U.S. EPA STAR Grant

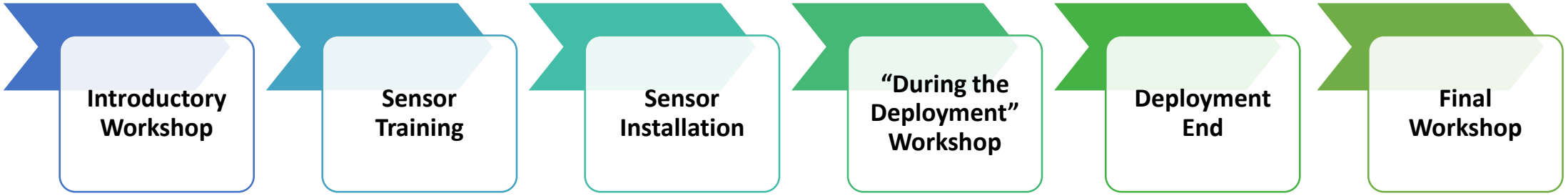
Engage, Educate and Empower California Communities
on the Use and Applications of Low-cost Air Monitoring Sensors

Post-Deployment Workshop

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

(Conducted January 2020 – September 2020)

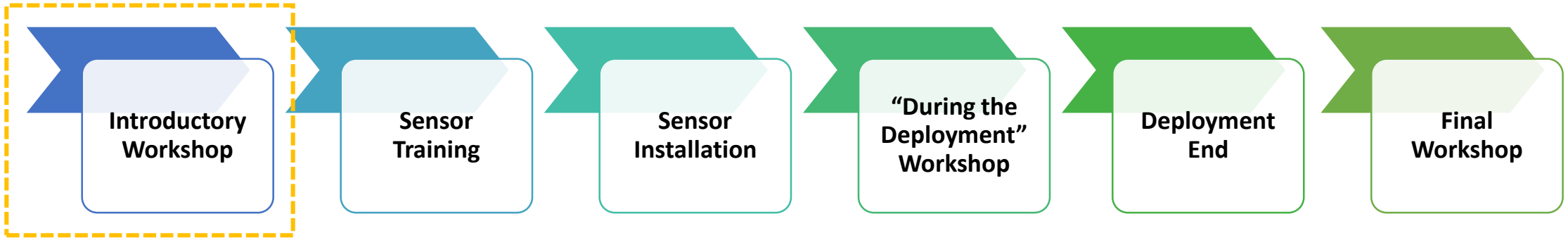
STAR Grant Project Timeline



A partnership was initiated with the communities

- Providing each community with low-cost sensors and the opportunity to learn more about their local air quality
- And providing South Coast AQMD and STAR grant partners with the opportunity to learn more about the use of these tools

STAR Grant Project Timeline



Main Objective: *Provide communities across California with the knowledge necessary to <u>appropriately</u> select, use, and maintain "low-cost" sensors and to correctly interpret the collected data*

Our Approach

Aim 1: Develop new methods to engage, educate, and empower local communities on the use and applications of "low-cost" sensors

Recruit local communities to help inform toolkit materials through in-person meetings as well as survey on their knowledge and perception of sensors

Draft guidebook, training videos, and data collection checklist

Share draft toolkit with community members and survey them regarding sensor use to assess if their interaction and perception of sensors has changed

Revise toolkit materials based on community feedback

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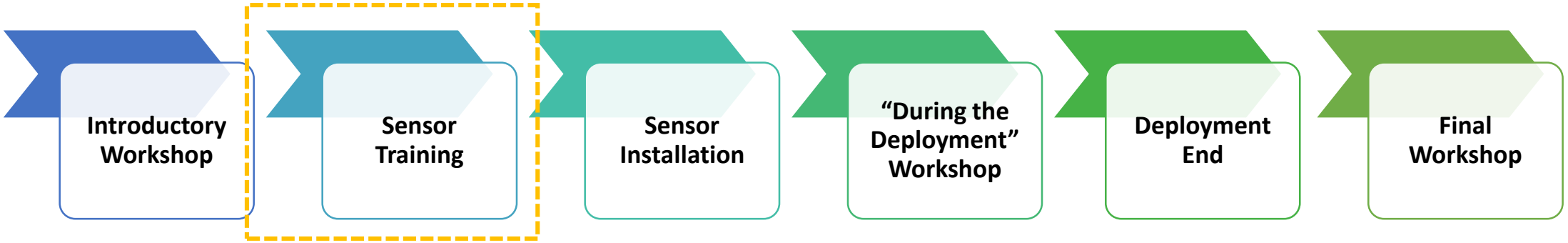
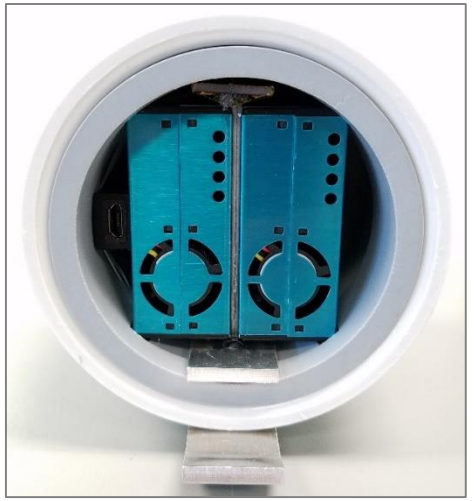


- Sensors selected: PurpleAir PA-II sensors
- Sensors measure: $PM_{1.0}$, $PM_{2.5}$, PM_{10} , temperature, humidity, & pressure
- Selected based on usability, open-access data, and performance



Sensor Testing

Aim 2: Conduct field and laboratory testing to characterize the performance of commercially-available "low-cost" sensors and to identify candidates for field deployment

- Field Testing:
  - Sensor tested in triplicates
  - Two months deployment
  - Comparison with FRM/FEM instruments
  - Testing performed at a fixed monitoring station

- Laboratory Testing:
  - State-of-the-art characterization chamber
  - Particle and gas testing
  - T and RH controlled conditions

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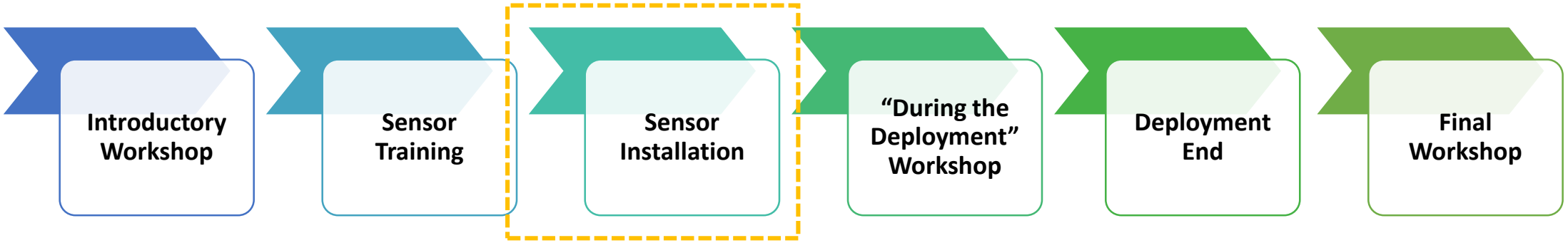
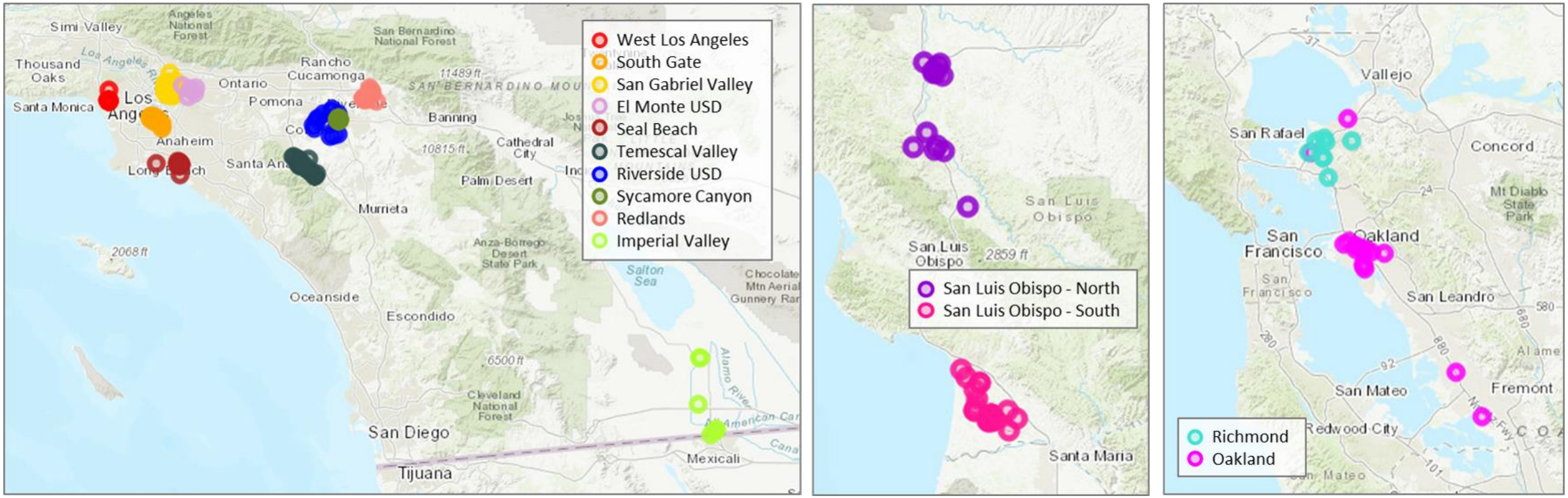


- In order to understand how to support community deployments of sensors, we…
  - Tracked sensor installations
  - Collected survey data on installation or non-installation experiences
  - Collected Log-book surveys on events
  - Collected surveys and feedback during workshops
  - Examined sensor performance

Sensors Distributed to 14 Communities

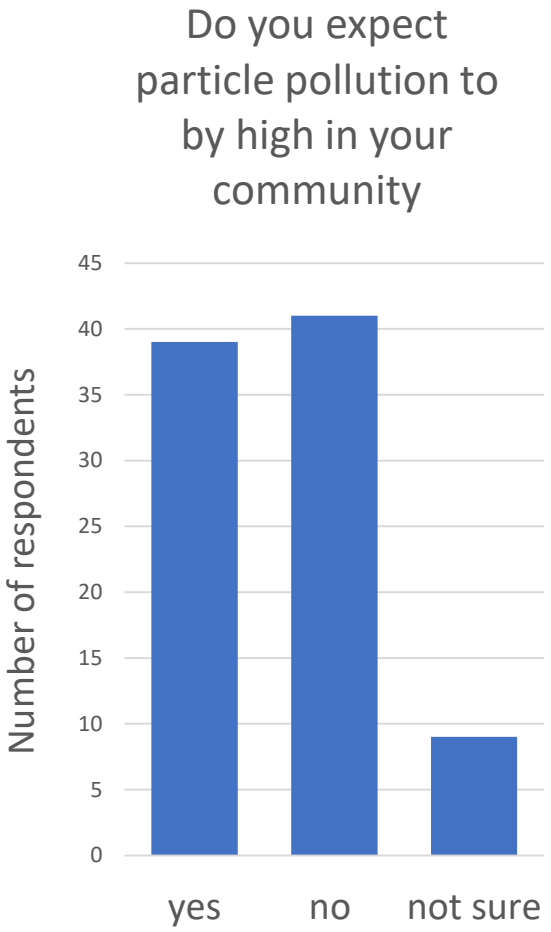
Aim 3: Deploy the selected sensors in multiple California communities and perform a thorough validation and interpretation of the collected data

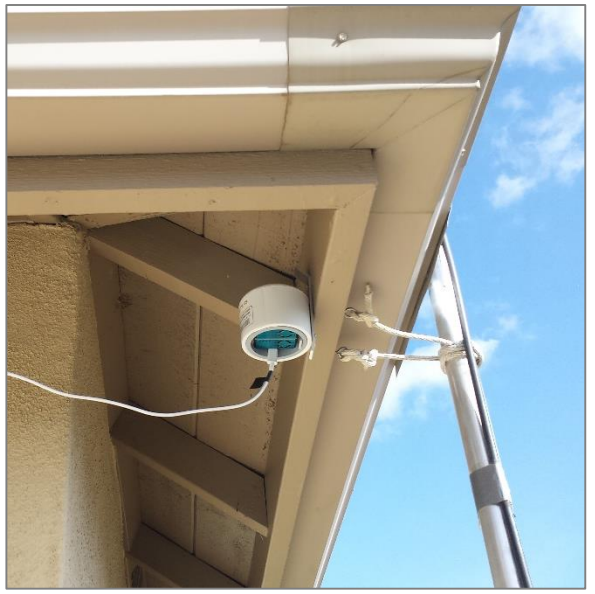


- *Total: ~300 sensors distributed; 286 installed*

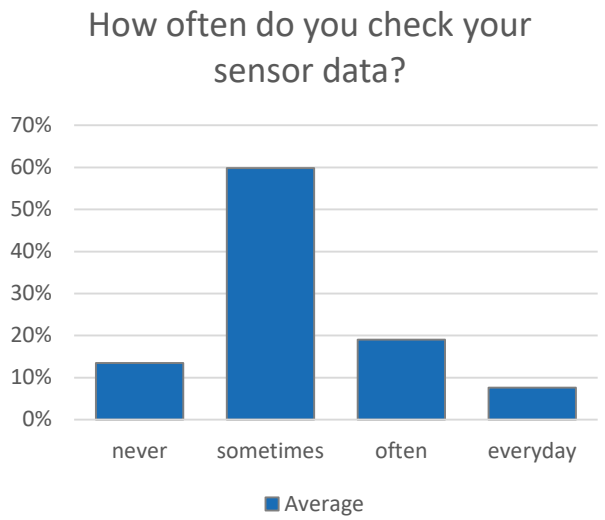
Sensor Installation/Non-Installation e-Survey

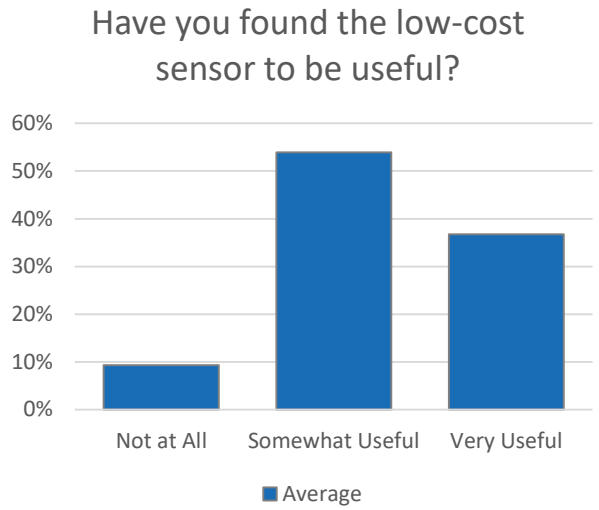
- 81 installation surveys submitted (in total)
- 7 non-installation surveys submitted
- For those who had trouble installing sensors, it was typically related to a variety of issues:
  - Trouble mounting the sensor
  - Trouble powering the sensor
  - Trouble registering the sensor

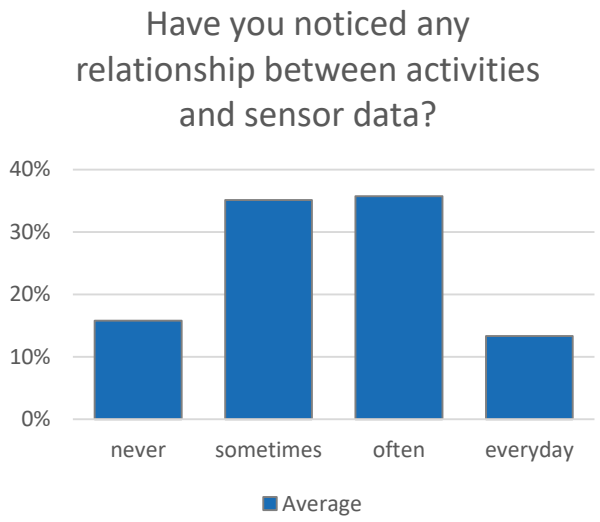




“During-the-Deployment” Questionnaire







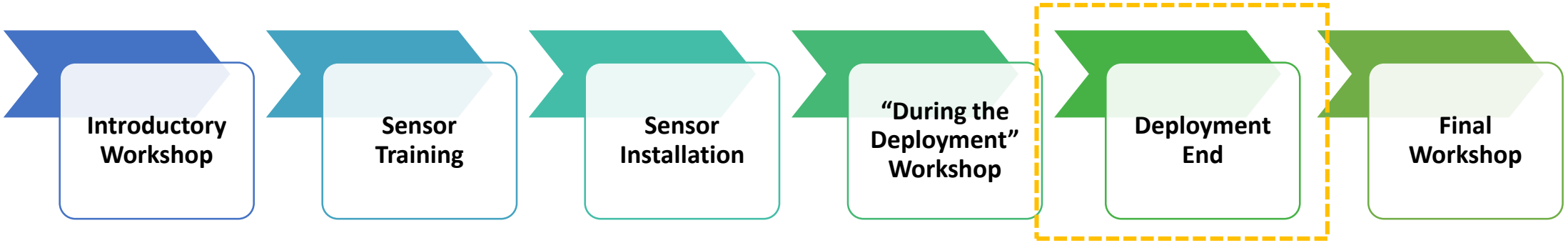
For average across all community responses, n = 64

Community Observations and Analysis

Open Discussion:

- How you would like to use the sensors?
- What additional support is still needed?
- What worked and what did not?
- Can you share an example of a time when you took action based on your low-cost sensor data?
- Observations, interesting events, or challenges?
- New ideas on sensor data analysis?
- Any other feedback?

STAR Grant Project Timeline

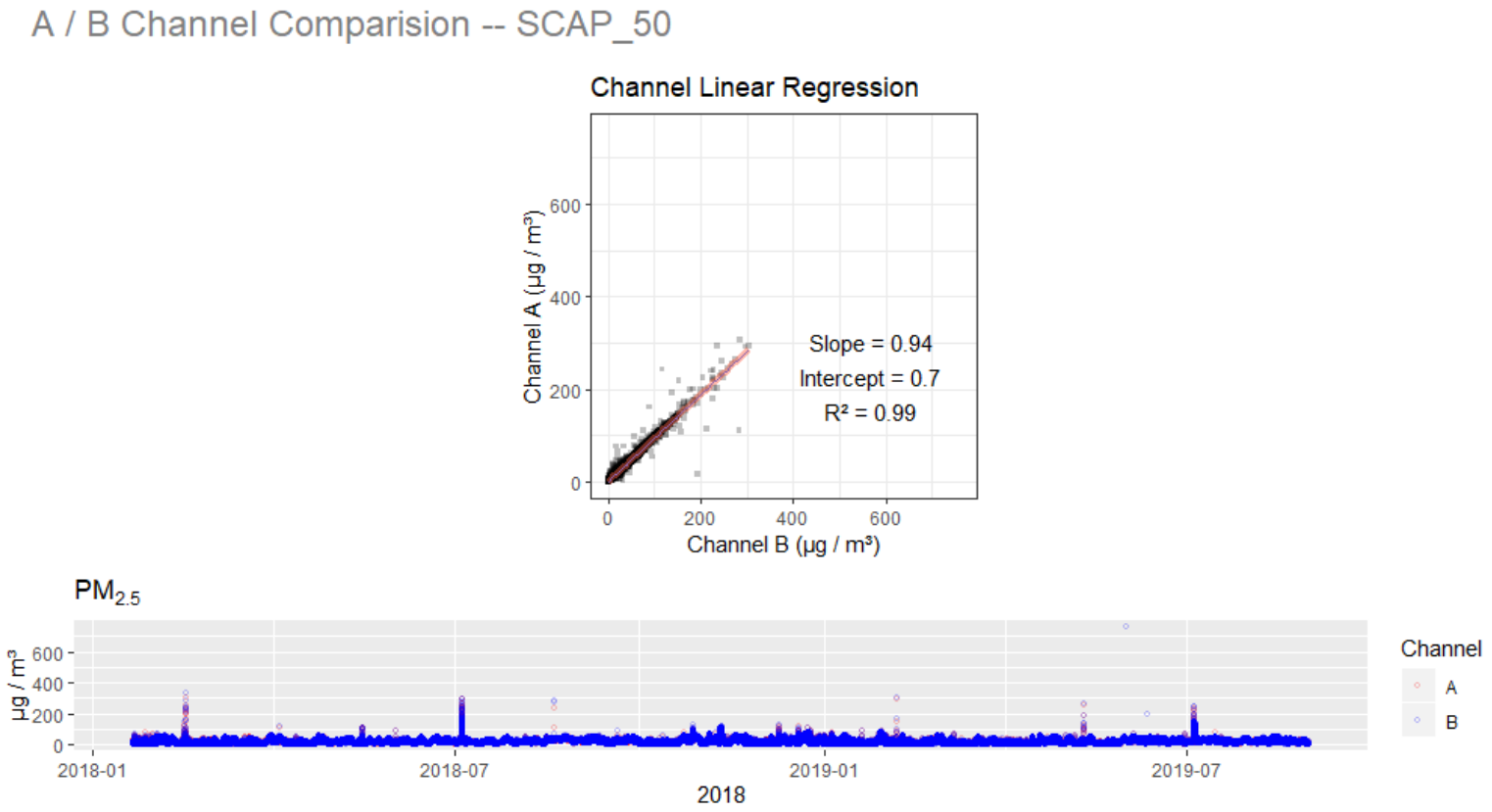


- 14 sensor networks with up to three years of data provides the opportunity to examine the reliability and longevity of sensors
- The following slides illustrate tools from the open-source AirSensor package that we can use to better understand sensor performance

Sensor Network Performance

How we assess performance

- **Data completeness – reliability**
- QA/QC
  - ✓ Is the data within reasonable parameters?
  - ✓ Do channels A and B agree reasonably well?
  - ✓ Is a certain proportion present per hour?
- Compared to the nearest reference site



(the example above shows a sensor providing complete data, where Channels A and B demonstrate high agreement)

Sensor Network Performance

How we assess performance

- Data completeness – reliability
- **QA/QC**
  - ✓ **Is the data within reasonable parameters?**
  - ✓ **Do channels A and B agree reasonably well?**
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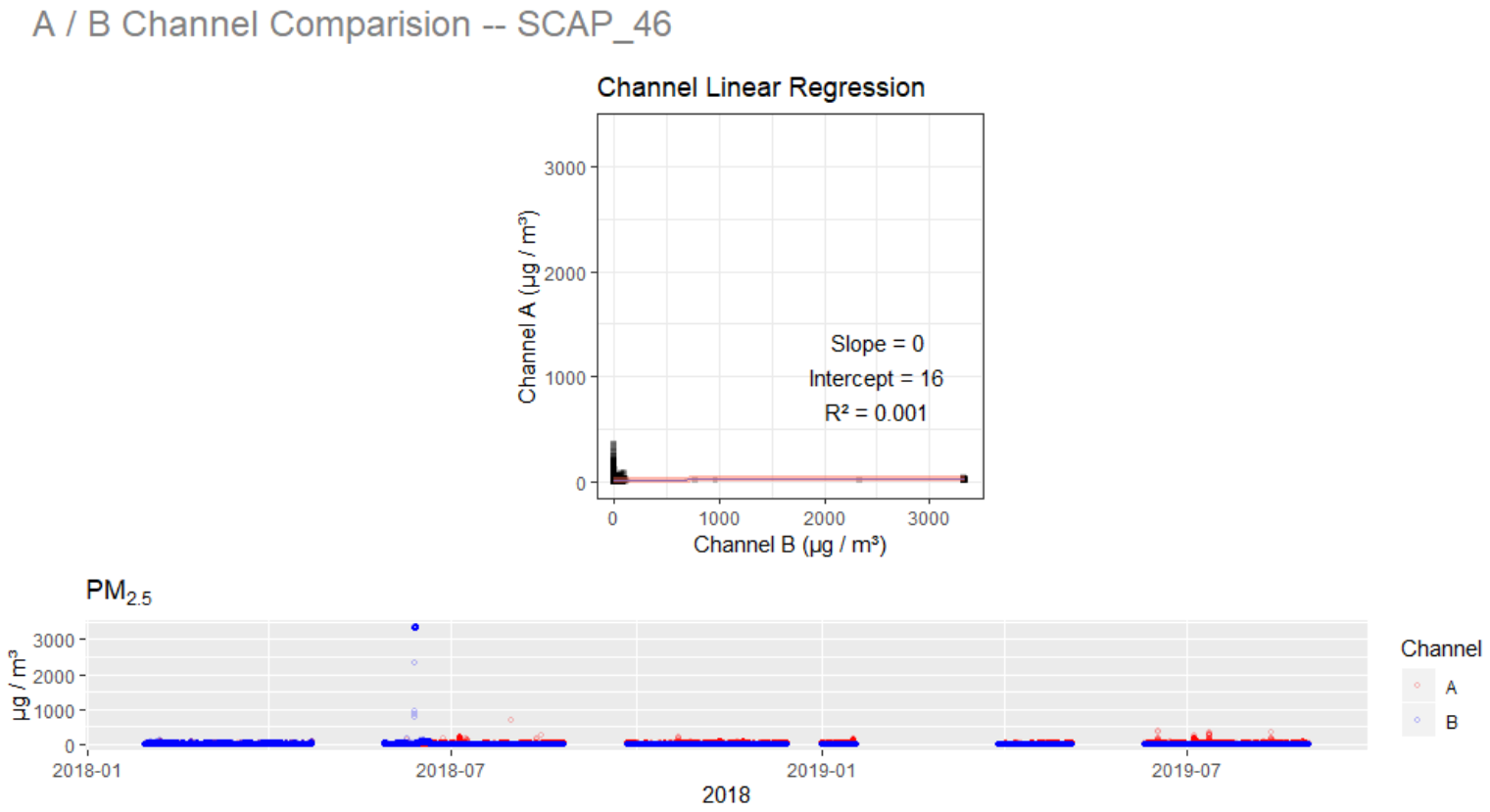
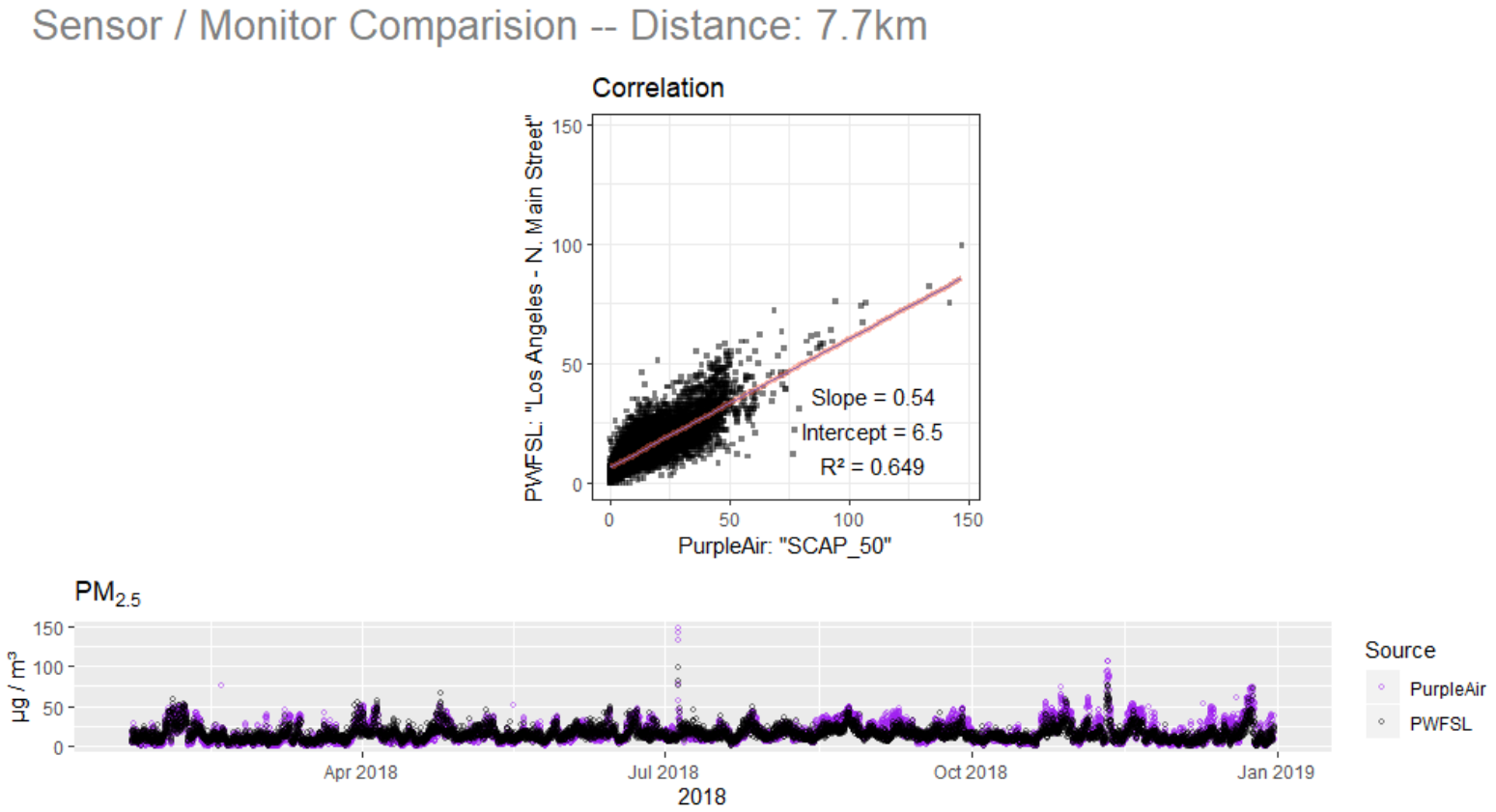


(the example above shows a sensor providing incomplete data, where Channels A and B demonstrate poor agreement)

Sensor Network Performance

How we assess performance

- Data completeness – reliability
- QA/QC
  - ✓ Is the data within reasonable parameters?
  - ✓ Do channels A and B agree reasonably well?
  - ✓ Is a certain proportion present per hour?
- **Compared to the nearest reference site**



(the example above shows how the data compares between a sensor and the nearest reference instrument ~8km away)

Sensor Network Performance

As there is the potential for:

- Up to 36 months of data, or 788,400 data points, from each deployed sensor - having a systematic approach for assessing sensor performance and processing data is vital
- The AirSensor package was developed to support data access, processing, and analysis

- Learn more from this publication: Feenstra, B., Collier-Oxandale, A., Papapostolou, V., Cocker, D., & Polidori, A. (2020). “The AirSensor open-source R-package and DataViewer web application for interpreting community data collected by low-cost sensor networks.” Environmental Modelling & Software, 134, 104832. https://doi.org/10.1016/j.envsoft.2020.104832

AirSensor Package and DataViewer

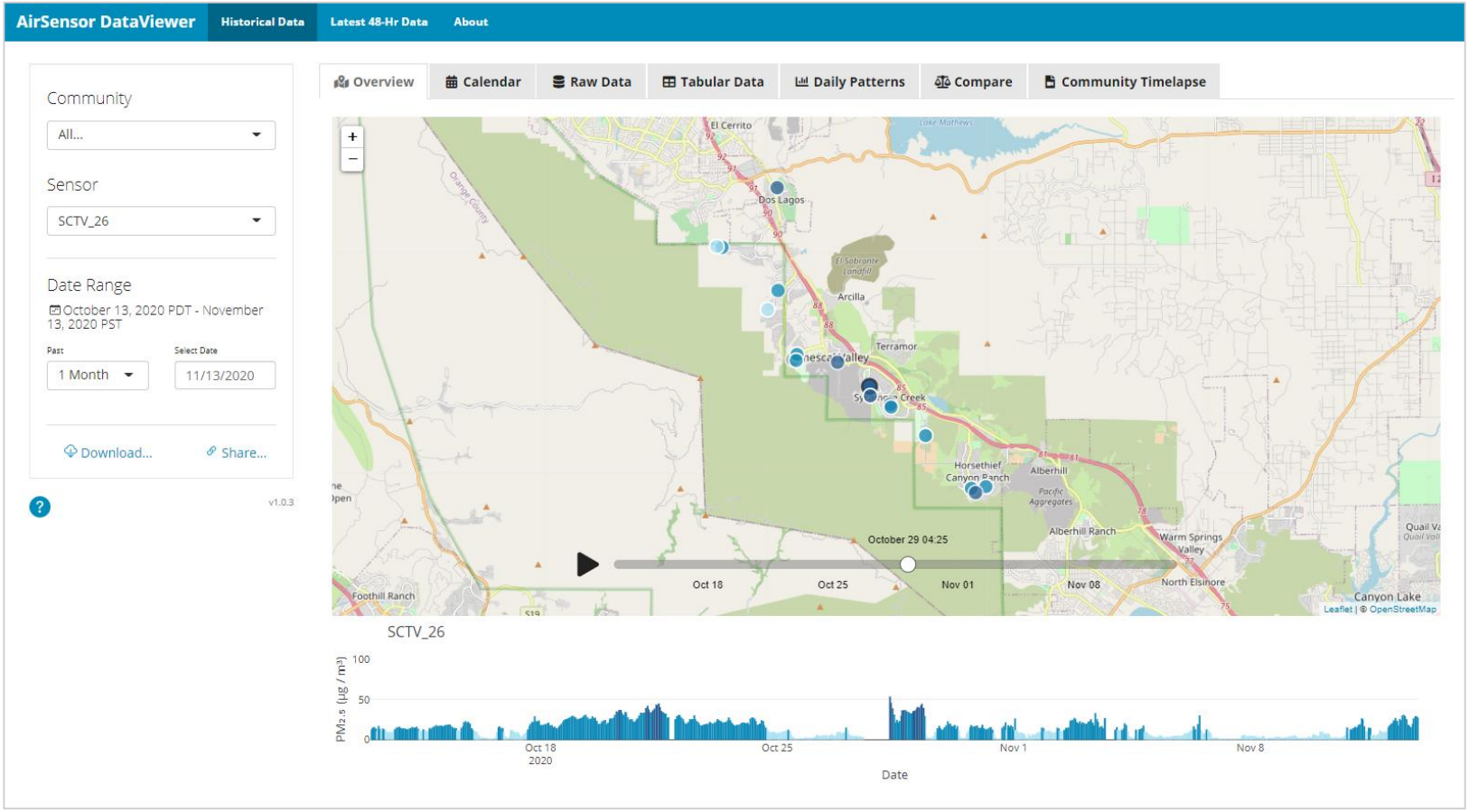
- Given the challenge and accessibility of low-cost sensor data, we partnered with Mazama Science to develop:
  - an open-source R-package for analyzing PurpleAir Sensor data – the “AirSensor” package
  - a web-based data viewer application – the “AirSensor DataViewer”

- The package requires some experience using R, but will allow users to easily access sensor data and analyze sensor data in a custom way
- While the DataViewer provides a set of different visuals, and is intended to be an intuitive tool for a broader audience

DataViewer Web Application

Focusing on the AirSensor DataViewer, you can:

- View averages on a map
- View data from a single sensor over time
- View Calendar Plots of the data from a single sensor
- Examine diurnal pollutant trends
- Compare sensors to the nearest reference site
- Examine sensor data w.r.t. supplementary data, such as wind data
- View timelapses of sensor data



DataViewer Web Application

Last workshop we discussed…

- General trends: Diurnal (daily), seasonal, weekday/weekend patterns
- Regional vs. local observations
- Individual events (e.g., wildfires, 4th of July fireworks)
- Identifying potential local sources
- The impact of factors such as meteorology

Live demonstration of DataViewer tool provided

- The DataViewer tool allows a user to explore these types of concepts as well as others without needing to work with the raw data or use any coding (using the PurpleAir sensors)

Conclusions

Regarding low-cost sensors

- Sensors are useful for providing real-time localized information
  - Esp. spatial variability
  - Esp. preliminary information during extreme events
- When compared to reference instruments, the sensors tend to over-estimate at higher concentrations
- The PA-II sensors seem particularly well-suited to detect wildfire emissions

Regarding the use of sensors

- Low-cost sensor could benefit from increased usability (e.g., simpler installation)
- Communities are interested in utilizing the data, and individuals participating in this project have taken action based on sensor data to reduce their exposure
- Tools are needed to make low-cost sensor data more accessible and useful (e.g., the AirSensor package and DataViewer)

Final Discussion

What are your reactions to the results shown?

How you would like to use the sensors?

What worked and what did not?

Can you share an example of a time when you took action or changed your behavior based on your low-cost sensor data?

Observations, interesting events, or challenges?

New ideas on sensor data analysis?

Any other feedback?

Thank you for your participation!