A Simple and Low-cost Mobile Sensor System for Measuring Spatial Concentration Gradient of $PM_{2.5}$

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Abstract

- Capturing spatial variations of air pollutant concentration are important for exposure assessment and air quality management purposes.
- Most research-grade mobile sampling instruments are large, expensive, and require vehicle modifications.
- Here we demonstrate a simple mobile sensor system based on low-cost optical particle sensors to characterize spatial concentration gradient of $PM_{2.5}$.
- The system is low-power consumption, small and can be easily attached to carrying vehicle without physical alternation to the vehicle.
- We tested the sensor along a fixed bus route and preliminary results suggest reasonable performance.

Mobile Sampling & Data Processing

- Sensor system attached to a UCF campus shuttle for a week (8/17/2018 – 8/24/2018)
- Shuttle drives between UCF campus and two off-campus apartments about 4 km away
- Sensor system and GPS powered through the 12V vehicle charging port using an USB adapter
- Configured to measure PM_1, $PM_{2.5}$, and PM_{10} concentration every 5s
- Data stored on a internal microSD card.
- ~119,000 data points collected during the week
- 30 s GPS data interpolated to time stamp of PM data, and averaged to 100 m roadway segments

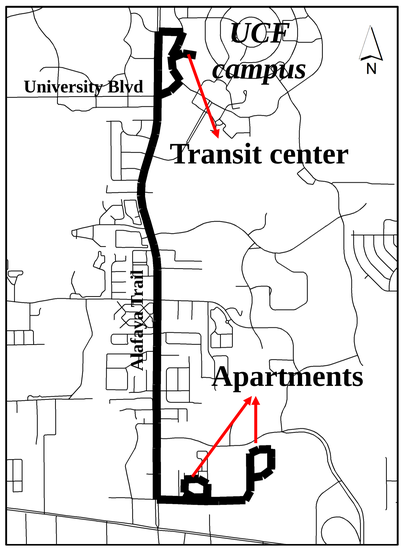

Figure 3. Driving route of the selected UCF shuttle bus

Figure 4. Outside of the bus

Figure 5. Inside of the bus

Low-cost sensor system

- Sensing units developed by Dr. Michael Bergin' group at Duke University.
- Plantower PMS 3003 optical particle sensor
- 3D printed weather-proof enclosure with a 5 V, 30 mm fan for air exchange (Fig. 1 & 2)
- Location tracked using QStarz's BT-Q1000XT GPS Travel Recorder at 30 s

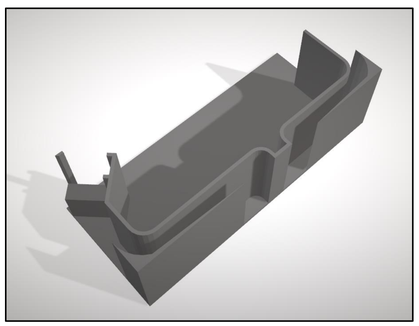

Figure 1. 3D model of enclosure

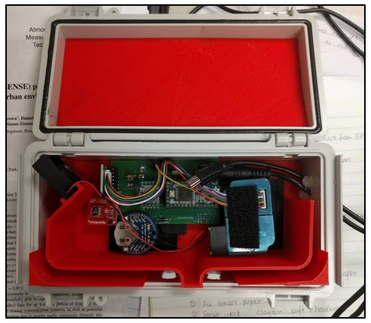

Figure 2. Assembled sensor

Results and Discussion

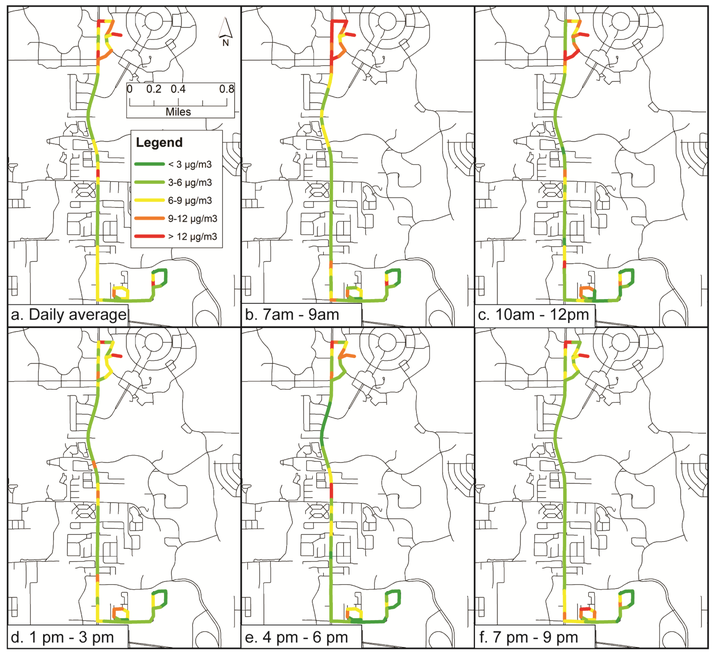

Figure 6. Measured $PM_{2.5}$ concentrations on 8/20/2018 along the sampling route

- The highest $PM_{2.5}$ concentrations were found near the transit center, where shuttle idling activities are common
- At the two intersections near UCF main campus, $PM_{2.5}$ concentrations are consistently higher than elsewhere. Heavy vehicle volumes are expected at these two intersections.
- $PM_{2.5}$ concentrations near UCF campus are higher during morning rush hour (7-9 am), but not as high during afternoon rush hour.
- The captured spatial and temporal patterns of concentration variations are reasonable.
- This sensor system is low-cost (~$400), easy to deploy and operate, and can be expanded to also measure concentrations of selected gaseous pollutants.
- It's suitable for the purpose of identifying pollution hotspot.
- This is a rather "hobbyist" style system with no accurate flow and turbulence control mechanisms. Careful calibration is needed.

Acknowledgement & Contact

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