Non-Purple Sensors: Successes, Surprises and Challenges with Other Brands

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Sensors by other brands

- **Clarity Node-S**
  - Solar-powered and cell-connected
    - No cords!
  - 1-minute average reading every 15 minutes
  - Single Plantower PMS6003 sensor

- **DIY Sensirion SPS30 box**
  - USB power and cell-connected
    - Needs wall power but not wifi
  - 1-minute average readings continuously
  - Two SPS30 sensors

- **Ambient Weather PM$_{2.5}$ Monitor (ORCAA)**
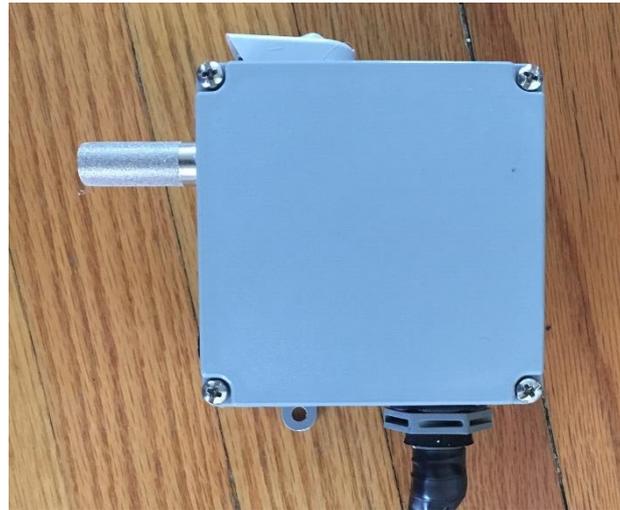 - Solar optional and wifi-connected
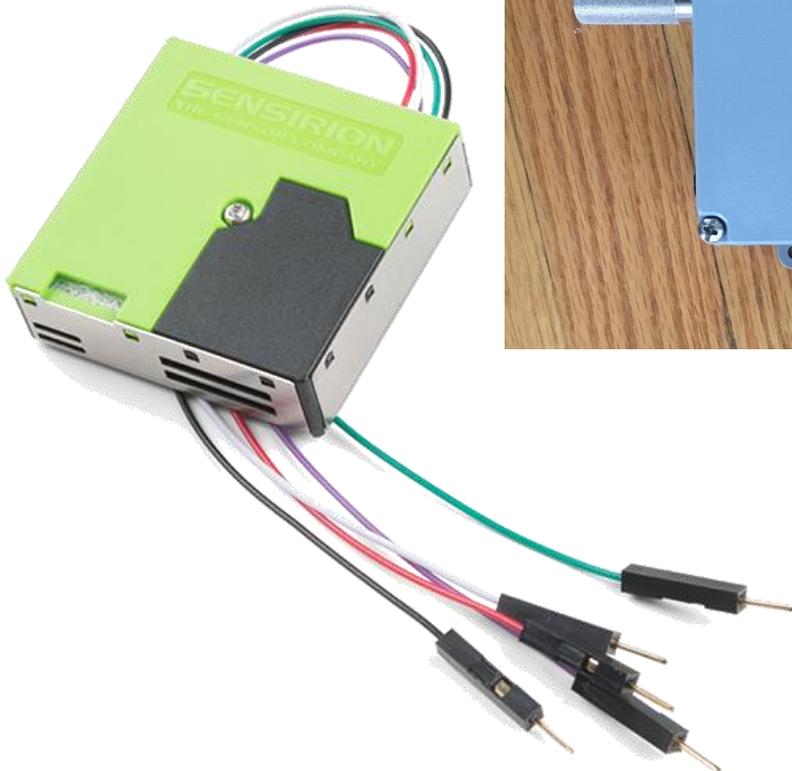 - Single Honeywell HPM sensor inside
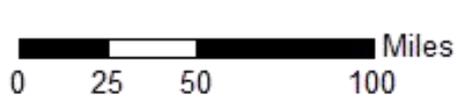
Clarity Node-S

Photo by Beth Friedman

DIY Sensirion SPS30 Box

Ambient Weather PM$_{2.5}$ Monitor (ORCAA)

Test locations
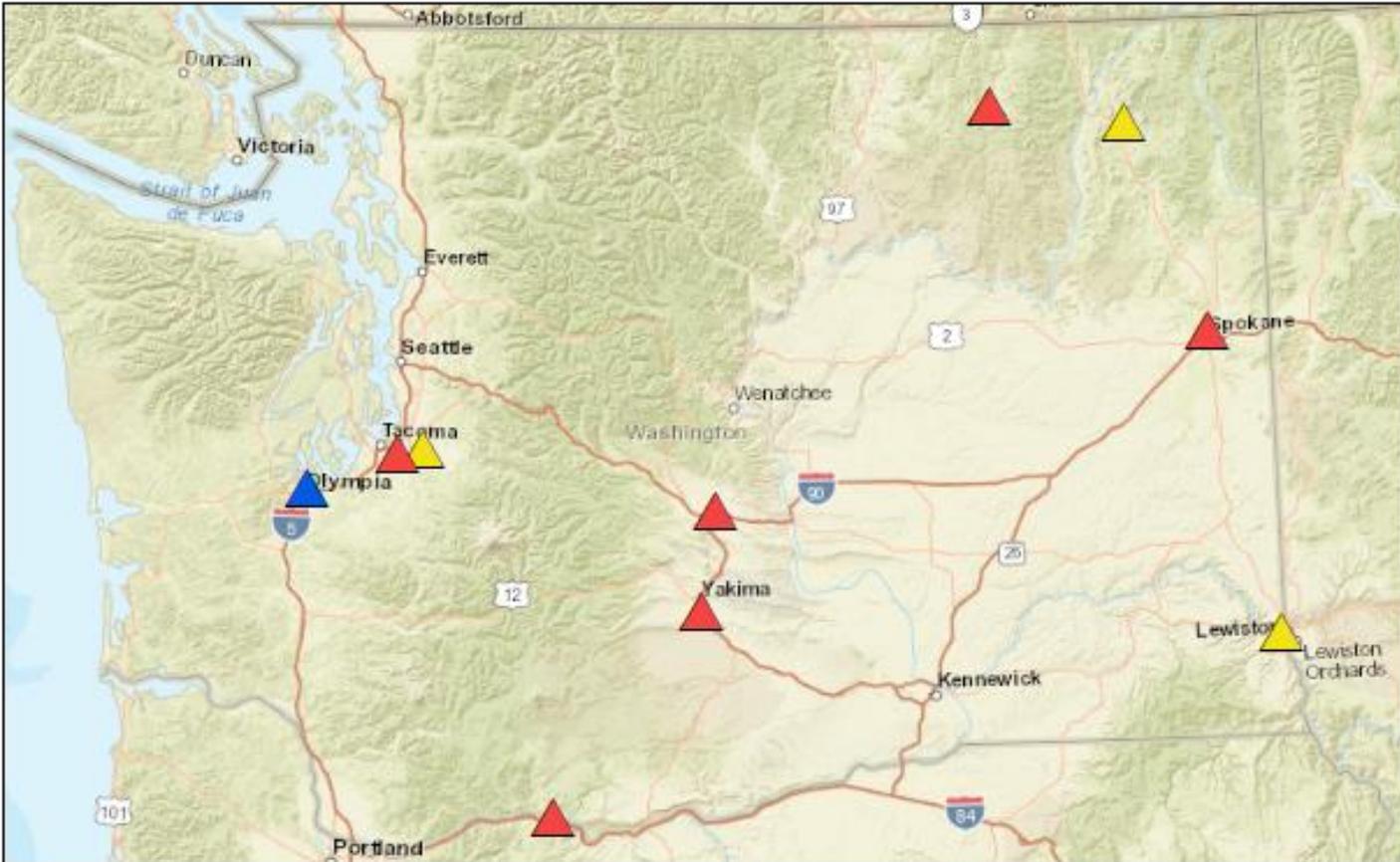
Legend:
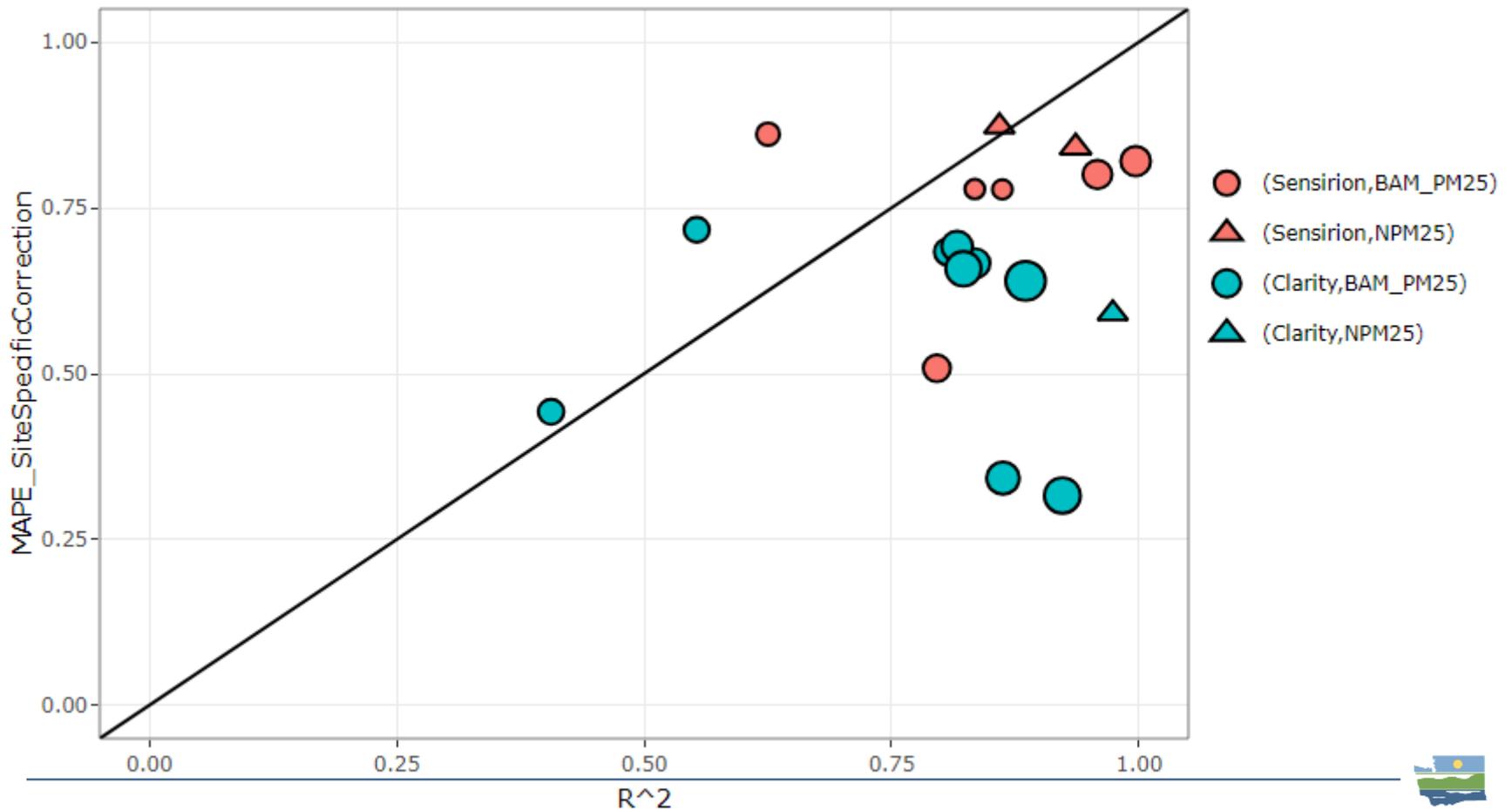- 🔺 (blue) Ambient Weather PM$_{2.5}$ Monitor
- 🔺 (red) Clarity Node-S
- 🔺 (yellow) DIY Sensirion SPS30 box

Overall Measures of Performance

R^2 and Accuracy (1-Mean Absolute Percentage Error) of Linear Fit by Sensor Type

Overall Measures of Performance

	Clarity Node-S	Sensirion SPS30
R^2	**0.84** [0.4 – 0.92]	**0.91** [0.62 – 0.99]
RMSE	**4.71** [2.61 – 11.69] µg/m³	**1.98** [0.73 – 2.81] µg/m³
MAPE	**44** [30-88] %	**25** [13-49] %

- Overall N-weighted measures are shown in bold and the range of site-specific measures are shown in [ ]
- All measures were calculated after site-specific correlation with only $PM_{2.5}$ concentrations as inputs (no temp/RH)
- Only sensors compared to BAM 1020s were included due to nephelometer correlation issues during smoke
- Sensirion SPS30 boxes outperform Clarity Node-S units in all measures
- Normalized performance metrics are challenging because of widely different ranges tested
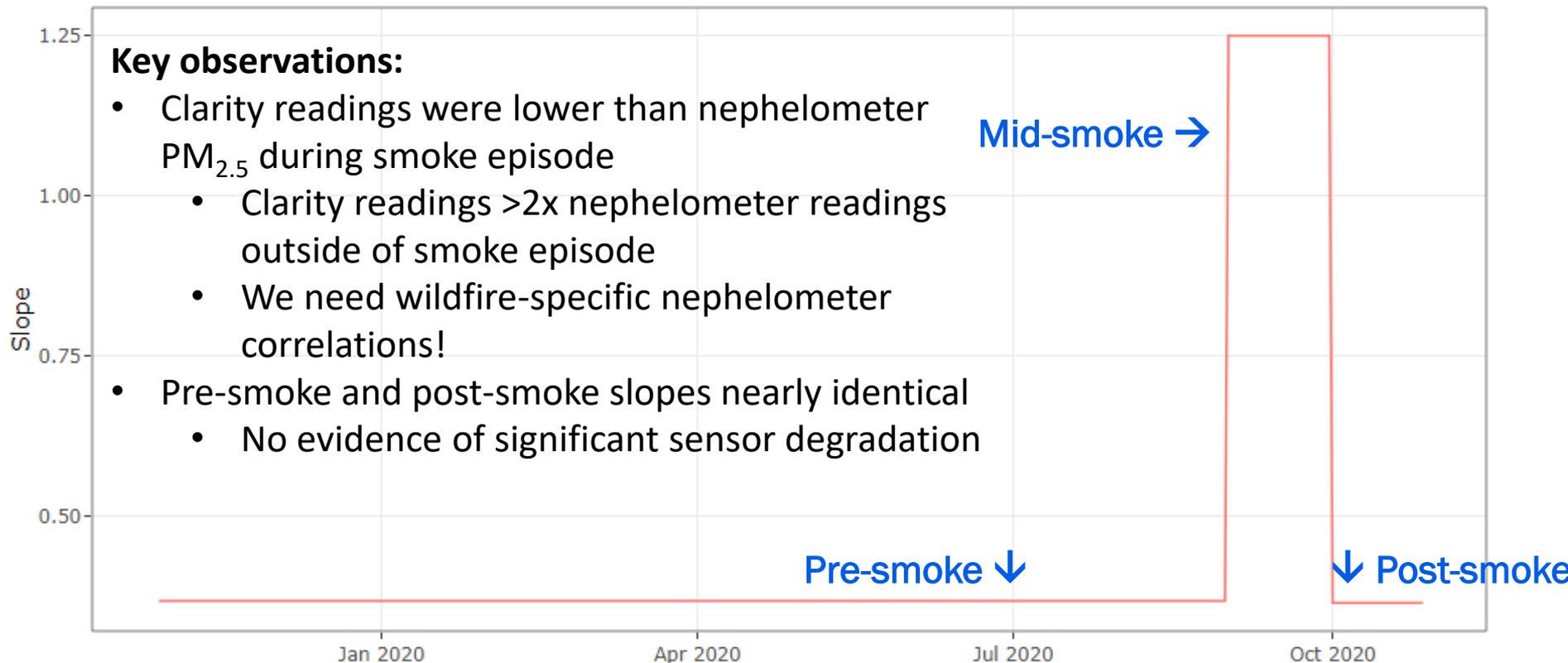 - 2020 smoke episode only reflected in some site/sensor pairs
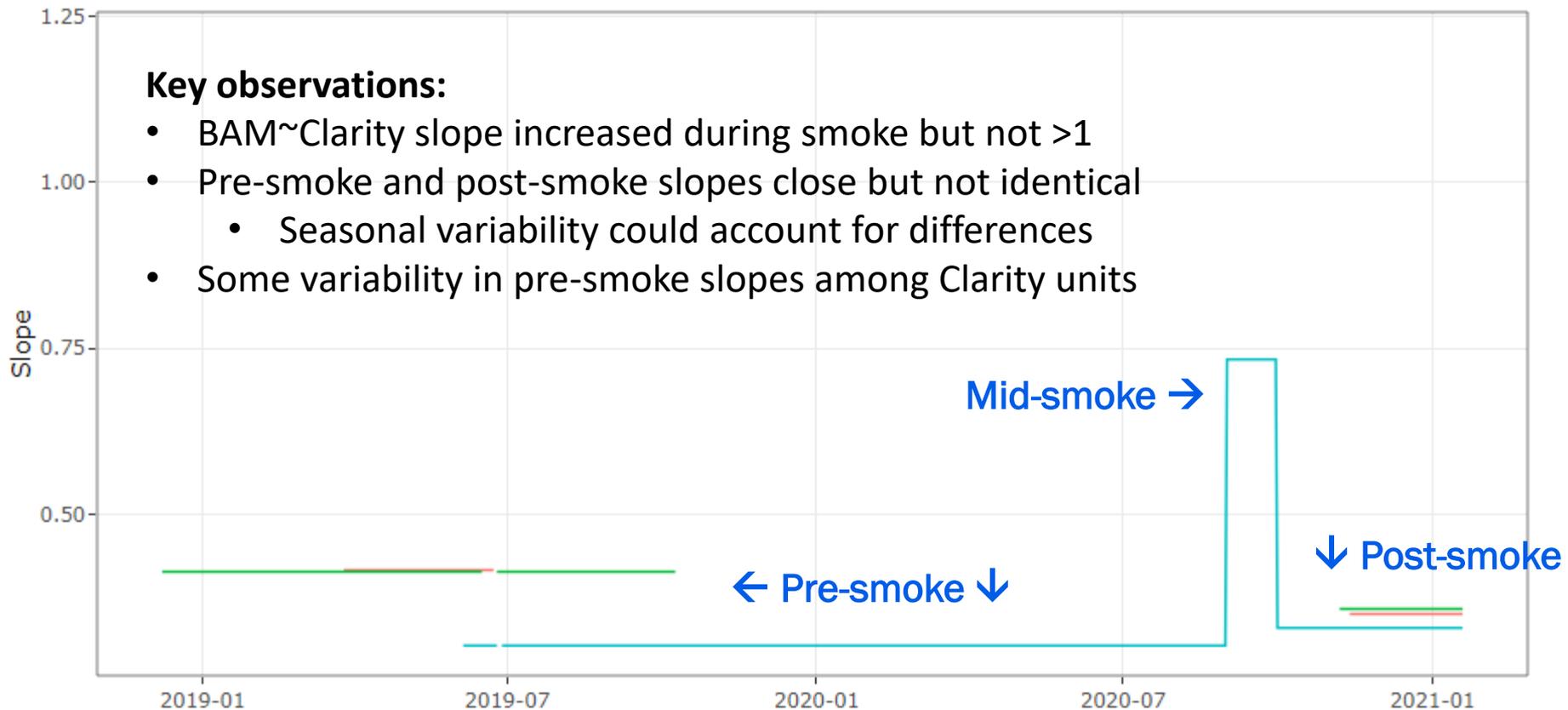
RH Impacts

- Didn't include RH in correlation models
  - Data availability varies
  - Switched RH sensor during Sensirion tests

- Including RH
  - R^2 up 0.02
  - RMSE down 0.51 µg/m^3
  - MAPE down 1.4%

- RH makes the **biggest** difference:
  - Eastern/Central WA locations (Ellensburg, Colville, White Salmon)
  - All multi-season tests
  - Clarity Nodes

- RH makes the **smallest** difference:
  - Urban locations (Tacoma near-road, Spokane)
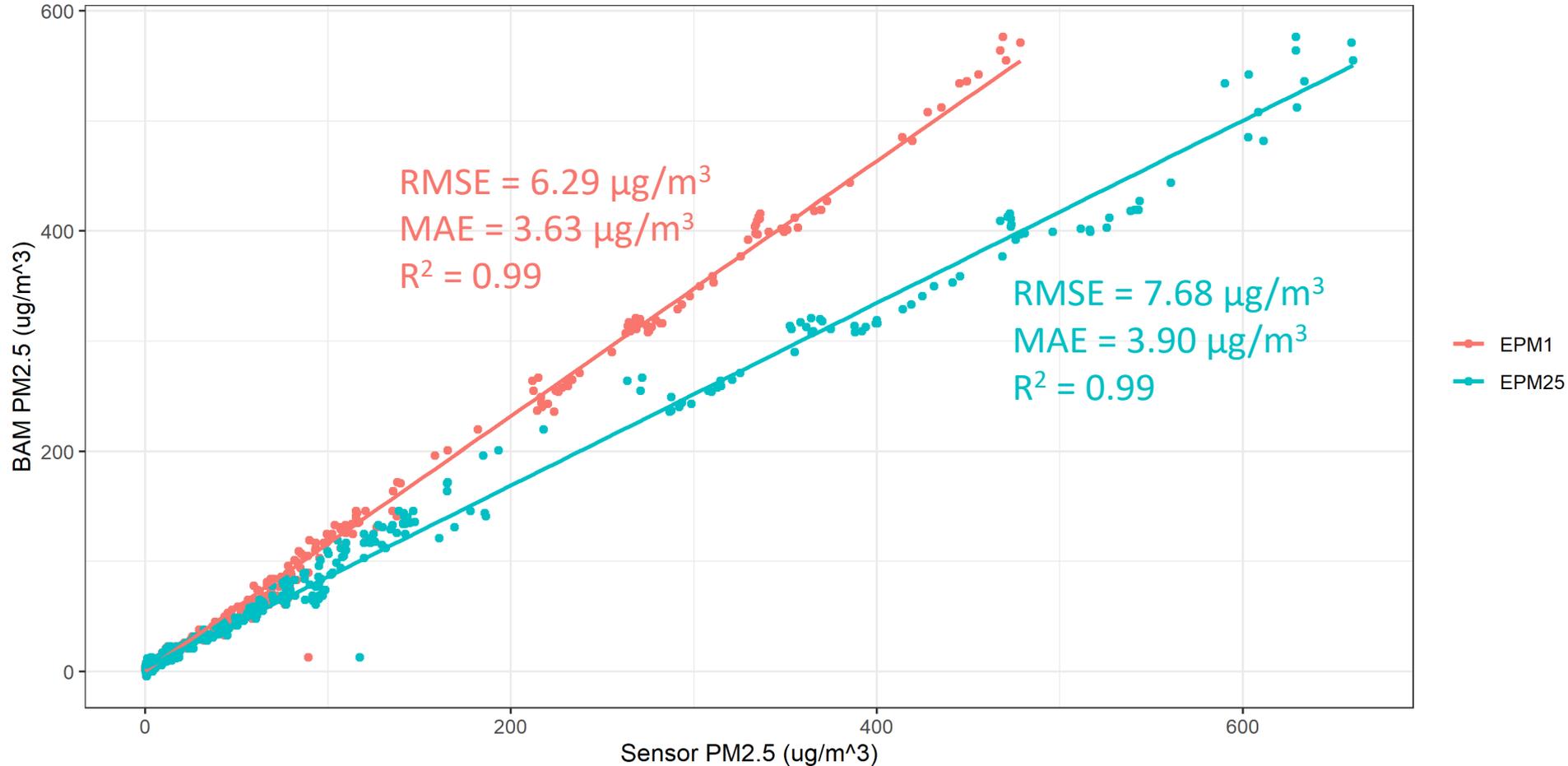 - Summer-only tests
  - Sensirion boxes

Clarity Node-S Slope vs Nephelometer PM$_{2.5}$, White Salmon

Key observations:

- Clarity readings were lower than nephelometer PM$_{2.5}$ during smoke episode
  - Clarity readings >2x nephelometer readings outside of smoke episode
  - We need wildfire-specific nephelometer correlations!
- Pre-smoke and post-smoke slopes nearly identical
  - No evidence of significant sensor degradation

Mid-smoke →

Pre-smoke ↓

↓ Post-smoke

Clarity Node-S Slope vs BAM PM2.5, Tacoma-S 36th St

Key observations:
- BAM~Clarity slope increased during smoke but not >1
- Pre-smoke and post-smoke slopes close but not identical
  - Seasonal variability could account for differences
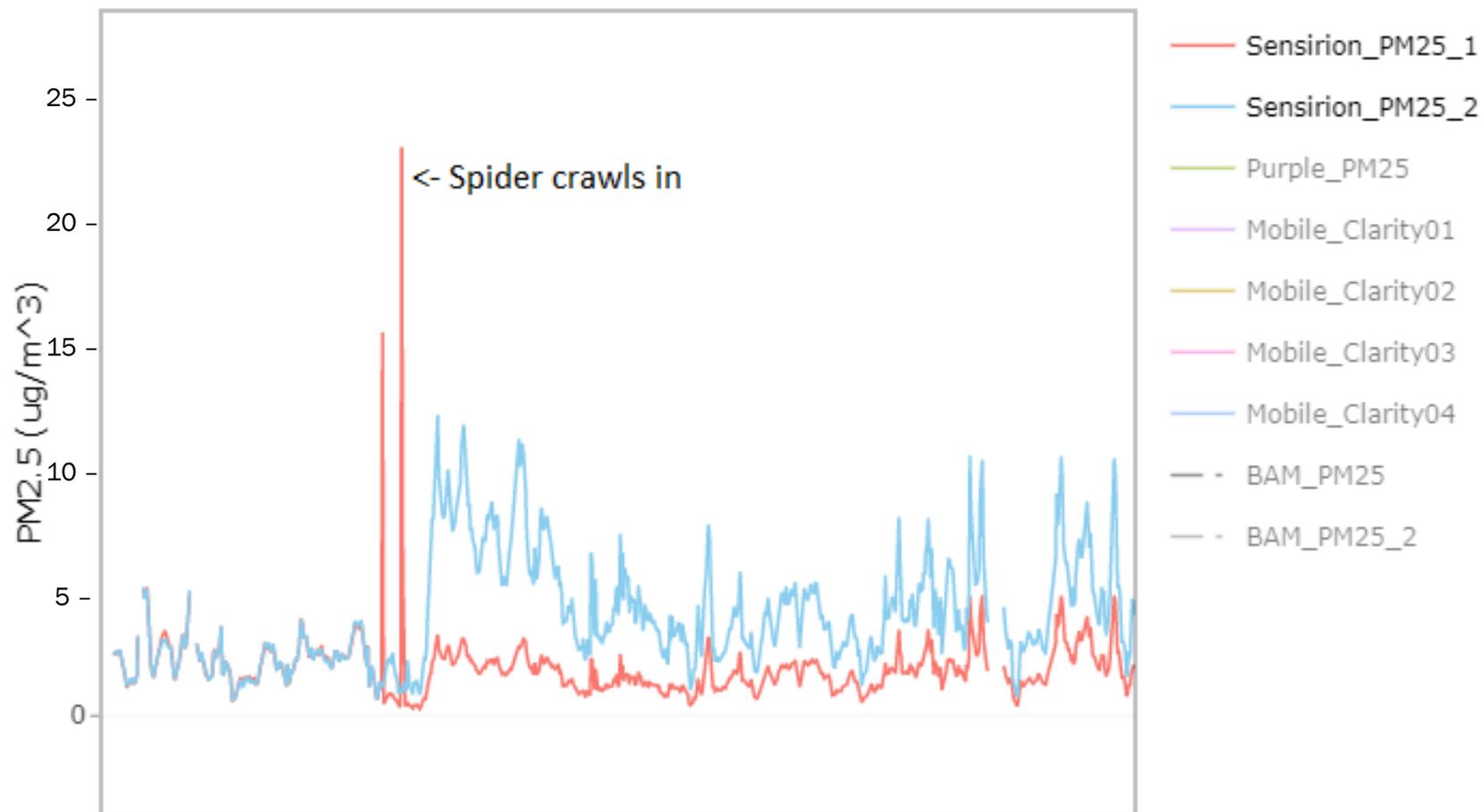- Some variability in pre-smoke slopes among Clarity units

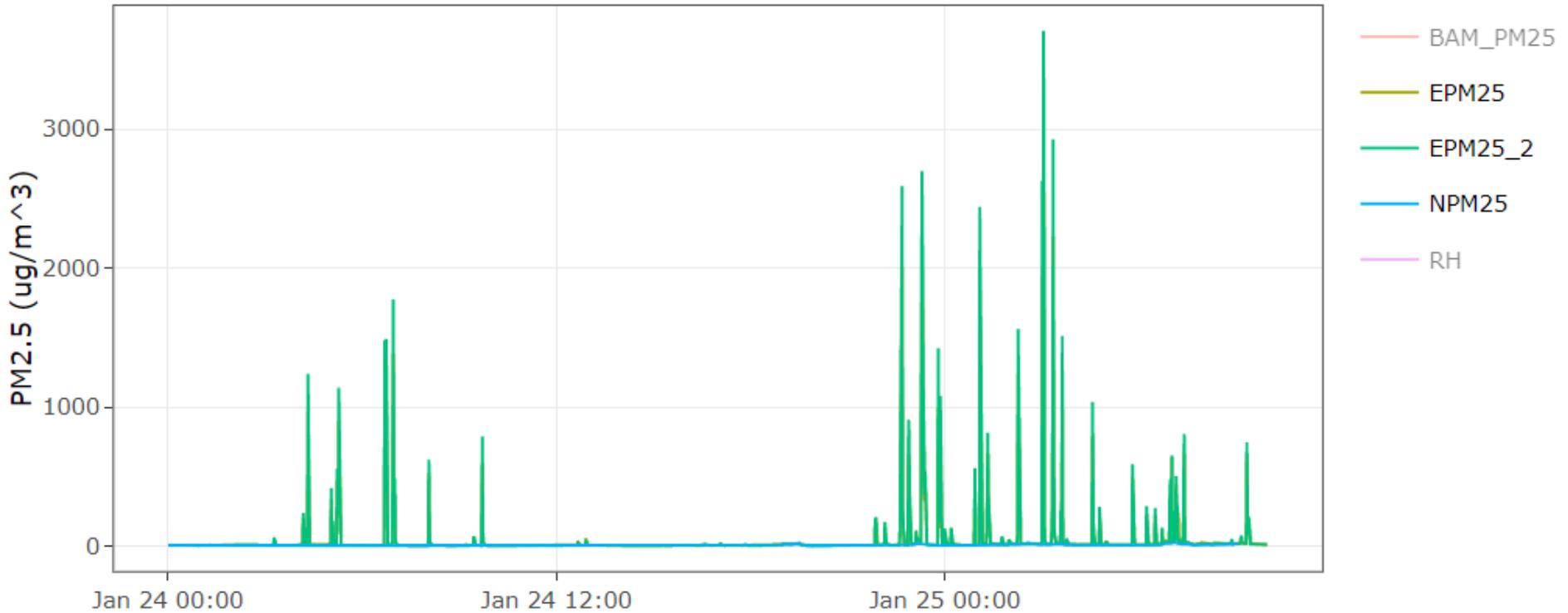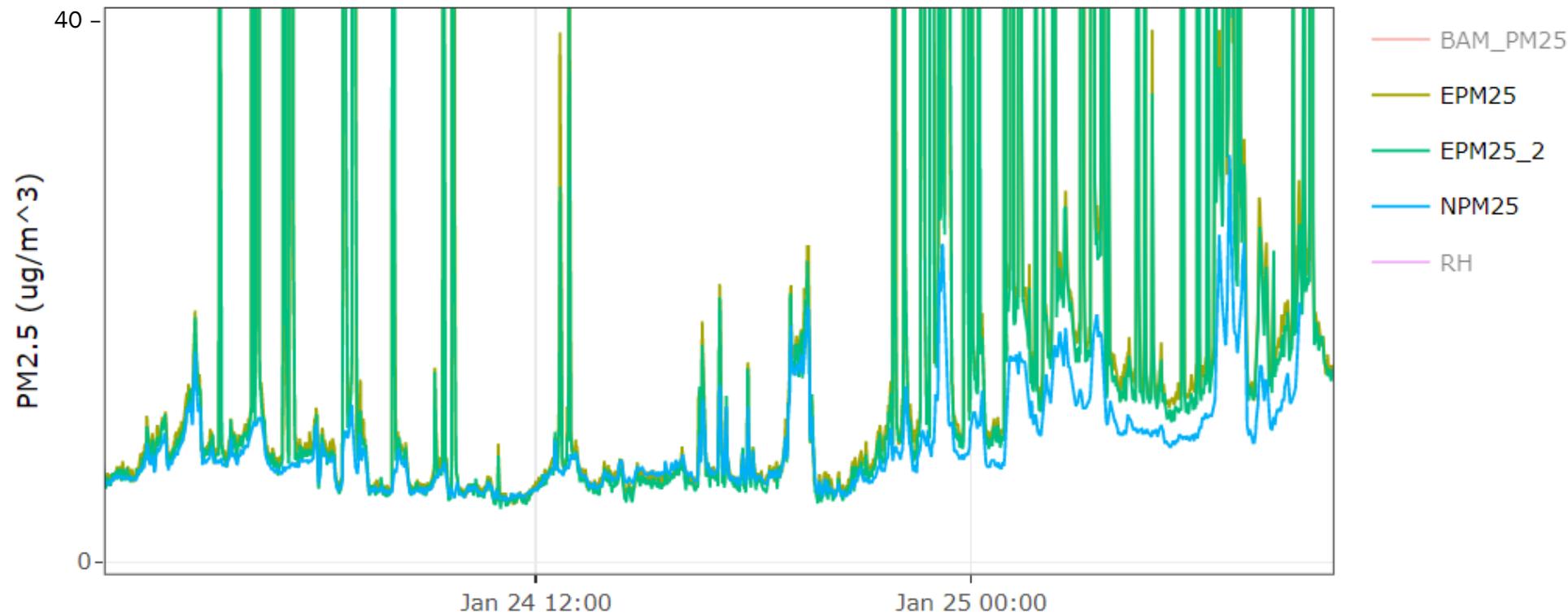# Sensirion PM$_1$ vs PM$_{2.5}$ at Colville

Challenges: Spiders

Sensirion SPS30 A & B Comparison, 7/22-8/28/2019
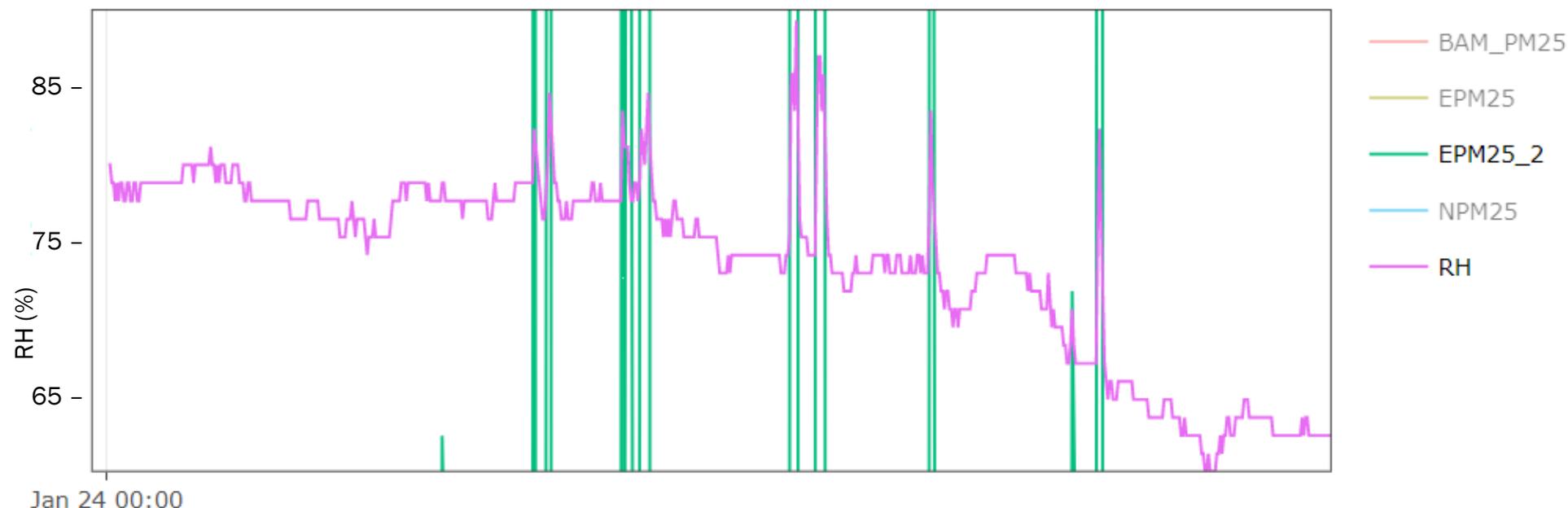
<- Spider crawls in

Challenges: Water droplets? Fog? TBD

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- Spikes began in October 2020 at Colville (sensor deployed in June)
- Spikes generally occur when:
  - Dewpoint is within 5 F of ambient temperature
  - Ambient temperature < 40 F
- RH temporarily increases by >4% for several minutes

Successes, Surprises, Challenges

- **Successes**
  - API data access and solar power worked well
  - Sensors show no signs of post-smoke degradation

- **Surprises**
  - Sensor readings were lower than reference instruments during wildfires in some places
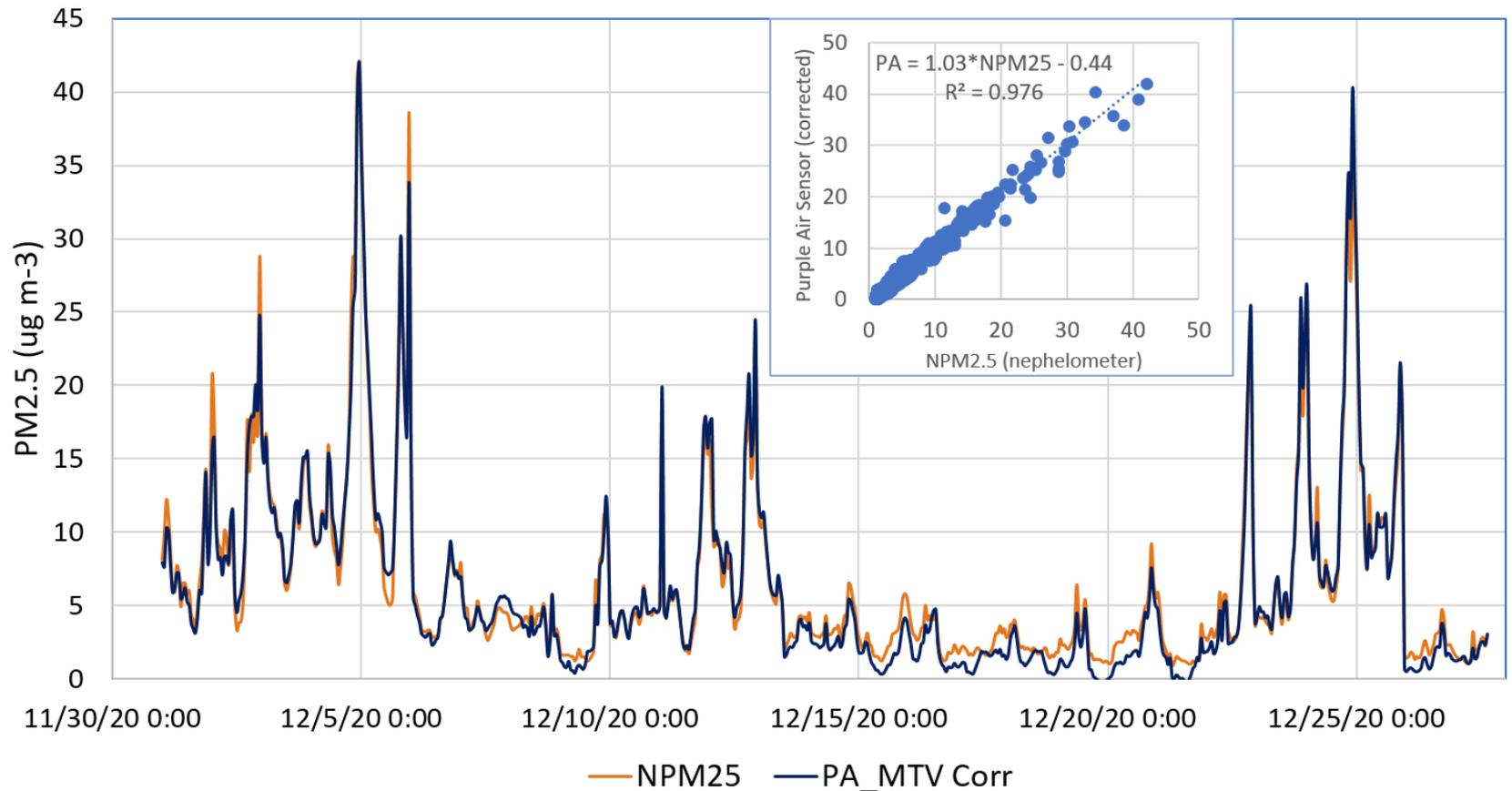 - Estimating $PM_{2.5}$ from sensor PM_1 was more accurate than using sensor $PM_{2.5}$

- **Challenges**
  - Spider webs
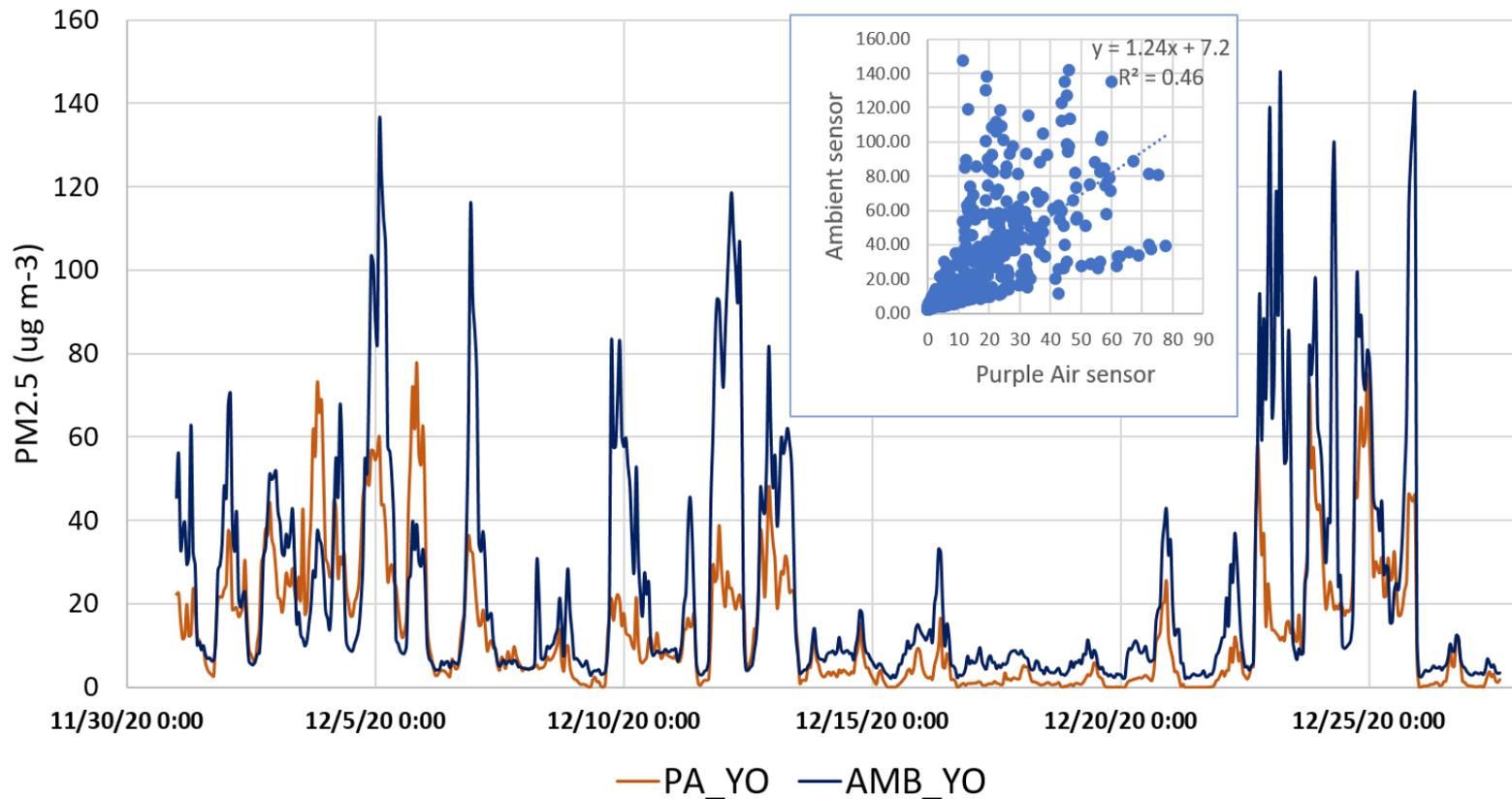 - Cold high-humidity environments

Purple Air (ORCAA)
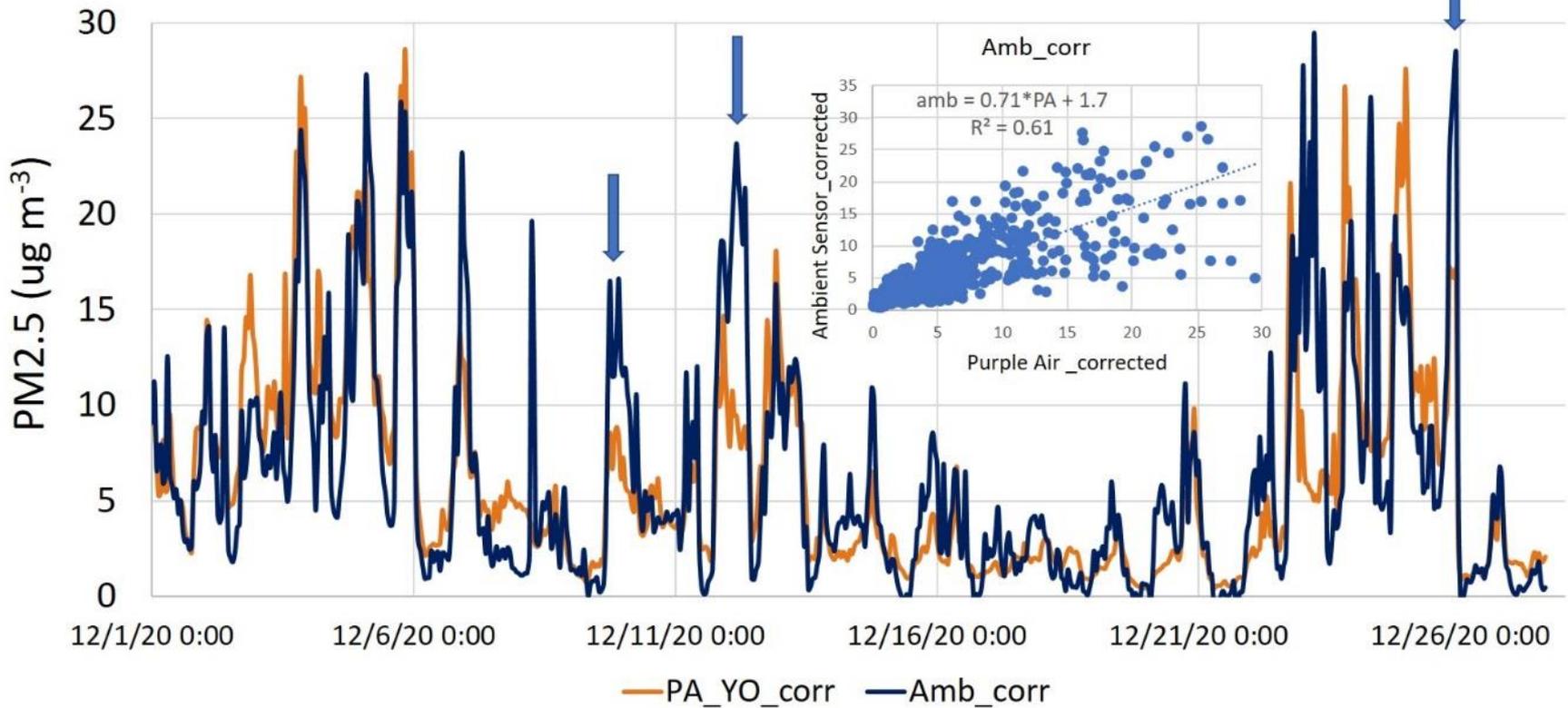

Purple Air vs M903 nephelometer

Ambient Weather PM$_{2.5}$ Monitor (ORCAA)

Purple Air vs. Ambient Air (uncorrected)

Ambient Weather PM$_{2.5}$ Monitor (ORCAA)

Ambient sensor vs. Purple Air (corrected)

Thank you for your time!

Any questions?

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