AIR QUALITY COMMUNITY ACTION NETWORK (AQ-CAN)

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CITY & COUNTY OF DENVER
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AGENDA

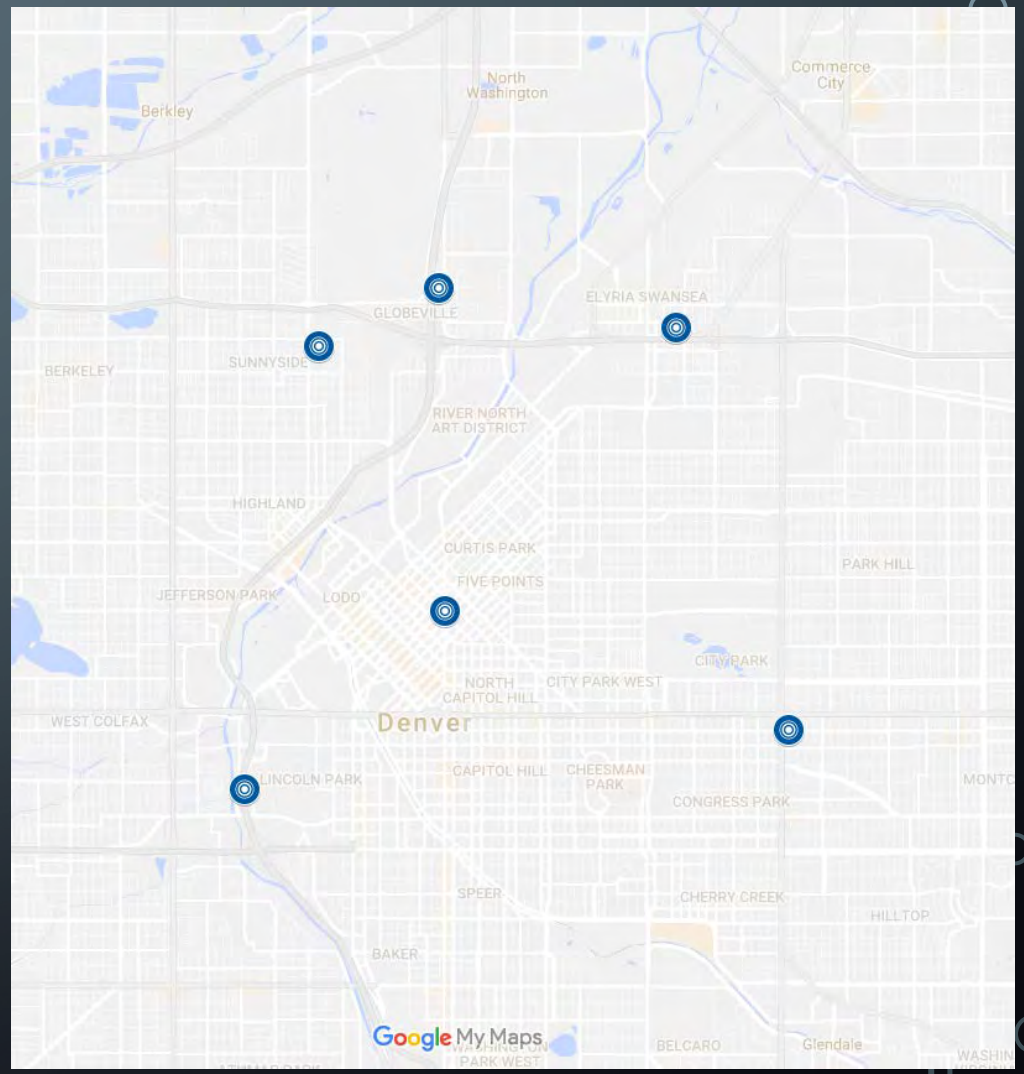
- Benefits/challenges of air sensors
- Current status CDPHE + DDPHE
- Why?
- Phase1 & Phase 2
- Lunar Outpost – Technology Presentation
- Network diagram/description
- Data - state vs sensor collocation
- Data - triplicate sensor collocation
- Data – adjustment factors

SENSORS VS REFERENCE INSTRUMENTS

- Benefits
  - Lower cost
    - About 1/10 the cost
  - Potential for greater density of network
    - Small footprint
    - Solar/battery + cellular communication
  - Hyper-local data set
    - Actionable
- Challenges
  - Data quality
  - Data management
  - Data communication
  - Resources to manage servicing of the network once deployed

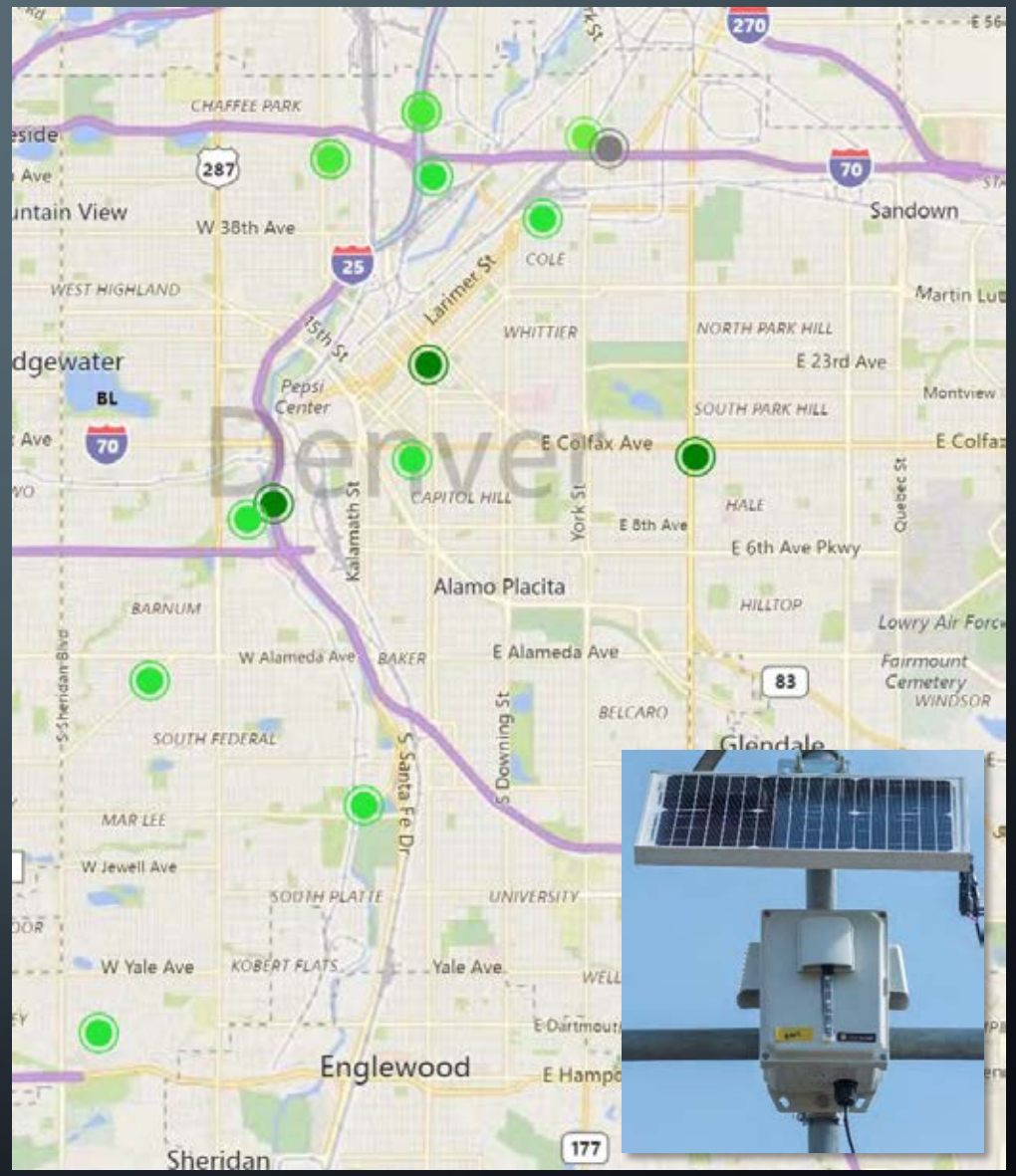
STATE MONITORING NETWORK (CDPHE)

- Currently 5 regulatory sites run by CDPHE in City & County of Denver (CCD) boundary
  - I-25 Globeville
  - LaCasa
  - CAMP
  - National Jewish Health
  - I-25 Denver
  - 31 per square mile density



AIR QUALITY COMMUNITY ACTION NETWORK (AQ-CAN)

- Currently 12 sensors deployed
- PM1, *PM2.5*, & PM10*
- Current locations
  - State sites
  - Construction sites
  - Schools
    - Swansea Elementary
    - Garden Place Academy
    - Fairview World School
- With state sites density of 9 per square mile



WHY DEPLOY SENSORS AT SCHOOL IN DENVER?

- Reduce inequitable exposure to poor air pollution to public school children in Denver
- Denver families spend an average of $3,100 a year on asthma-related medical costs, resulting in more than $30 million spent annually.
- The City of Denver will use cutting-edge air pollution sensor technology to create a city-wide air quality monitoring program at public school buildings, resulting in better informed policy decisions using environmental, health, and economic data.

DENVER PUBLIC SCHOOLS
Discover a World of Opportunity™

PHASE 1 (FEB 20 – AUG 20, 2018)

- $100,000 budget
- 10 Schools
  - 3 Tests: Behavior change, Buy-in, Data communication
- Development of sensor technology with local aerospace engineering start up Lunar Outpost
- Development of air sensor platform with TD Environmental
- Collaboration with Bloomberg Philanthropies
  - Frog Design – Mayo Nissen – Innovation Coach
  - Delivery Associates – Minza Zahid – Implementation Coach
  - UsCreates – Experience design consultants
- Primary stakeholder collaboration with Denver Public Schools

Lunar Outpost™

TD ENVIRONMENTAL SERVICES
Air quality sensing, analytics, and insights

uscreates

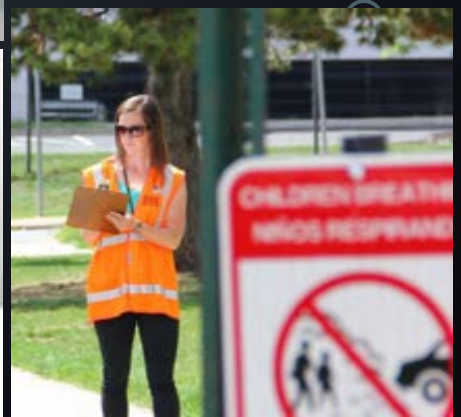
frog design

Delivery Associates

DENVER PUBLIC SCHOOLS
Discover a World of Opportunity™

PHASE 2 (JAN 2019 – DEC 2021)

- $1 - $5 million budget
- 40+ DPS Schools
  - Elementary, Middle, High
- $8k budget for each school to use for programming
- Menu of options for reducing exposure of kids as well as limiting local sources of pollution
  - Anti-idling
  - Walking school buses
  - Education
  - Behavior change
- Reduce asthma incidents at DPS schools leading to improved live long health and economic benefits for DPS families



CANARY TECHNOLOGY


LUNAR OUTPOST
The Next Leap

LUNAR OUTPOST MISSION:

Our mission is to develop technology that enables a presence on the Lunar surface, while creating Earth analogs that drive innovation and have positive impact.

Terrestrial Spin-Offs

Lunar Outpost uses developed technologies in terrestrial markets

1. These technologies fill an immediate need and have a positive impact
2. Drive near-term revenue generation

Current Terrestrial Application: Air Quality (AQ) Monitoring IOT Sensor Technologies

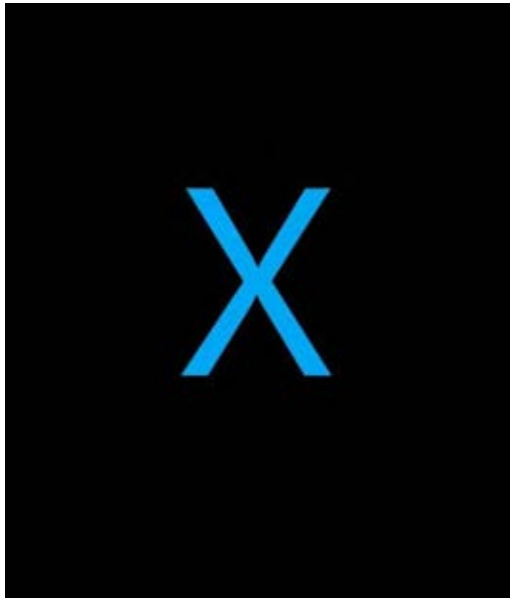
Commercial Products

Air Quality Systems

Canary-E

Canary-S

Canary-X



Commercial Products

Flexibility ingrained into product lines

Canary-E

- **POE**
- Data flexibility ->
- System health info ->
- Watchdog enabled ->
- On-board storage ->

Canary-S

- **Solar option ->**
- Cellular, any network
- Very low power
- GPS ->
- Encrypted data ->

Canary-X

- **Cellular, WiFi, Bluetooth, POE**
- Walk up interface
- Optimized airflow
- Higher resolution gas sensors

Base Model: PM1, 2.5, 10, temperature and humidity
-> means applicable to next tier

Big Boi
Additional sensors: VOC, CO, Ozone, NO2, H2S, and custom packages

Base Model Sensors

- **Redundant Particulate Matter**
  - PM1.0, 2.5, and 10
  - Binning 0.3-1.0, 1.0-2.5, 2.5-10
  - Efficiency 98%>= 0.5um
- **Temperature**
  - -40-80C +/- 0.5C
- **Humidity**
  - 0-100 +/-2% RH

Additional Sensors

- **Gases – ppb resolution**
  - Total VOC (PiD) (0.5 ppb)
  - Ozone
  - NO_2
  - H_2S
  - CO

Additional Sensors

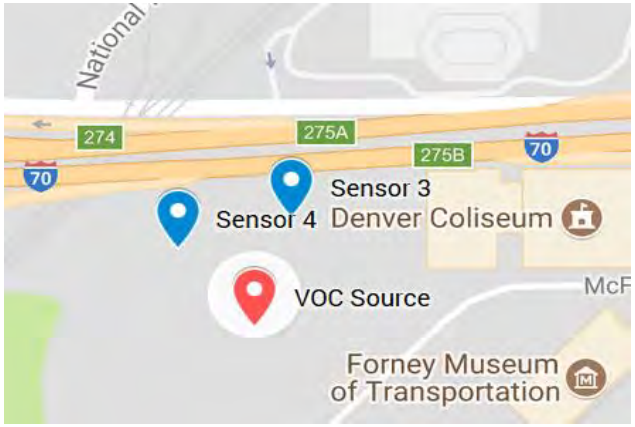
- **Ultrasonic Anemometer**
  - **Wind Speed:** 0 to 75 m/s (0 to 168 mph)
    Resolution: 0.01 m/s
    Accuracy: ± 2% ± 0.1m/s (30 m/s), ± 3% (75 m/s)
  - **Wind Direction:** 0 to 360 degrees
    Resolution: 0.1 degree
    Accuracy: ± 2 degrees

Performance

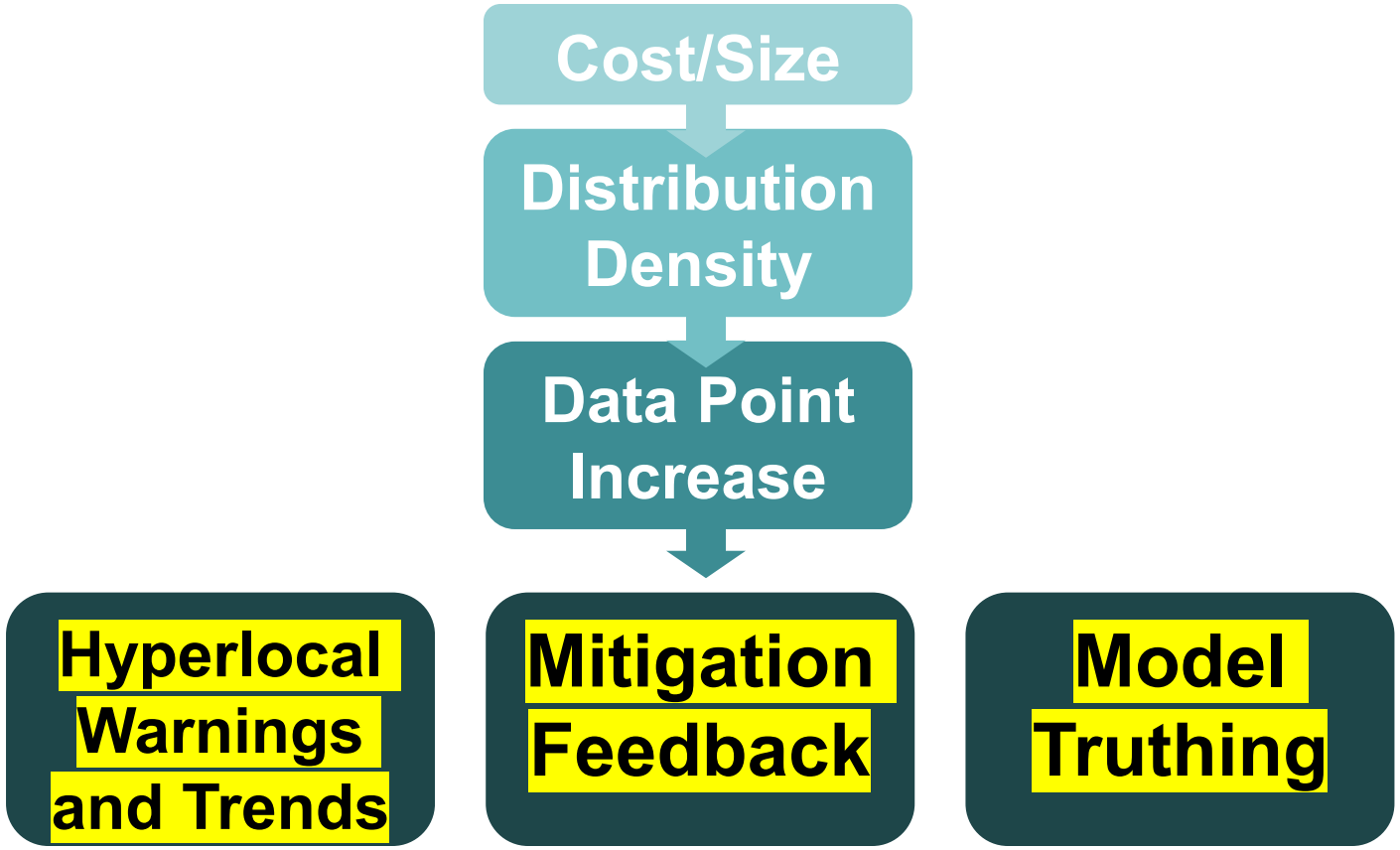
- **Size**
  - 7x6x8.5in
  - <5lb
- **Power**
  - 72 hour battery life (Canary-S)
  - Power over Ethernet (PoE) (Canary-E)
- **Communication**
  - 2G/3G, 4G LTE upcoming (Canary-S)
  - 256 bit Advanced Encryption Standard
- **Data**
  - Database agnostic
  - Message 1/min

Fenceline Monitoring

- Anemometer + Sensor = Source Triangulation



Unique Value Added



THANK YOU

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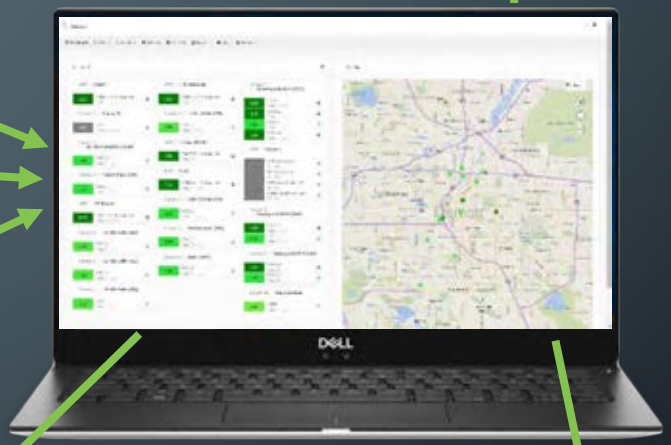
NETWORK DIAGRAM

Sensors

CCD Enterprise Data Management Ecosystem

Data Platform



Public Sensor Networks

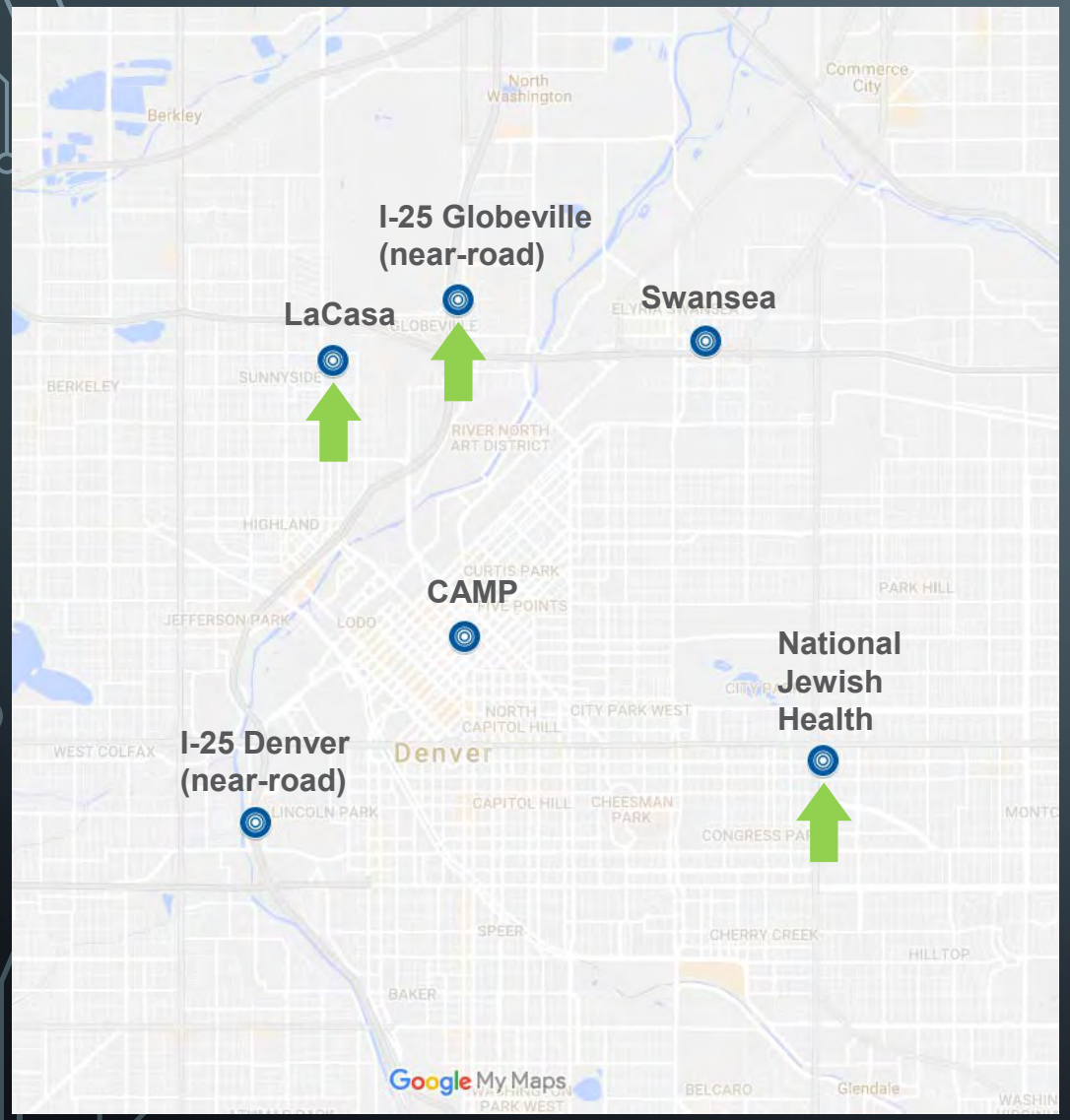
CCD

SFTP

State Reference Sites

In-school Community Dashboards

TESTING NETWORK DESCRIPTION



Reference Instrumentation

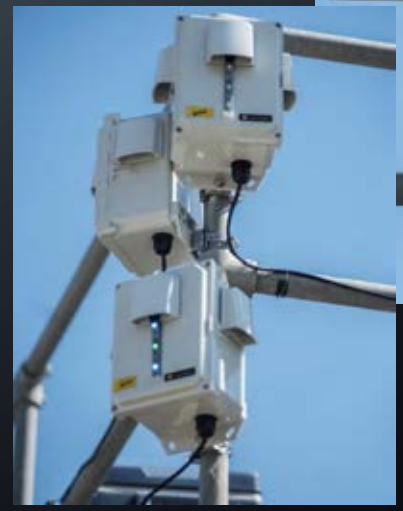
- I-25 Globeville
  - Grimm EDM 180
- LaCasa
  - Grimm EDM 180
- National Jewish Health
  - Teledyne API 640

Grimm EDM 180

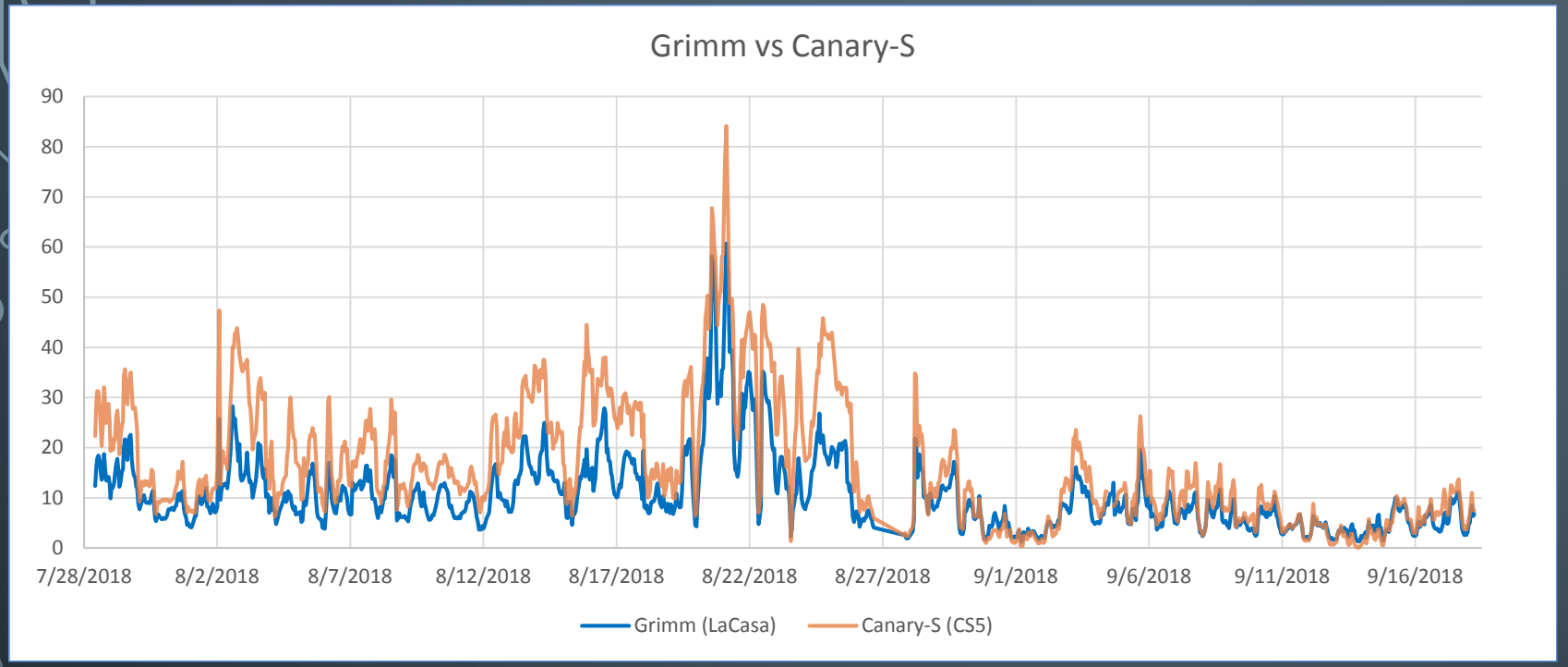
Teledyne API 640

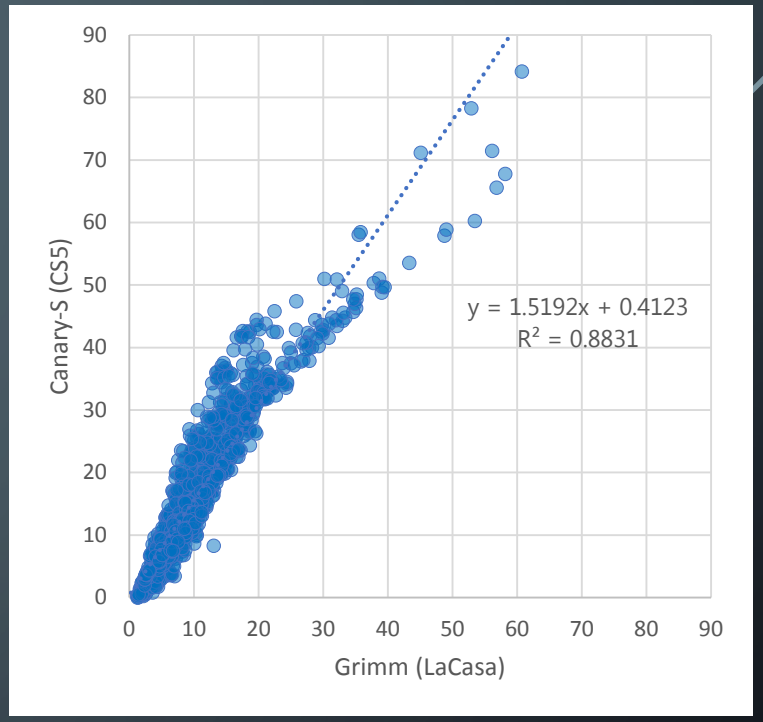
Sensors

- I-25 Globeville
  - Canary-S v1.0
  - Deployed in triplicate
  - CS2, CS3, & CS4
- LaCasa
  - Canary-S v1.0
  - CS5
- National Jewish Health
  - Canary-S v1.0
  - CS1

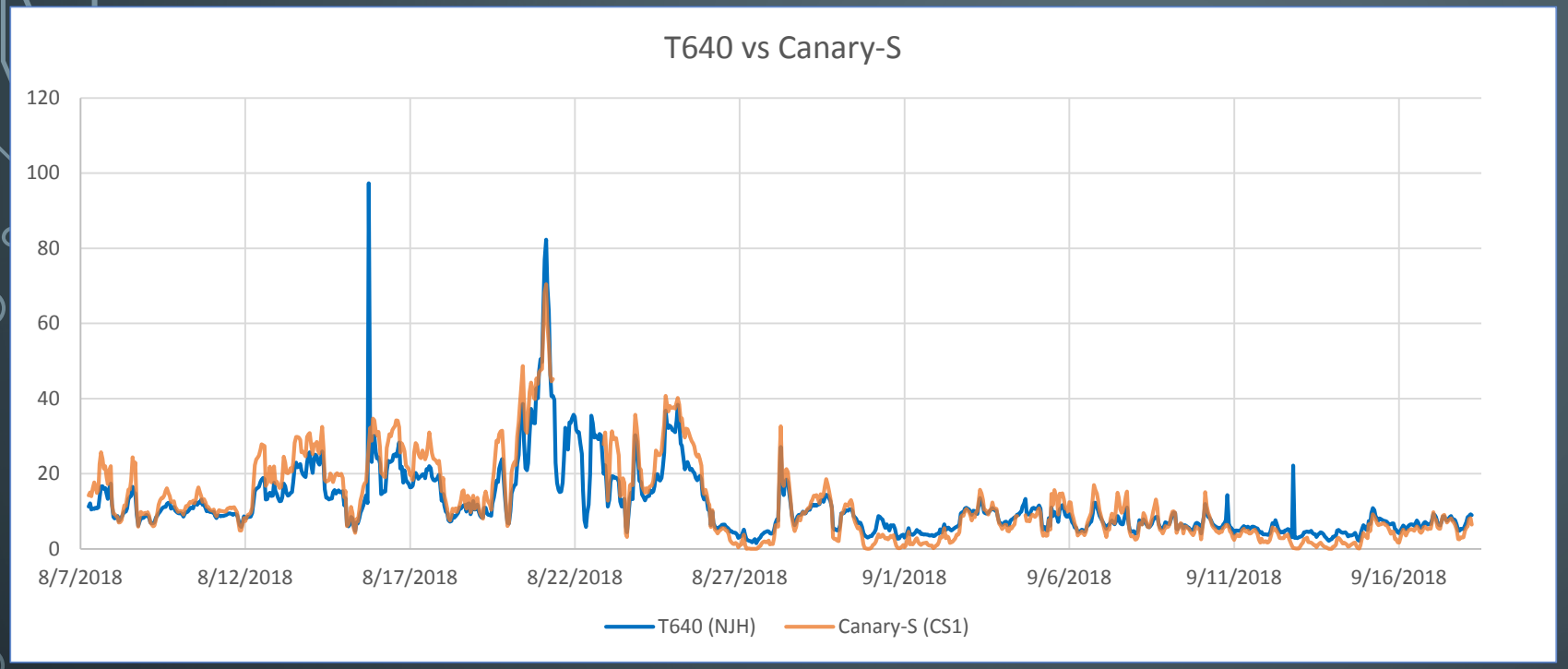


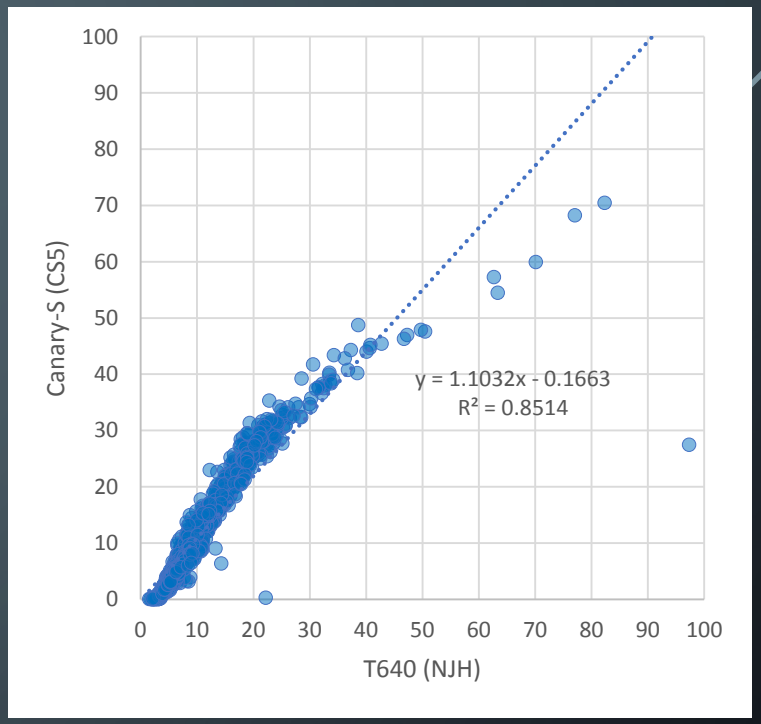
COLLOCATION (GRIMM) ~50 DAYS – 1HR AVG



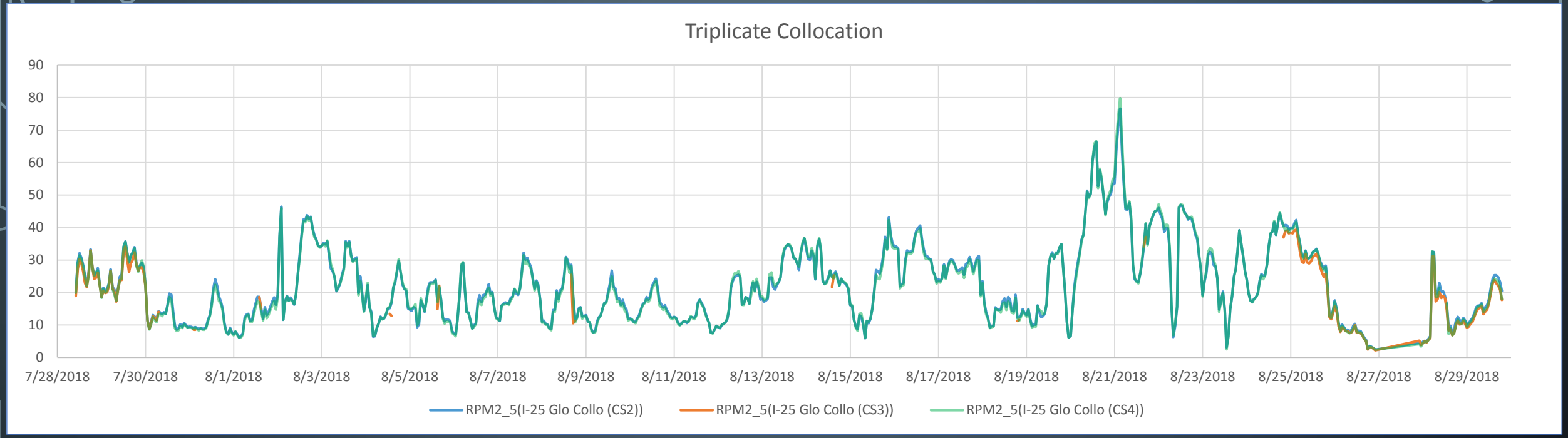


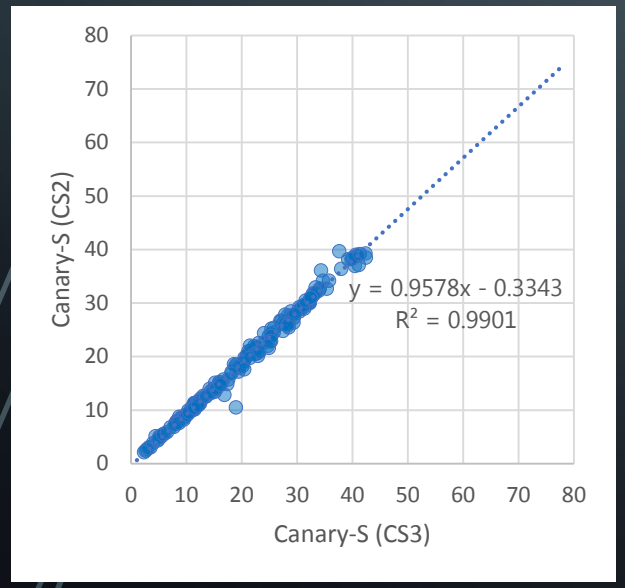
COLLOCATION (T640) ~40 DAYS – 1 HR AVG

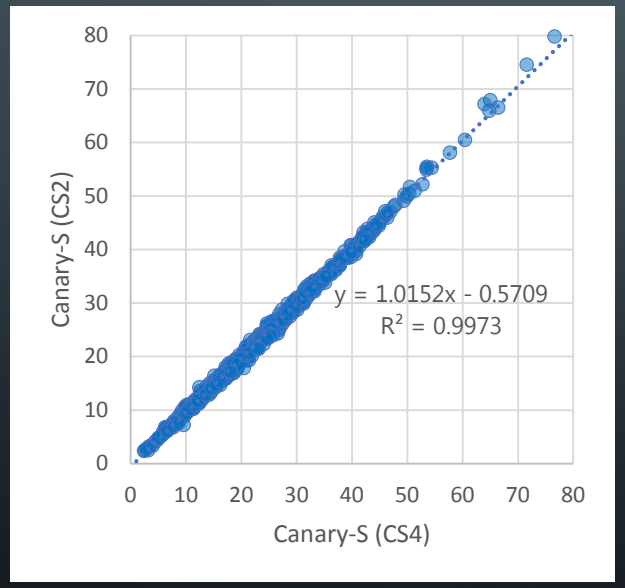


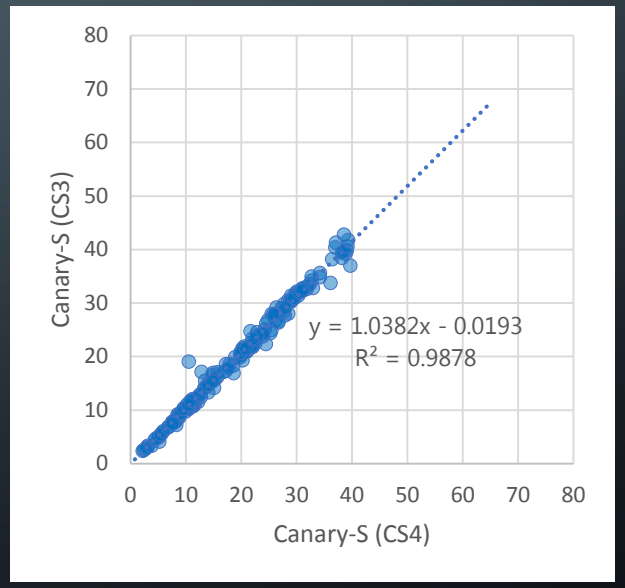


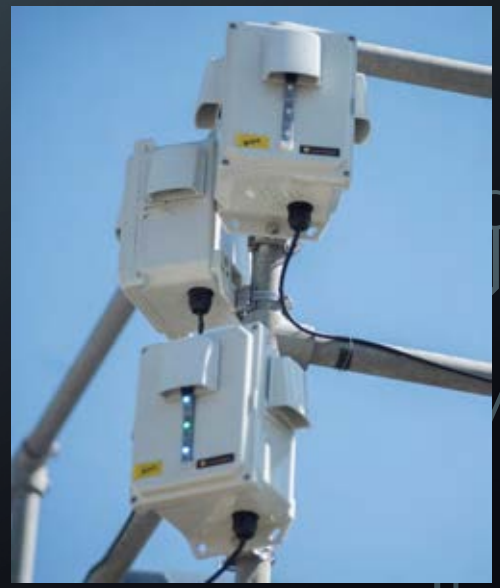
TRIPLICATE COLLOCATION ~31 DAYS – 1 HR AVG



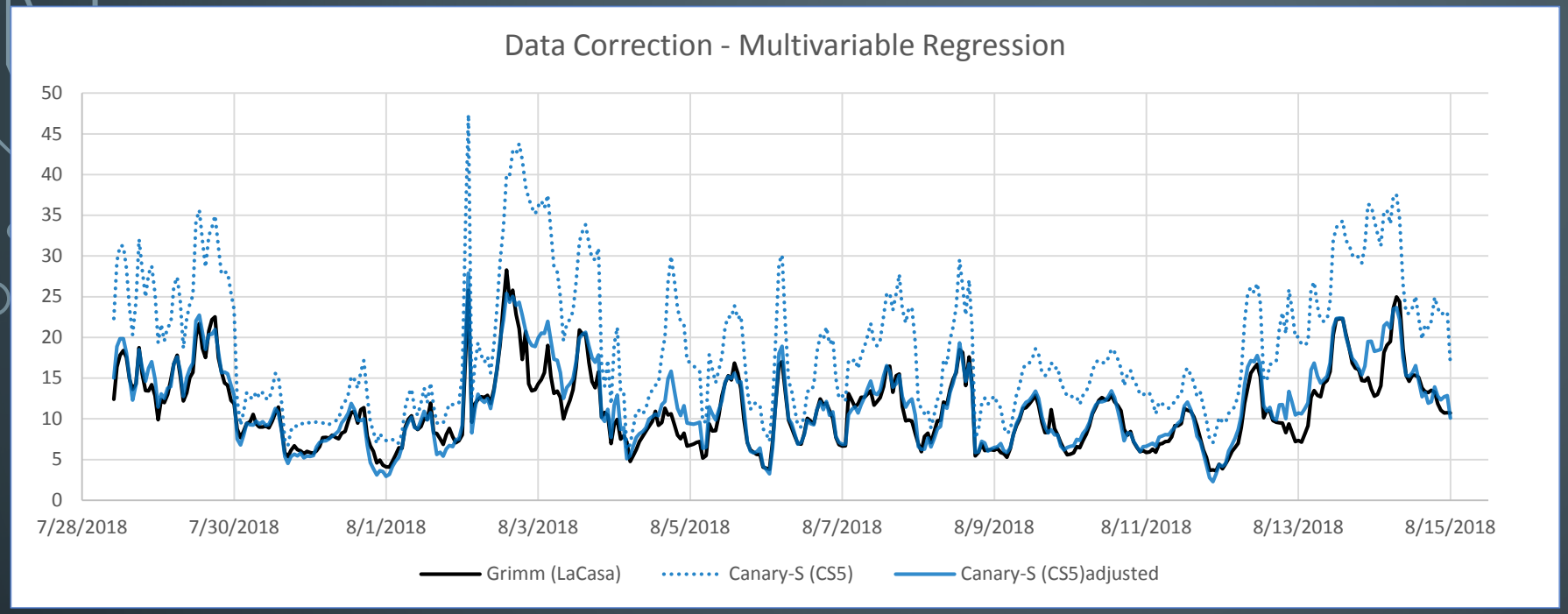


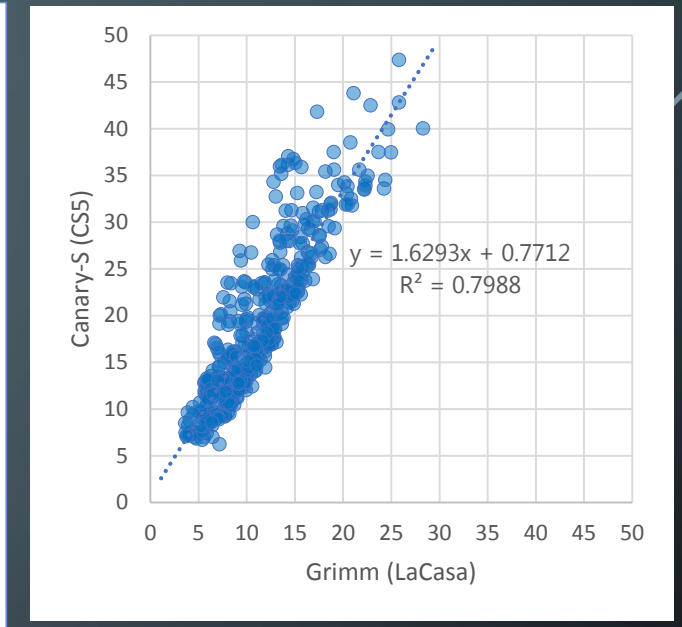


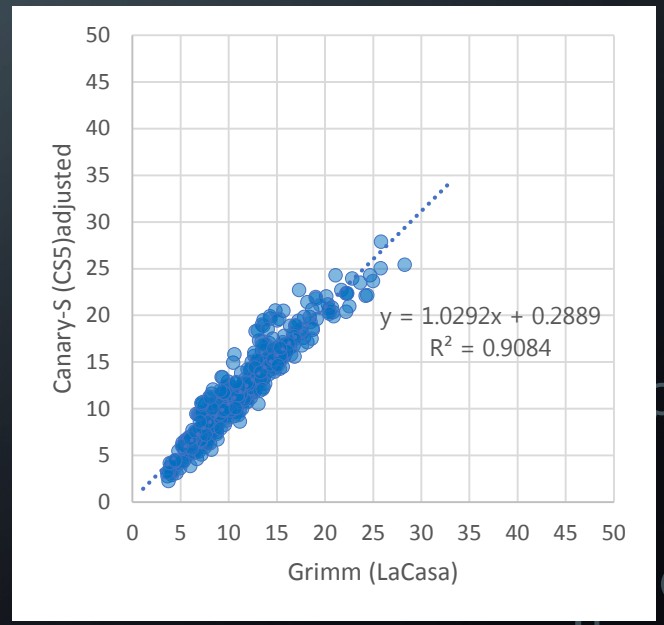




DATA ADJUSTMENT







Reference To Compare	Adjustment Sensor 1	Adjustment Sensor 2	Active
PM2.5 Total Atmospheric (La Casa NCORE)	humidity (La Casa Collo (CS5))	tempf (La Casa Collo (CS5))	True

Active	x1Coef	x2Coef	x3Coef	Intercept	R2	Data used for Normalization	
23	11.93236673	0.57736079	-0.01728246	-0.13346448	0.91467407	9/17/2018 10:48:36 PM - 9/17/2018 10:48:36 PM	True
21	10.83720282	0.48861630	0.00636227	-0.12068125	0.92203351	9/17/2018 10:43:14 PM - 9/17/2018 10:48:36 PM	False
19	10.94276246	0.49186459	0.00524868	-0.12232122	0.92510264	9/9/2018 12:40:45 AM - 9/17/2018 10:43:14 PM	False
17	10.94276246	0.49186459	0.00524868	-0.12232122	0.92510264	9/9/2018 12:39:29 AM - 9/9/2018 12:40:45 AM	False
16	10.94276246	0.49186459	0.00524868	-0.12232122	0.92510264	9/9/2018 12:37:36 AM - 9/9/2018 12:39:29 AM	False
15	10.94397601	0.48926274	0.00562000	-0.12167970	0.92257378	9/6/2018 10:55:05 PM - 9/9/2018 12:39:29 AM	False

(Mockup)

WHAT'S NEXT?!

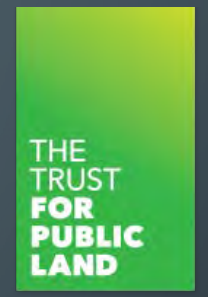
Continue working with schools to identify air pollutions patterns and put programs in place to reduce exposure and reduce local pollution sources

Continue refine the sensor technology and work with the data platform developer on ways to correct data utilizing regional reference instrumentation

Win the grand prize of $5 million in October. Scale to encompass the schools within Denver that are most impacted by air pollution.

THANKS!

Bloomberg Philanthropies



Aspen Outlook, LLC

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