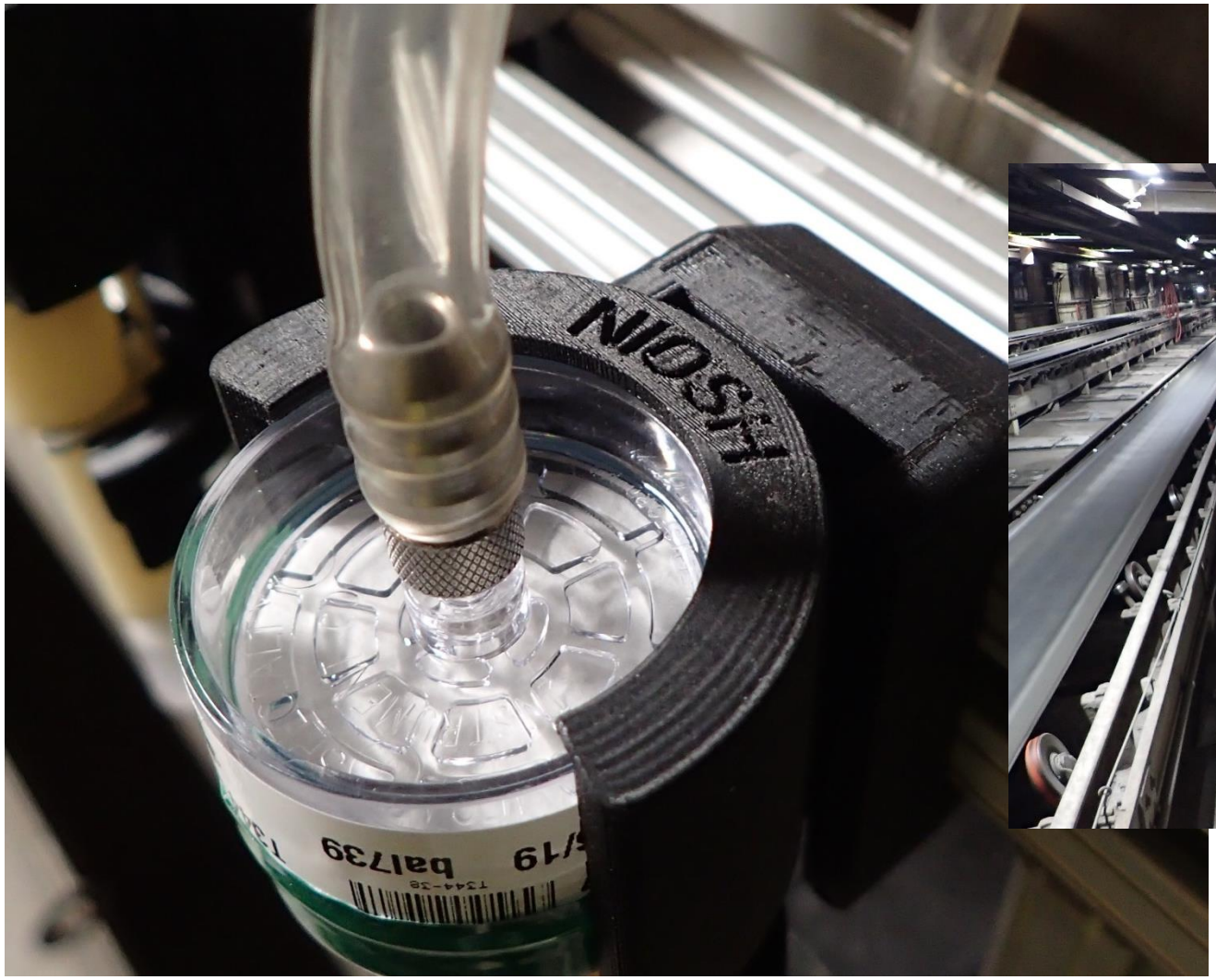






Parallel Gravimetric Sampling to Establish In-Field Calibration

Taking the lab in the field…



Confirmation of deployed interventions

2. Field testing…

We have set up four networks of sensors in the lifetime of this project

Confirmation of deployed interventions

2. Field testing…

How do LCDMs compare to gravimetric sampling?

Do the sensors drift over time?

How many gravimetric samples are needed to create a correction factor?

Confirmation of deployed interventions

2. Field testing…

How do LCDMs compare to gravimetric sampling?

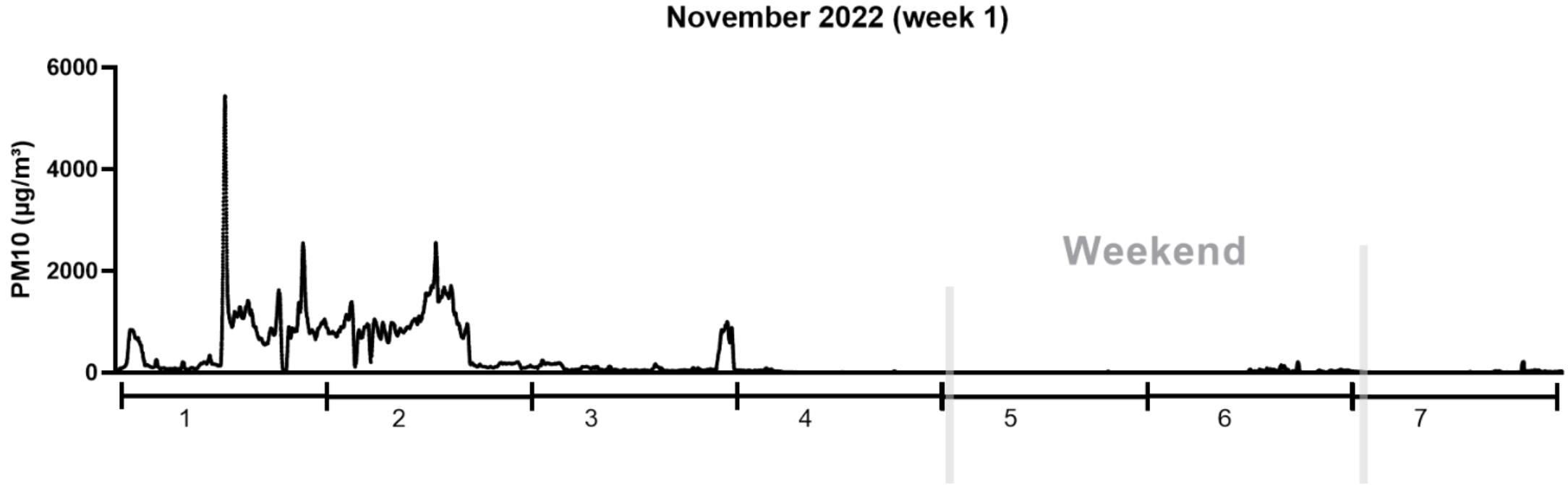
Do the sensors drift over time?

How many gravimetric samples are needed to create a correction factor?

About 15-18 samples

Confirmation of deployed interventions

2. Field testing…



What have we found?

A single monitor (node) located in a strategic location of the indoor workplace will generate a tremendous amount of data in a relatively short period of time.

Confirmation of deployed interventions

2. Field testing…

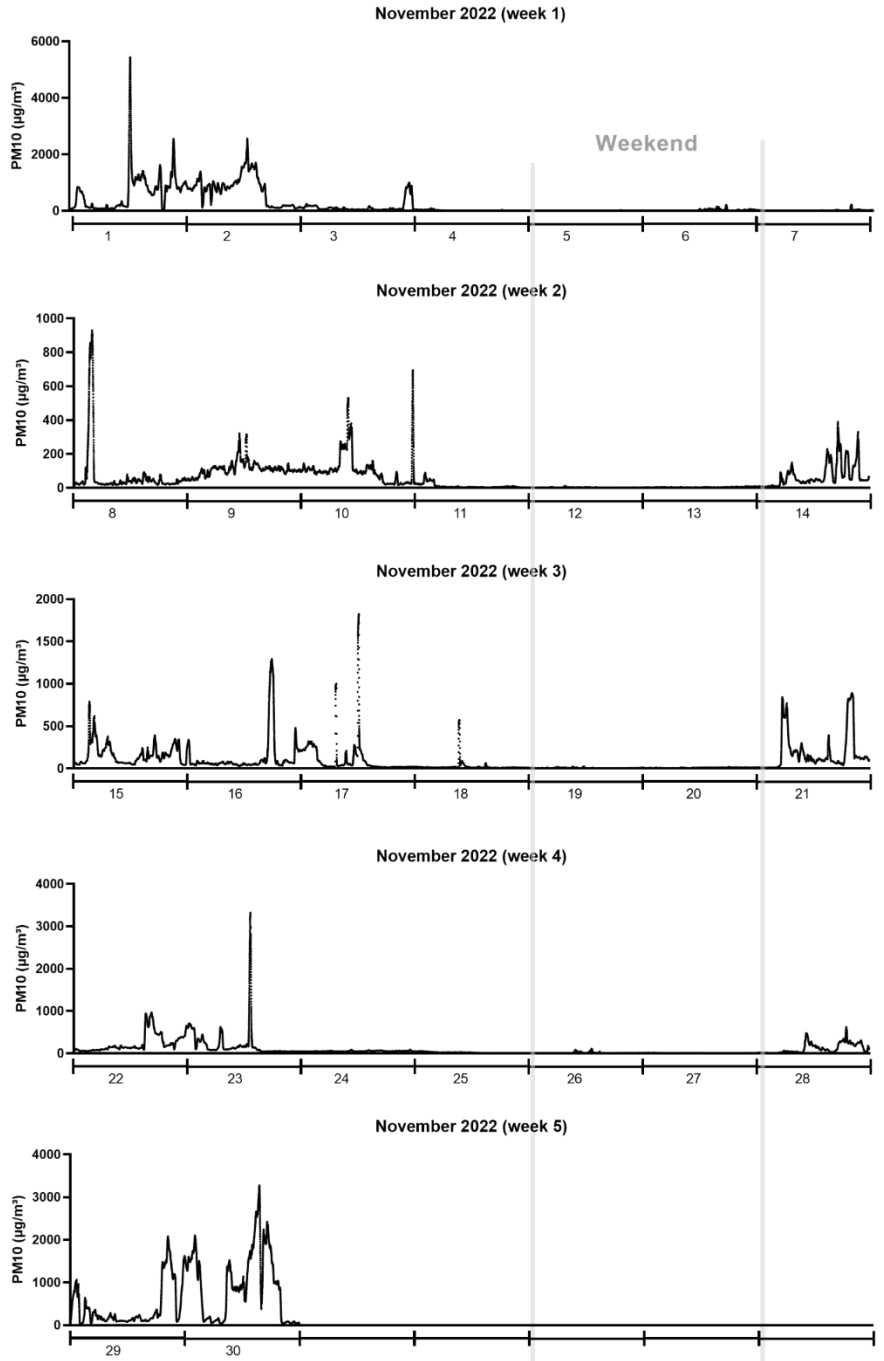
Is the workplace environment [aerosol concentration] kept at levels that are considered optimal (safe)?

More importantly can the OSH professional quickly answer this question by just observing the data plotted?

Not always

The data needs to be presented in a more digestible format and in correlation with some form of production data.

- what screens were running
- what product was being milled
- when was the last maintenance
- what shift was working
- what were the weather conditions outside



Confirmation of deployed interventions

2. Field testing…

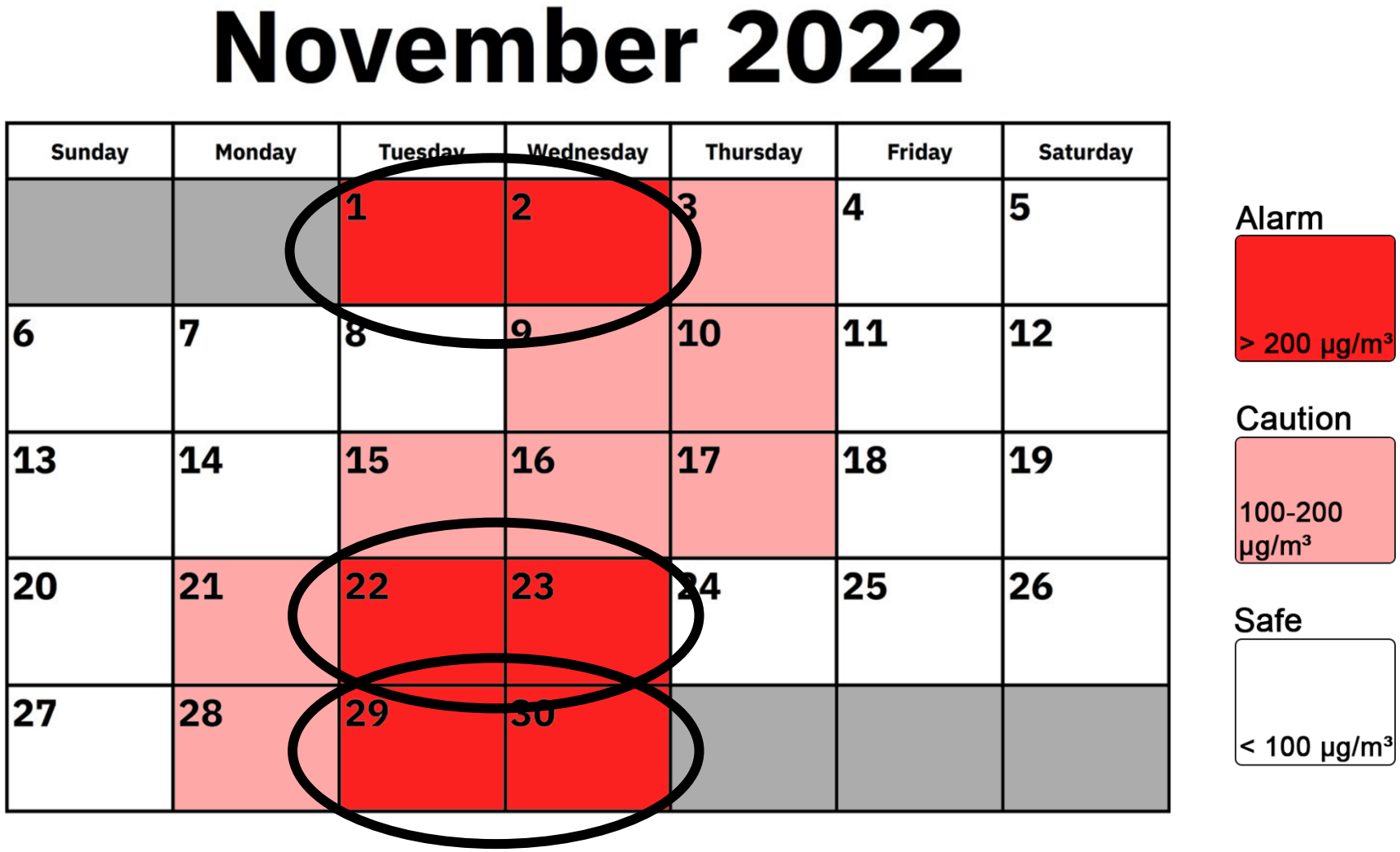
Optimal level (safe) – If the level is optimal there is no action to be taken.
Caution level – Conditions are getting worse? Should we be worried?
Alarm level – Conditions are not optimal (safe). What is the plan of action?

How do we define the levels?

- Are there established PEL, REL, TLV (TWA) limits?
- How many hours does a worker(s) spend in that micro environment ?
- What is the buffer between safe-caution-alarm? Do we need more than 3 levels?
- What are the actions for caution levels and alarm levels?
  - When are we planning to act?
- What is the relationship in the environment between PM10 and respirable dust and silica?

Confirmation of deployed interventions

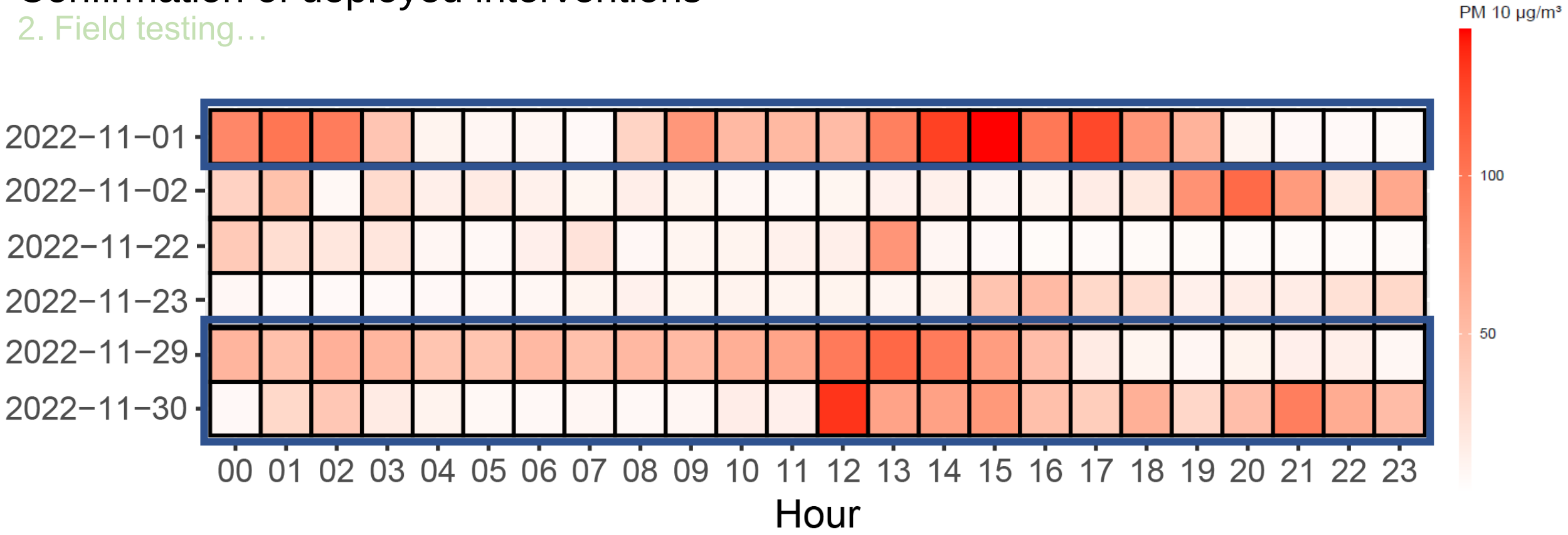
2. Field testing…



Proper use of (processed) data visualization can help answering the question

Confirmation of deployed interventions

2. Field testing…



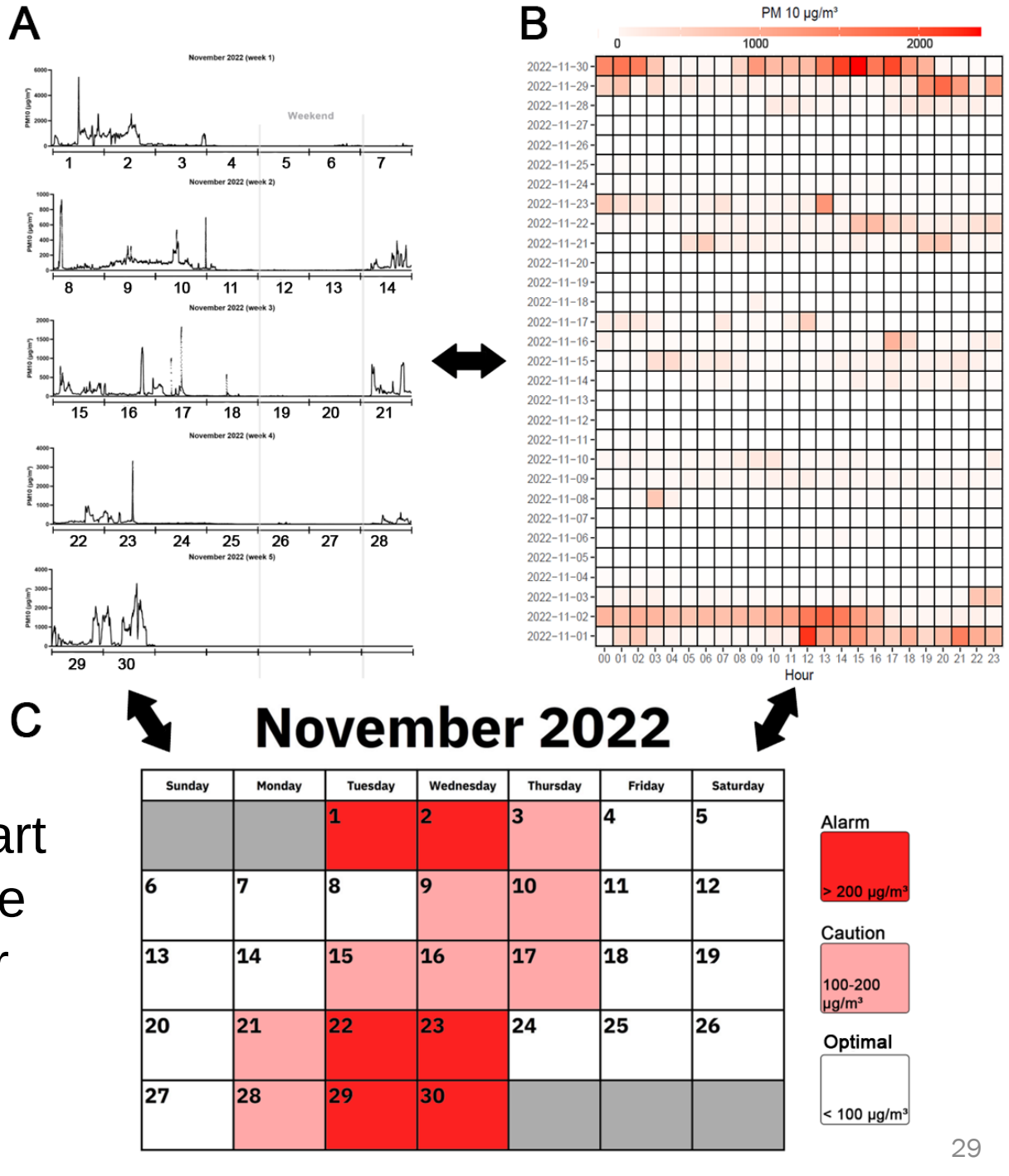
- Drilling through the sensor data for the “non-optimal” days can provide insight. Not every day is the same.

- Contextual information is essential to understand the causes and fix them. Production data, process data, plant data

Confirmation of deployed interventions

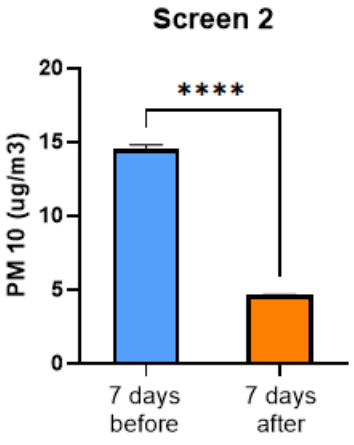
2. Field testing…

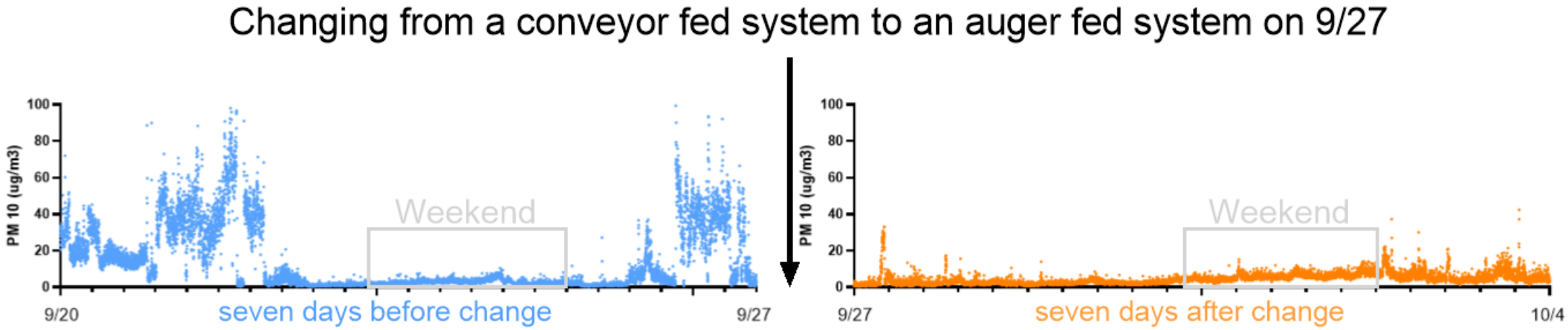
- This workflow led to the creation of periodic reports for each sensor.
- We send out weekly reports that show the last seven days, and at the end of each month we send a monthly report like the one shown here.
- At this mine, they use the reports as a part of their weekly IH meetings to discuss the dust levels at their operation and plan for future dust mitigation strategies.



Confirmation of deployed interventions

2. Field testing…





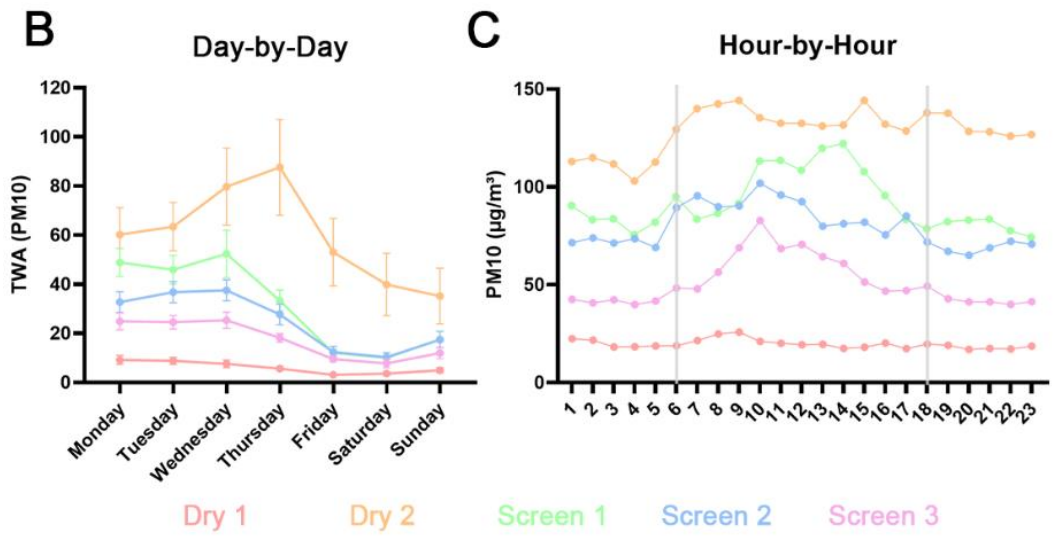
- Anecdotal evidence can now be backed up by data.
- The manufacturer saw a 300% reduction in airborne particulate levels in the week following a change from a belt-driven feed system to an auger feed system.

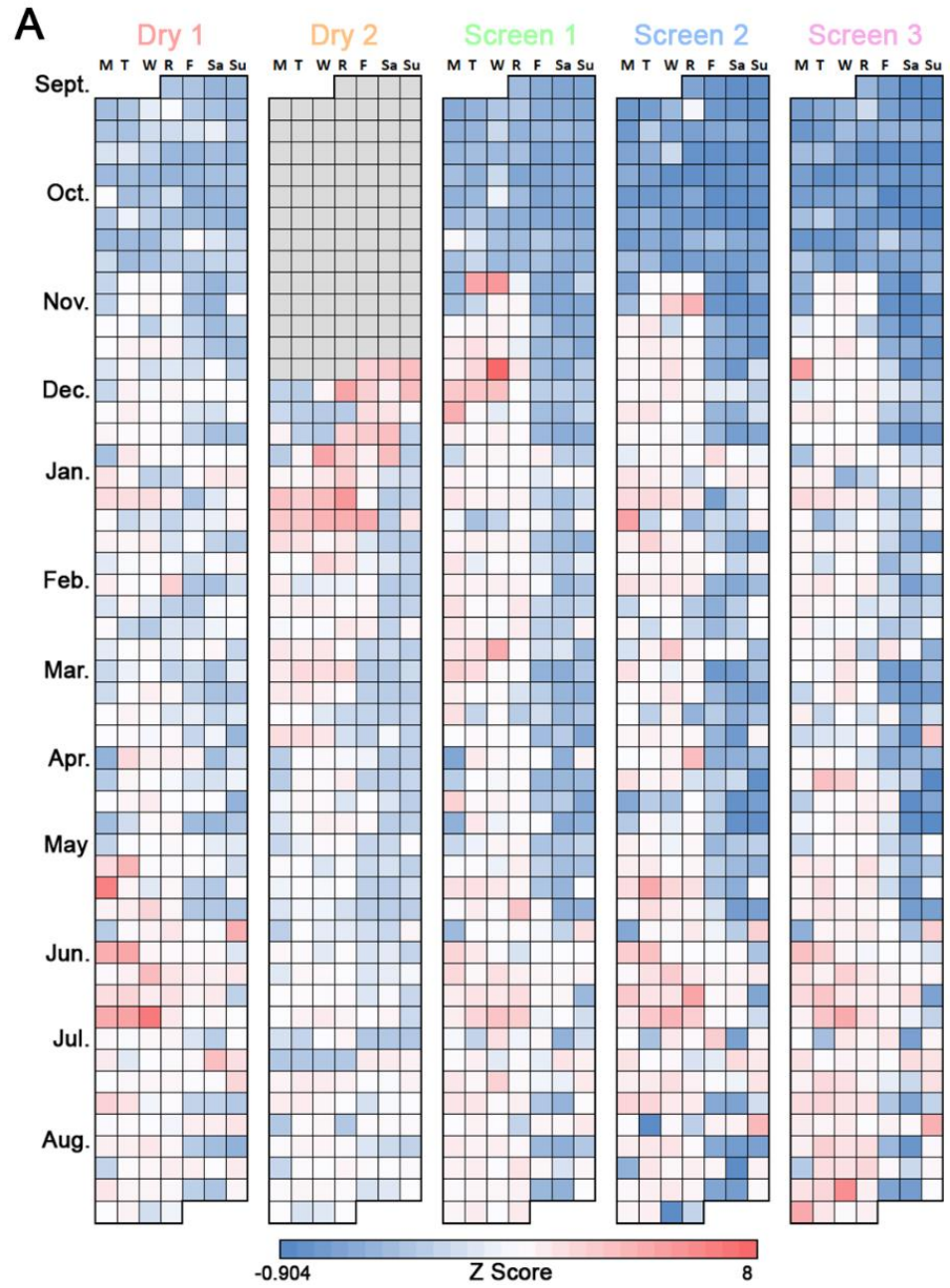
Confirmation of deployed interventions

2. Field testing…

This type of data can also give clarity to longer-term trends
Here is 1-year of data visualized in one figure

Looking at the data this way comparisons between sensors can be done, between months of the year, between days of the week, or hours in a day.





Z-score = (x-μ)/σ, x = PM10 value being evaluated
μ = sensor mean, σ = sensor standard deviation

Emerging Respirable Dust Sensing and Control for M/NM Mining

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To determine the suitability of low-cost dust sensors for continual monitoring applications in the mining industry.

1. Lab testing

   Low cost monitors can compete with and even out-perform some higher cost monitors in a lab setting

2. Field testing

   Networks of LCDMs can provide huge amounts of data which when applied correctly can help empower OSH professionals to enact change where its most needed

FAST

Field Analysis of Silica Toolkit, brief overv
future directions.

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Field Analysis of Silica Toolkit:

A brief overview and future directions

Collect samples using gravimetric dust samplers

Analyze samples with a portable FTIR unit

Process the FTIR data with NIOSH FAST software

(optional) Verify field analysis with laboratory tests

FAST
Field Analysis of Silica Tool

Respirable Dust/Silica: Real-Time Monitoring

A Case Study on Using Low-Cost Dust Monitors for Enhanced Data Collection and Analysis

Mine Dust Conference
Johannesburg, South Africa
June 21, 2024

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Advancing Exposure Monitoring for Airborne Particulates in Mining

NIOSH Mining Program