South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

# 39th AAAR Annual Conference

## Particle Measurement on Mobile Platforms: Considerations in Using Reference-Grade Monitors, Low-Cost Particle Sensors, and Particle Trajectory Modeling

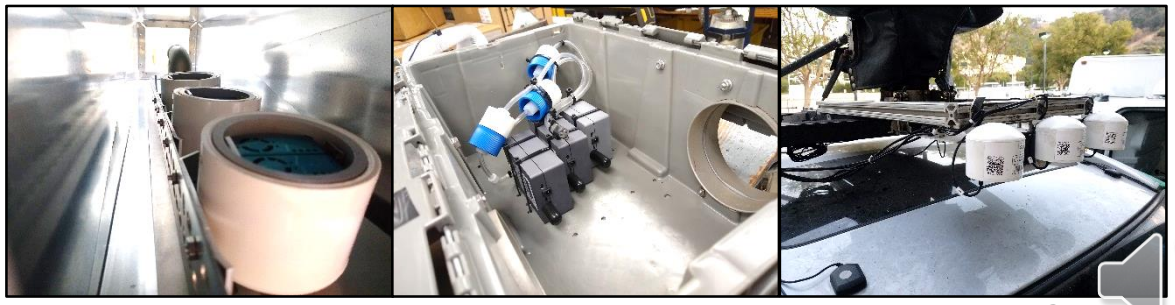

Wilton Mui, Air Quality Specialist
Berj Der Boghossian, Air Quality Specialist
Ashley Collier-Oxandale, Air Quality Specialist
Steve Boddeker, Air Quality Specialist
Jason Low, Monitoring & Analysis Assistant Deputy Executive Officer
Vasileios Papapostolou, AQ-SPEC Supervisor
Andrea Polidori, Advanced Monitoring Technologies Manager


Virtual – October 18-22, 2021

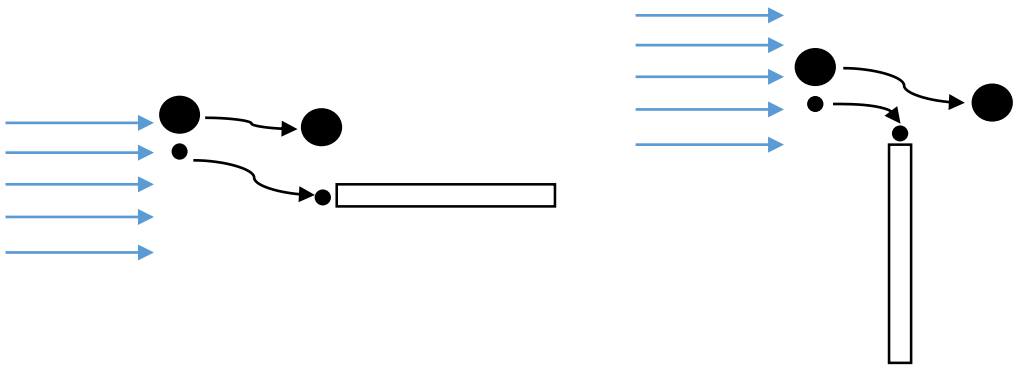
# AQ-SPEC

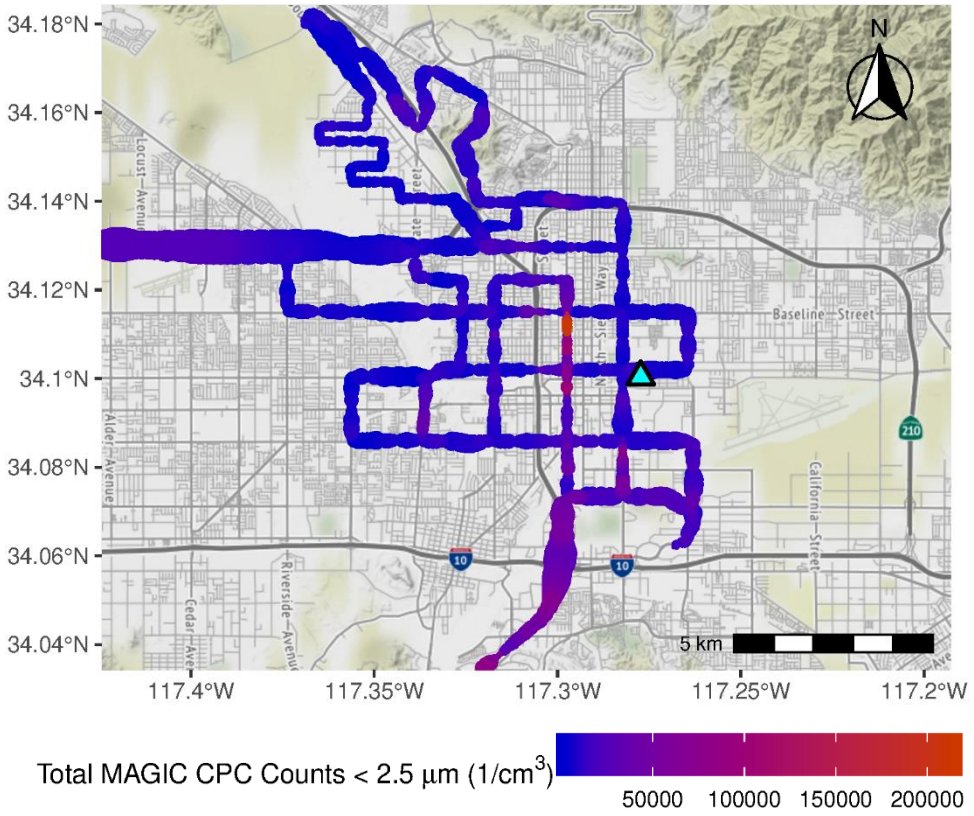
## Air Quality Sensor Performance Evaluation Center

- Mobile Measurements
  - Higher spatial resolution and coverage for less capital cost
  - Potential to sample difficult locations
  - Space and power constraints
  - Labor intensive (e.g. driver)
  - Particle sampling difficult
  - Data interpretation difficult
- Low-Cost PM Sensors
  - Less capital cost (~1-2 orders of magnitude)
  - Less space and power needs
  - Data interpretation difficult
  - Mui et al. **2021**, *ES&T*, "Development of a Performance Evaluation Protocol for Air Sensors Deployed on a Google Street View Car" (DOI 10.1021/acs.est.0c05955)

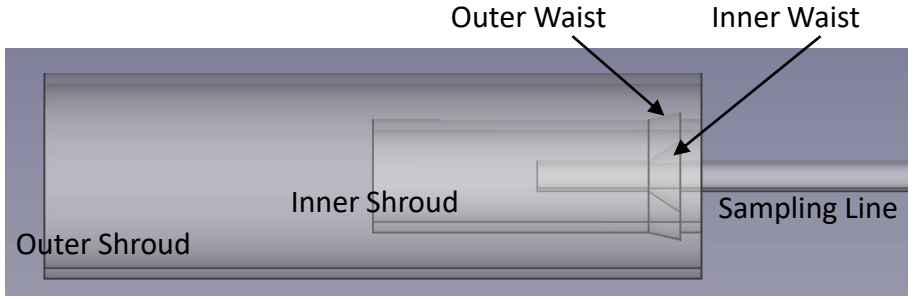



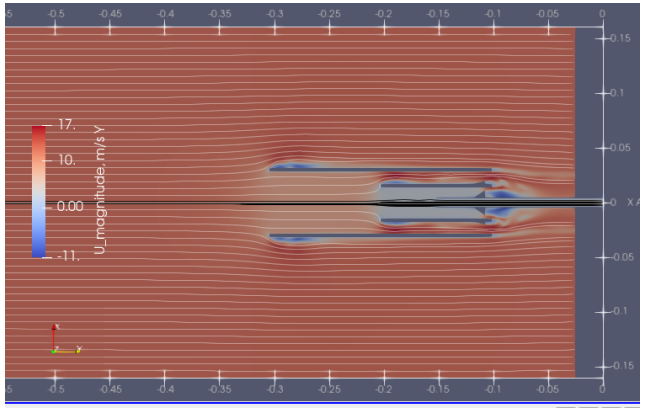
- Sampling a moving airstream with reference monitors – anisokinetic and anisoaxial penalties on higher inertial particles (large $d_p$)
  - Ultrafines negligibly impacted (e.g. CPCs)
  - $PM_{2.5}$ somewhat impacted (e.g. optical $PM_{2.5}$ monitors)
  - $PM_{10}$ severely impacted (e.g. $PM_{10}$ filter samplers)

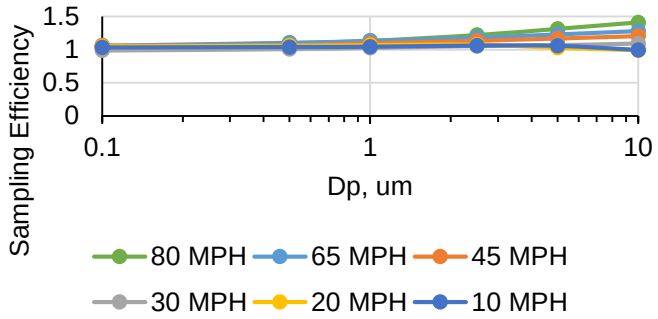




- Reference monitor probe design
  - *Aerocalc* Excel sheet tool (by Paul Baron, 2001)
  - *Particle Loss Calculator* Igor tool (by SL von der Weiden et al., 2009)
  - Computational fluid dynamics (CFD) + particle trajectory simulations using free, open-source software
    - *FreeCAD* with *CfdOF* workbench: Geometry, plotting, easy UI
    - *OpenFOAM*: Meshing, CFD
    - *ParaView*: Visualization, fluid streamline, fluid field solution export, easy UI
    - *R*: Trajectory simulations of particles (with mass)



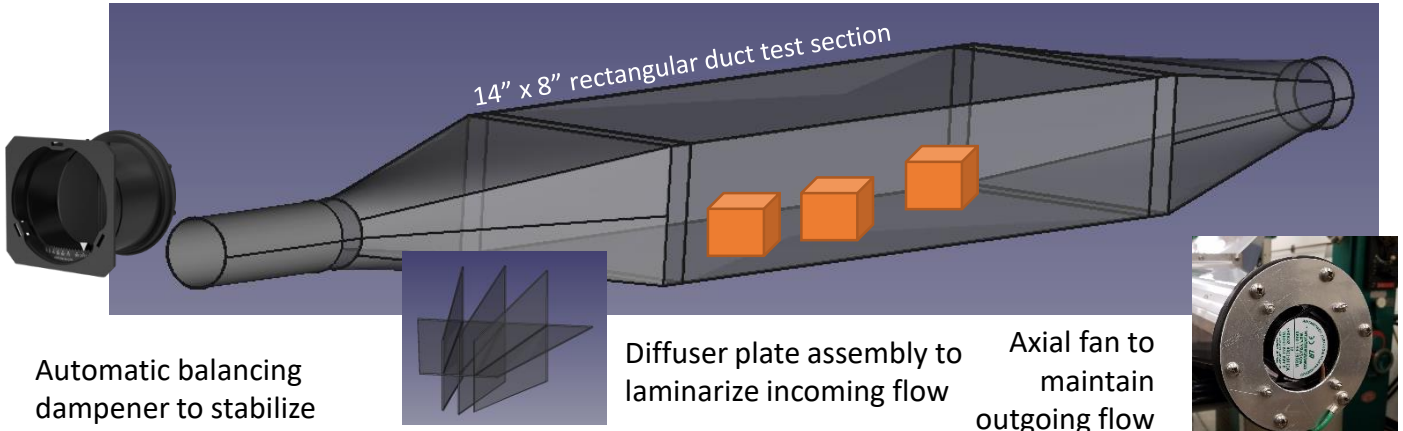
- Sampling a moving airstream with low-cost PM sensors – even more challenges
  - Sampling with fans or passively
  - Ill-defined inlets
  - Flow-rate assumed constant, not monitored







- Sampling with low-cost PM sensors in a controlled-flow duct
  - Designed to actively maintain non-turbulent conditions inside regardless of vehicle speed

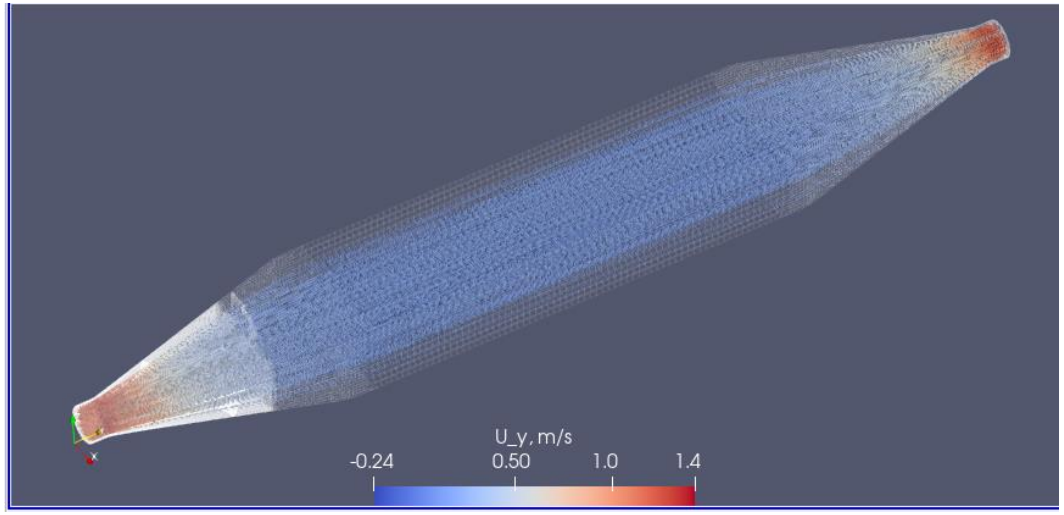



Automatic balancing dampener to stabilize incoming flow rate

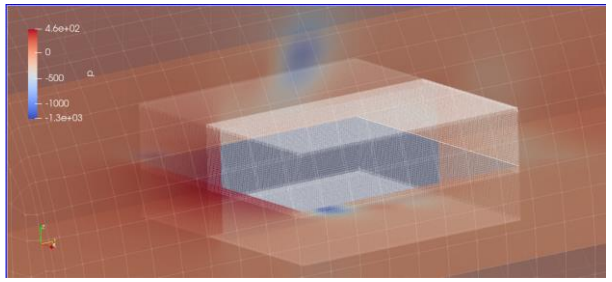
Diffuser plate assembly to laminarize incoming flow

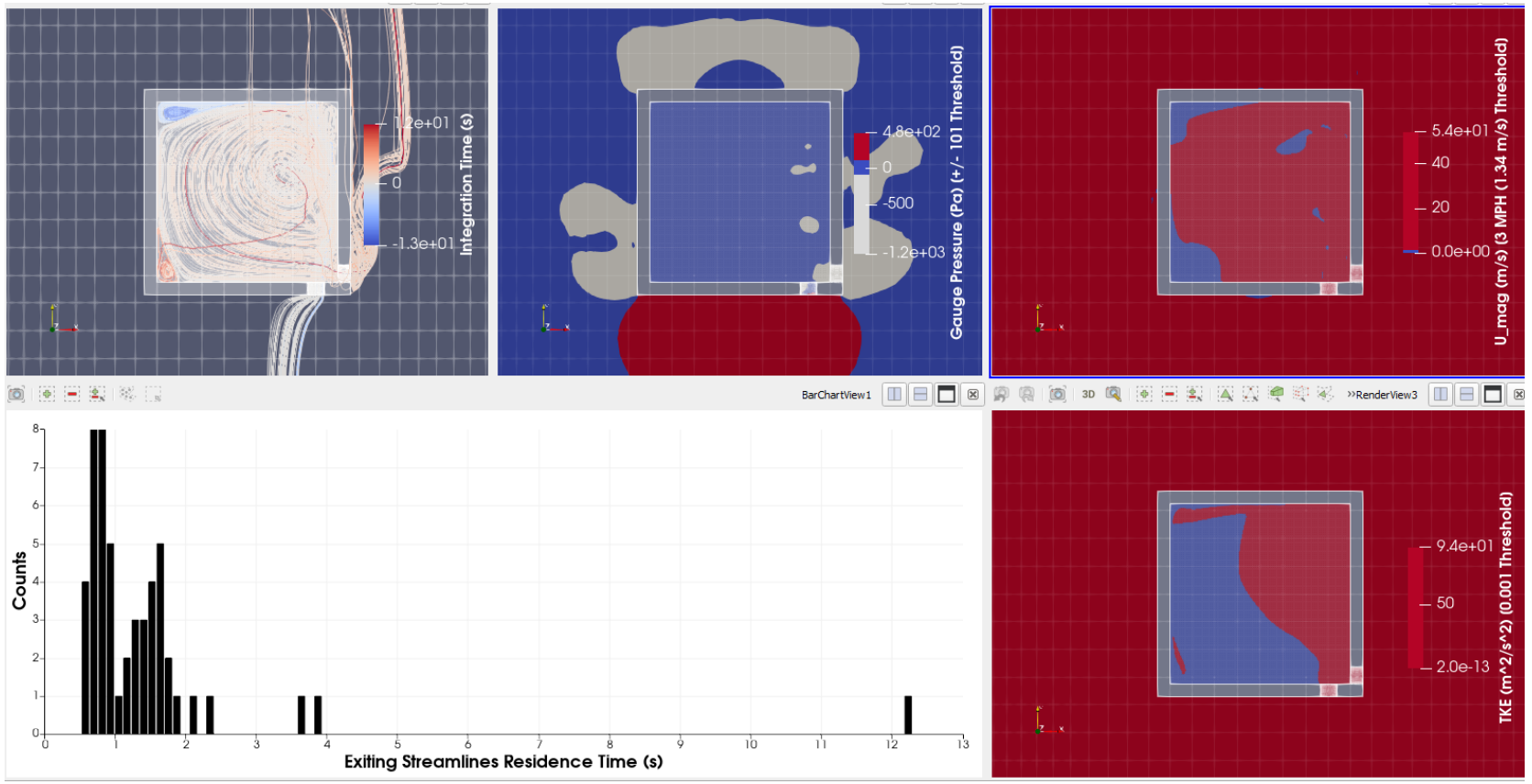
Axial fan to maintain outgoing flow rate



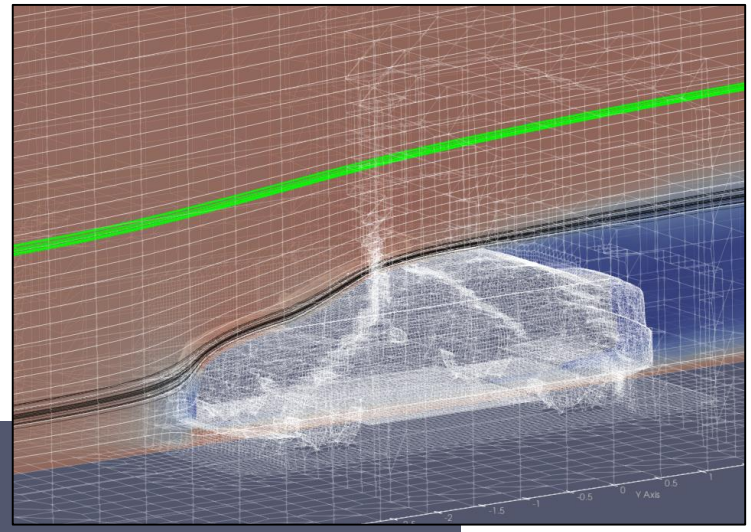


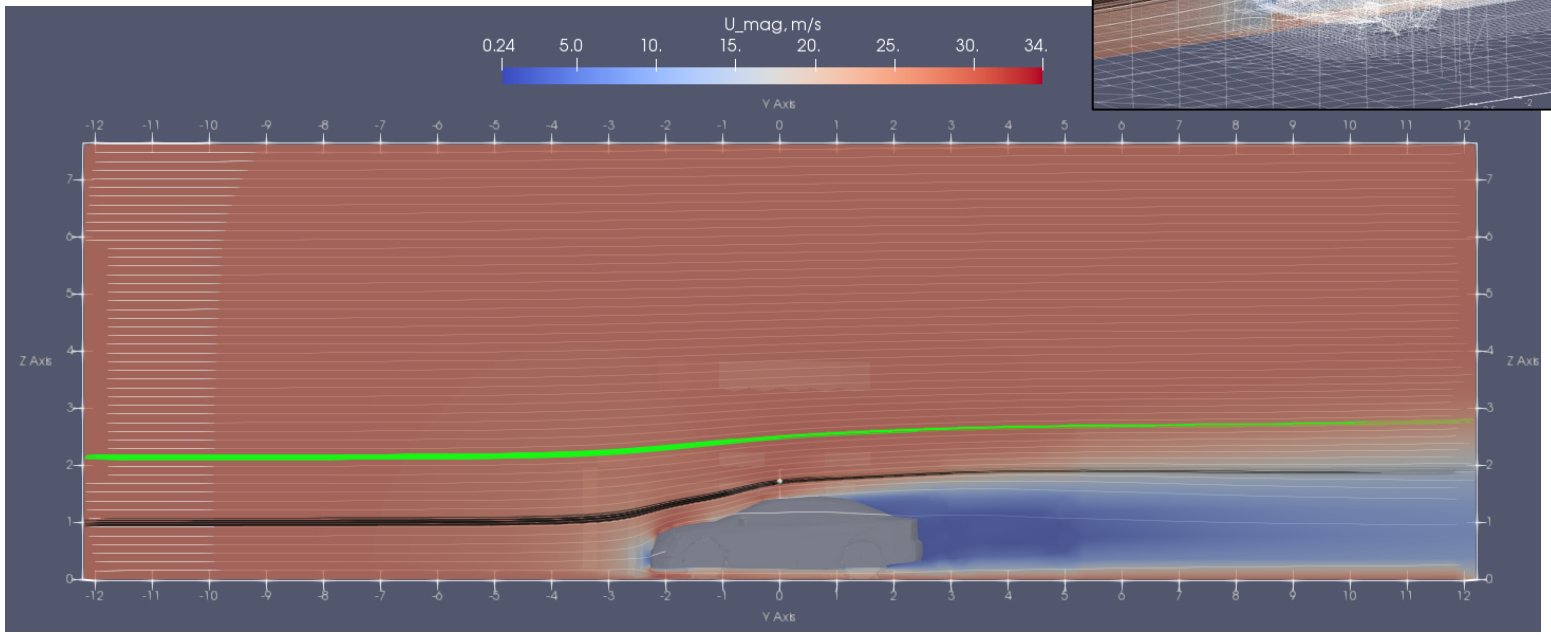

- Sampling with low-cost PM sensors in a semi-controlled rooftop box
  - Designed to passively result in low-turbulence conditions inside regardless of vehicle speed



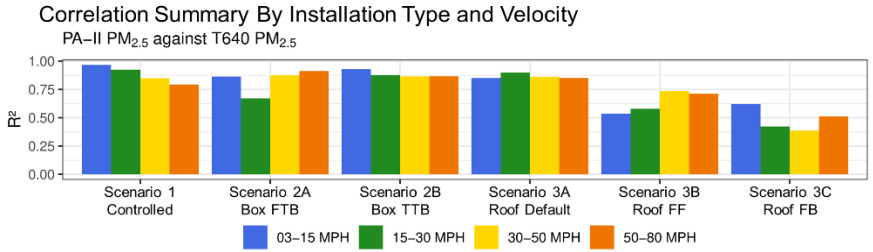



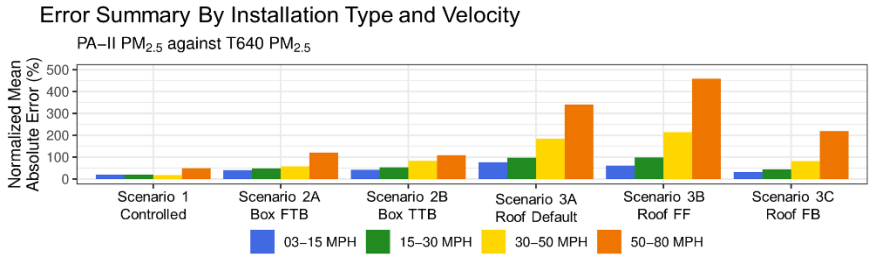
- Sampling with low-cost PM sensors completely unprotected on vehicle rooftop
  - Lowest-resource options for sampling with low-cost PM sensors





- Future Developments
  - Next-gen mobile platform buildout
  - Low-cost sensor mobile deployment performance evaluations
  - Supplementary mobile deployment testing using new chamber (vibration tests)
  - Guidance for community scientists – sampling with low-cost PM sensors, and improving data quality with limited resources




# Contact AQ-SPEC

**www.aqmd.gov/aq-spec**

info.aq-spec@aqmd.gov

# Contact the Speakers

Vasileios Papapostolou, Sc.D.
Program Supervisor, AQ-SPEC
vpapapostolou@aqmd.gov
(909) 396-2254

Wilton Mui, Ph.D.
Air Quality Specialist
wmui@aqmd.gov
(909) 396-2260