# the air you breathe

**LESSONS FROM THE COMMUNITY AIR MONITORING PROJECT**
at UCLA's University Village Apartments.

**June 2019**




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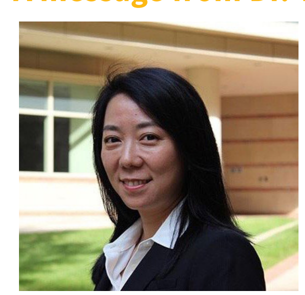
**A message from Dr. Yifang Zhu:** We are so thrilled to be working on this air monitoring project with your community. With your help, we have gained a better understanding of how freeway emissions impact the air quality in neighborhoods like yours and the many other near-freeway communities across Los Angeles. Our hope is that the air sensors located throughout your community and within select apartments will empower you to gain a better understanding of what is in the air you breathe, allowing you to take measures to protect your family's health and wellbeing. As a former resident of University Village Apartments, I know just how important it is to have access to this information, which is why all of the data from our air sensors are publicly available online in real time. After a year of collecting outdoor and indoor air quality data, we are excited to present you with our most important findings to date. We hope this information can serve as a practical guide for understanding your air quality and protecting your health. Please don't hesitate to reach out if you have any questions or thoughts about the project.



Best,

Yifang Zhu

Professor of Environmental Health Sciences, Fielding School of Public Health in short

# Executive summary

This report presents the most up-to-date findings from the air monitoring project at University Village Apartments (University Village or UV). South Coast Air Quality Management District (SCAQMD), UCLA researchers, and the University Apartments South Resident Association (UASRA) worked together to initiate this project to address community concerns about the impact of the freeway on air quality. In late 2017-early 2018, we installed twelve particulate matter (PM) sensors outdoors throughout the community, along with eighteen sensors inside of participating apartment units. The overarching goals of the project are broad and discussed in detail in the introduction of this report. This report seeks to present community members with the preliminary findings of the project, recommendations for minimizing exposures to pollution, and background information about air quality at University Village and the health impacts of the freeway, as well as information about how to view and interpret the air quality data in real time.

We report on the research questions and methods shown in Box 1 to the right. The outdoor analysis included assessing seasonal, temporal, and spatial trends, as well as regression modeling and correlation analysis to understand the impact of the freeway. Indoor air quality analysis involved using the activity logs and indoor and outdoor PM data to measure the impacts of household activities and outdoor PM on the indoor air quality, including regression and correlation analysis to assess the relative importance of these factors. Key findings are summarized on the following page (Boxes 2 and 3).

While we found some evidence of the freeway impacting outdoor PM levels and that this significantly influences the concentration of PM

Above: I-405 traffic during Thanksgiving weekend 2017
Source: KABC-TV

**BOX 1. RESEARCH QUESTIONS AND METHODOLOGY**

RESEARCH QUESTIONS

- What are the outdoor air quality characteristics at UV and which factors influence this?
- Which factors influence indoor air quality at UV?

DATA AND METHODS

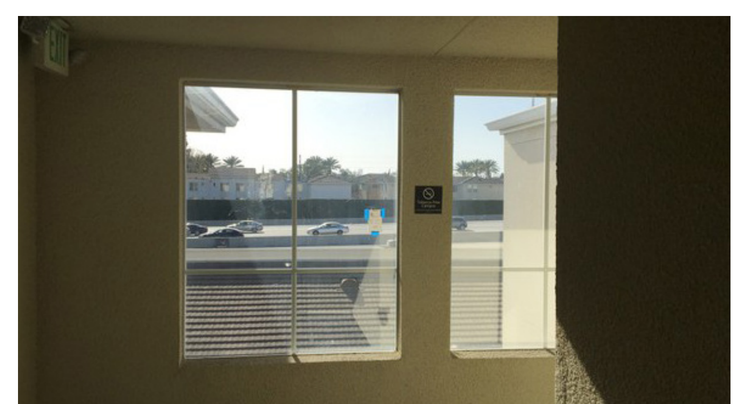
- 12 outdoor PurpleAir II (PA-II) PM sensors & 18 indoor PA-II sensors (measure PM0.3, PM0.5, PM1.0, PM2.5, & PM10)
- 13 hourly indoor activity logs with 1-week of data
- Meteorological & PM reference data from nearest SCAQMD stations
- Vehicle & truck flows on I-405 from CalTrans



## Short on time and want to know the key takeaways? Check out the boxes below.

indoors, the observed effect is modest. Though there are many other pollutants associated with traffic, including the smallest particles, that we were not able to measure, the relatively minor impact of I-405 on indoor PM2.5 is good news for the entire community given that PM2.5 is a pollutant of top concern for health and that most people spend approximate 90% of their time indoors.[1] In the upcoming months, the research team will bring high-quality research equipment to the community to further test for freeway impacts on air quality.

Our findings indicate that residents can protect their indoor air quality by using the stove fan and opening windows during cooking and cleaning activities, using an air purifier, and turning on the HVAC system (even just in fan mode). Residents can consult the real-time PurpleAir map online to see if the outdoor air has low PM levels, indicating that it is a good time to open windows and bring fresh air into the home. Additionally, our findings indicate that residents should avoid outdoor exercise in their community during the early morning and late at night, when PM levels are highest. The real-time nature of the air sensor network can also help residents plan outdoor activities with their children and infants by indicating whether the PM in the community is at a healthy level for these sensitive groups. These results highlight a suite of options residents can utilize to minimize exposure to both indoor and outdoor pollutants. ❑



Above: view from outside the window of one UV building
Source: KCRW

**BOX 2. KEY FINDINGS: OUTDOOR AIR QUALITY**

Spatiotemporal trends:
- PM levels are highest in the winter due to a lower atmospheric boundary layer that traps pollution and less atmospheric mixing
- PM levels are highest in the early morning and late at night due to a lowering of the atmospheric boundary layer after sundown
- Locations sheltered from the freeway by structures seem have lower PM levels than non-sheltered locations

Freeway impacts:
- There is a moderate correlation between traffic flow and PM in winter (r=0.53-0.54), but not in summer (r=0.17-0.18)
- Rush hour traffic on weekday mornings causes a PM peak
- During morning rush hour, the source of PM0.3 (closest size particle to typical tailpipe emissions detectable by PA-II) on each side of the community is the freeway
- PA-II is excellent at picking up ambient PM, wildfires, and barbequing, but is not ideal for measuring fresh tailpipe emissions (predominantly composed of smaller particles than the sensor can accurately detect)

**BOX 3. KEY FINDINGS: INDOOR AIR QUALITY**

Sources:
- Though indoor air quality is positively associated with outdoor PM levels ($p<0.001$), the strongest predictors of indoor PM are activities occurring inside the house
- Cooking can increase indoor PM by 5-20x
- Candle burning can increase indoor PM by up to 50x
- Across seasons, indoor PM is slightly elevated during morning rush hour compared to non-rush hour. I/O ratios indicate that this is not due to indoor activities

Mitigating factors:
- Using the fan/opening windows during & after cooking helps quickly decrease indoor PM
- Apartments that used air purifiers all the time had significantly cleaner indoor air than those that only used an air purifier sometimes and not at all
- MLR found that HVAC use was significantly negatively associated with indoor PM ($p<0.001$)

**NEXT STEPS**

- Further air quality testing... using research-grade equipment
- Increase awareness... of actions to reduce exposure
- Community action... to increase availability of air purifiers for residents

introduction

# What's the deal with low-cost air sensors?

## LOW-COST SENSORS: EMERGING TECHNOLOGY

Air quality is of paramount concern in Los Angeles, which was recently ranked for the 19th consecutive year as the most polluted metropolitan area by the American Lung Association.[2] In recent years, hotter days and stronger inversion layers have led to the entrapment of vehicle emissions in the basin, creating smog that exceeded National Ambient Air Quality Standards (NAAQS) for a total of 126 days in 2018.[3] In the past decades, air pollution has consistently ranked as one of the top five causes of morbidity and mortality globally.[4] In 2015, an estimated 4.2 million people perished due to fine particulate matter (PM2.5) exposure, with an associated 103.[5] million Disability Adjusted Life Years (DALYs).[5] In that same year, ozone exposures led to an additional quarter-million deaths and 4.1 million DALYs due to chronic obstructive pulmonary disease.[6] When indoor exposure to air pollution is factored in, the results are astounding: an estimated 7 million people perish annually due to poor air quality.[6] For these reasons, air pollutants, like PM and ozone, are regulated by the EPA under the Clean Air Act.

As individuals have become increasingly concerned about pollution, a new market has emerged to fill consumer demand for personal air monitoring in the form of "low-cost" sensors (e.g. commercially available sensors at a low cost relative to research grade instruments). The low-cost sensor industry has rapidly expanded over the past decade and, today, numerous models with prices ranging from US$150 to US$2,000 are available to the public, measuring pollutants ranging from PM to carbon monoxide.[7] These sensors can help augment data from stationary air monitoring, provide comprehensive information about personal exposures for epidemiologic studies,

Above: tailpipe emissions from gasoline-powered vehicles
Source: The Independent

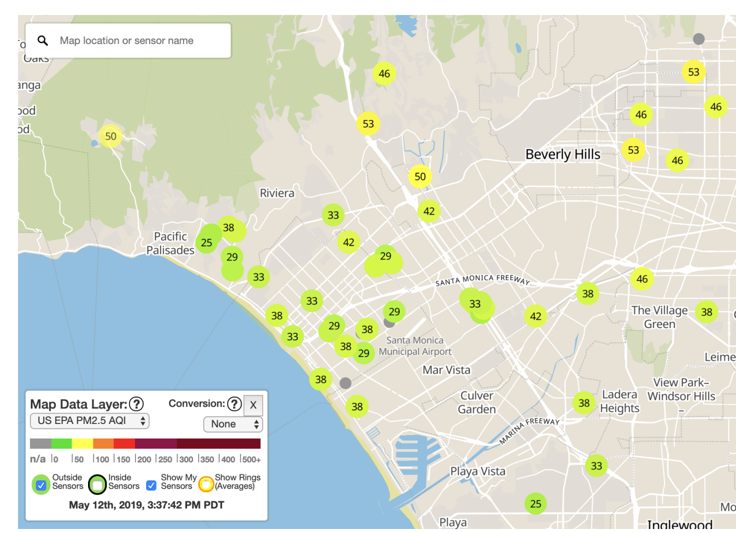
supply a means for communities to increase engagement and understanding of local air quality issues, and identify particular sources of air pollution, such as leak detection monitoring at industrial facilities.[7-10] However, there is significant concern regarding the validity and reliability of the data recorded by these devices. Many of these sensors are released to the public with minimal testing and calibration procedures and without the benefit of peer-review by researchers.[7,10–12]

## LOW-COST SENSORS AND THE EPA STAR GRANT

Recognizing the utility of this new air sensor technology, the U.S. Environmental Protection Agency (EPA) released a report detailing its goals and plans to encourage development of new and improved low-cost sensors, the systematic testing of such sensors to characterize performance, and greater community engagement and outreach regarding their use.[8] As a part of their efforts to accelerate what they call the "Next Generation of Air Monitoring", the EPA has partnered with South Coast Air Quality Management District (SCAQMD), UCLA, and others through the Science to Achieve Results (STAR) grant program (EPA STAR Grant#R836184). The goals of the project are to provide communities across California with the knowledge necessary to select, use, and maintain low-cost sensors and to correctly interpret their data. This includes sensor testing to provide consumers with information about their accuracy, the initiation of community air monitoring projects throughout the region, and the development of a toolkit that community organizations can use to start their own air monitoring projects utilizing low-cost sensors.

## THE UNIVERSITY VILLAGE PROJECT

In late 2017, your community, University Village Apartments ("University Village" or UV), became the first to embark upon this research with SCAQMD. Recognizing the significant need for access to air quality information so that residents can protect themselves from exposure




Above: the purple air sensor network nearby University Village Apartments. Map shows outdoor PM2.5 levels

to vehicle pollutants, SCAQMD initiated the air monitoring project at UV with the help of UCLA and University Apartments South Residents Association (UASRA) as the pilot community for the larger STAR grant. The overarching goals of this project are to provide residents with real-time access to air quality information, gain an understanding of how freeway emissions impact neighborhoods, and gather community feedback to help develop the toolkit.

Over the past year, residents at UV have opened their homes—and WiFi networks—to an air sensor system that has been collecting air quality data throughout the entire complex. This report presents an analysis of the air quality trends observed, as well as information about air pollution and health, actionable ways to minimize exposure to pollutants, and details about how to use the sensor network in your daily lives.

## RESEARCH QUESTIONS AND METHODS

In Los Angeles, vehicles are responsible for 50% of all PM2.5 emissions in the city, a pollutant linked with numerous health impacts and one of the top causes of premature death worldwide.[13] As such, a PM sensor, called "PurpleAir II" (PA-II), was selected for this project. Through prior testing, SCAQMD has found that this sensor is highly accurate, and the real-time reporting to an online map makes it ideal for providing widespread access to information. While the air monitoring research at University Village has a number of goals related to the larger EPA STAR Project (as mentioned above), the focus of this report is the assessment of air quality in the community and how it is impacted by the freeway. The primary research questions we explore in this report are as follows:

Research Topic 1: What are the outdoor air quality characteristics in the community and which factors influence them?

cont.

# Project background

Research Topic 2: Which factors influence indoor air quality at University Village?

To explore these questions, we installed twelve PA-II air sensors outdoors, six on each side of the freeway. The locations were chosen to capture air quality along the length of the freeway, as well as moving away from it. When feasible, sensors were located near outdoor play areas and other key communal spaces, like the childcare center, playgrounds, and pool. We also placed eighteen air sensors inside apartments and asked participants to keep detailed activity logs in order to assess the indoor air quality trends in the complex.

**WHAT WE HAVE LEARNED**

These sensors have been collecting data for over a year and reporting the air quality in real-time on an open-source map, providing residents with access to important information about air quality in the neighborhood. Readings from the air sensors, along with additional data sources, have allowed us to explore trends like the impact of the freeway, seasonal changes, and wildfires on the air quality at University Village over the past year. We found evidence for strong seasonal variability in air quality and that traffic on the freeway has some impact on outdoor PM levels in the neighborhood. We also learned that outdoor PM affects indoor air quality, but that peoples' activities inside their apartments play the largest role in determining indoor air quality. We found that activities like cooking, cleaning, and candle burning increase indoor PM, but that these impacts can be partly offset by increasing ventilation through stove fan, HVAC, and air purifier use. Lastly, through this project, we learned that the PA-II is a valuable resource for informing individuals about their indoor air quality and general outdoor ambient air quality trends, wildfire impacts, and other unique events (like weekend barbeques in the common areas), but that it is not the ideal device for studying fine-scale freeway impacts due to inaccuracy of estimating the smallest PM sizes. This project is one of the first to use a low-cost sensor to study freeway impacts, so these new understandings of the limitations of the PA-II will help communities and researchers select the most useful sensors for their needs.

Above: a PurpleAir II placed on a user's patio
Source: purpleair.com

In the following pages, we will provide a review of the relevant background information and the results of the research. In Section 2 of the report, basic information about outdoor and indoor air quality and health impacts related to the freeway are presented, along with actionable methods for protecting your health. In Section 3 of the report, we review the findings of the research, including an analysis of outdoor and indoor air quality characteristics in your community and the factors that impact them. Lastly, in Section 4, the supplement, you will find directions for how to view the air sensor data online, download the data for your personal use, and advice on how to select an indoor air purifier. ❑

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# Air quality in your neighborhood

## Each community has unique characterstics that contribute to the outdoor air quality.

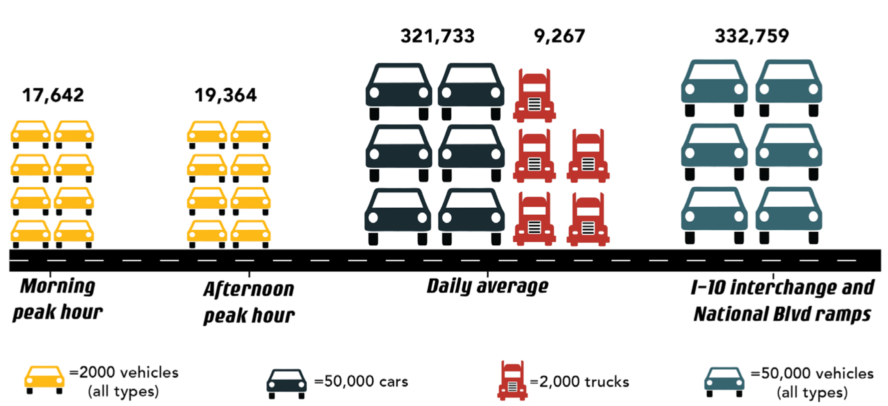
**YOUR'S INCLUDE:**

- **DISTANCE TO THE 405: ABOUT 150 FEET**
- **TRAFFIC VOLUMES, FLOWS, & VEHICLE MIX ON THE 405**
- **LOCALIZED WIND AND WEATHER PATTERNS**

Pollutants associated with freeways include particulate matter (PM), ultrafine particles (UFP), black carbon (BC), ozone, carbon monoxide (CO), volatile organic compounds, polycyclic aromatic hydrocarbons (PAH) and nitrogen and sulfur oxides (NOx & SOx).[14] The amounts of these pollutants in your community are directly related to proximity to the freeway, traffic flows, the types of vehicles using the road, and local weather patterns. University Village is located about 150 feet away from the freeway, well within the 500 foot zone that California air quality experts say is dangerous for locating homes, schools, and hospitals.[15] Fortunately, there is relatively low freight traffic on the 405 in this area, which emits, on average, 5x more PM than passenger vehicles and can emit up to 60x more PM.[16,17] However, the proximity of the complex to the I-10 interchange and National Blvd ramps puts the area at risk of heightened pollution levels due to congestion at these locations.

Several studies from around the world have found that congestion and peak hour traffic result in significantly higher pollutant emissions.[13,18–24] These studies rely on either modeling, on the ground measurements (in situ), or a combination of the two to assess the impact of the freeway on air quality. Recently, researchers at UC Riverside utilized phone GPS data, traffic counts, and the California Air Resources Board emissions model to estimate emissions on freeways and arterial roads. They found heightened pollutant levels during peak hours, particularly around intersection and interchange bottlenecks.[24] In addition to the modeling study mentioned above, a few in situ studies of traffic emissions have been conducted in the Los Angeles area.[13,22,23] In 2008 and 2011, researchers collected UFP, PM2.5, particle-bound PAH (PB-PAH), NO, and CO measurements in West Los Angeles on a mobile monitoring platform. They found higher concentrations of pollutants on weekdays, which had higher congestion, compared to weekends.[13] In eastern Los Angeles County, researchers using a vehicle carrying a variety of sensors took measurements along freeway and arterial routes and found that vehicle emissions were significantly higher as congestion increased. However, the greatest predictor of pollutant levels was truck density, as these vehicles are the most polluting.[23] In another study in Los Angeles and Riverside Counties, researchers recorded real-time traffic counts, speeds, and vehicle mix on freeways and arterials and combined this information with an emissions model to estimate tailpipe emissions under the observed traffic conditions. They found that emissions of CO, hydrocarbons, and NOx were highest at very high speeds (e.g. 70+ mph) and at heavily congested, slow speeds.[22] In general, during peak hours and the late night/early morning, you can expect the highest levels of pollutants outside.[25–27] ❑

### TRAFFIC VOLUMES ON THE 405 NEAR YOU



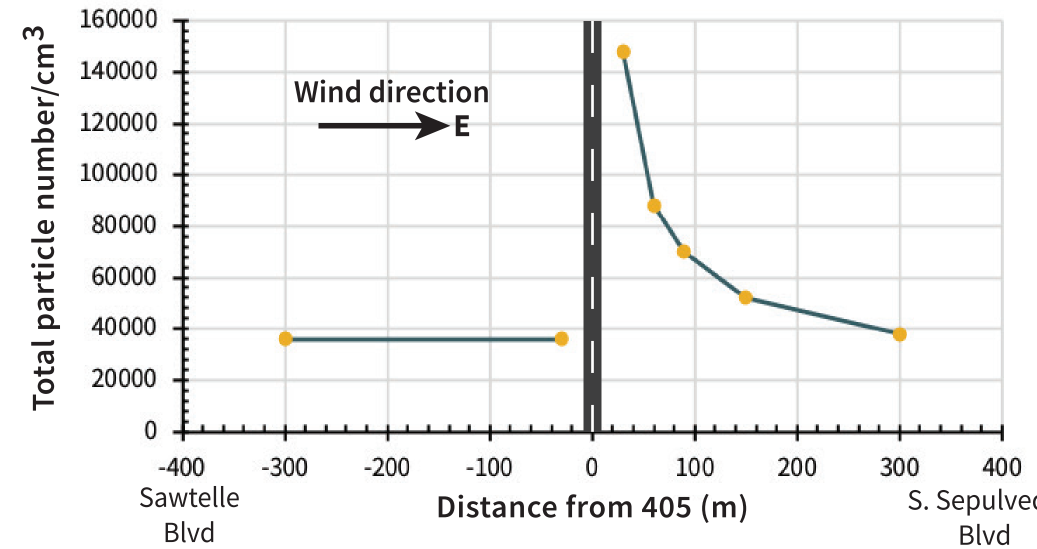

Traffic data from CalTrans Traffic Census Program. All data from 2017 counts, except truck data (from 2016)

## Predominant wind patterns influenced by the local geography create unique air quality conditions that vary by location and time of day.

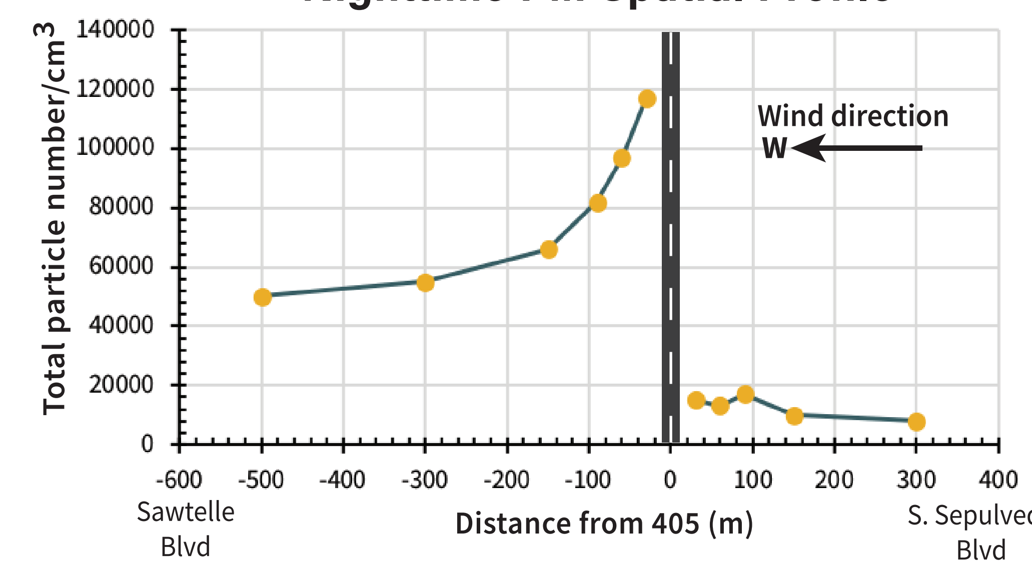
During the day, the breeze blows inland from the ocean, which means that the S. Sepulveda Blvd side of the apartment complex is downwind of the freeway. At night, the winds reverse, and freeway pollution blows towards the Sawtelle Blvd units. Because of these wind patterns, PM is generally higher on the S. Sepulveda side of the apartment complex during the day and higher on the Sawtelle Blvd side at night. Another noticeable trend is that PM is lowest at nighttime overall.

The graphs to the right illustrate these trends. This data was collected by Dr. Yifang Zhu in 2005 at the Los Angeles National Cemetery, approximately 3 miles north of your community.[28] While these graphs are useful for illustrating the general pollution patterns, keep in mind that traffic volumes have increased significantly, vehicles have become cleaner, and conditions at the cemetery are not the same as in your community. Therefore, the absolute levels of PM shown here are not necessarily reflective of those in your community today. ❑

### Day PM Spatial Profile




### Nighttime PM Spatial Profile



# Particle 101

## What is particulate matter (PM) and why should it be important to you?

**WHAT IS PM?**

Particle pollution, or PM, is a general term to describe a mixture of airborne particles and droplets.[29] PM is one of the major pollutants associated with freeways and can seriously impact health. In fact, in Los Angeles, vehicles are responsible for 50% of all PM2.5 emissions in city, which is why it is being monitored at University Village.[13] Particles are both directly emitted into the air and can be formed by chemical reactions between other pollutants. The image on this page shows the views of several different types of PM under a microscope.[30]

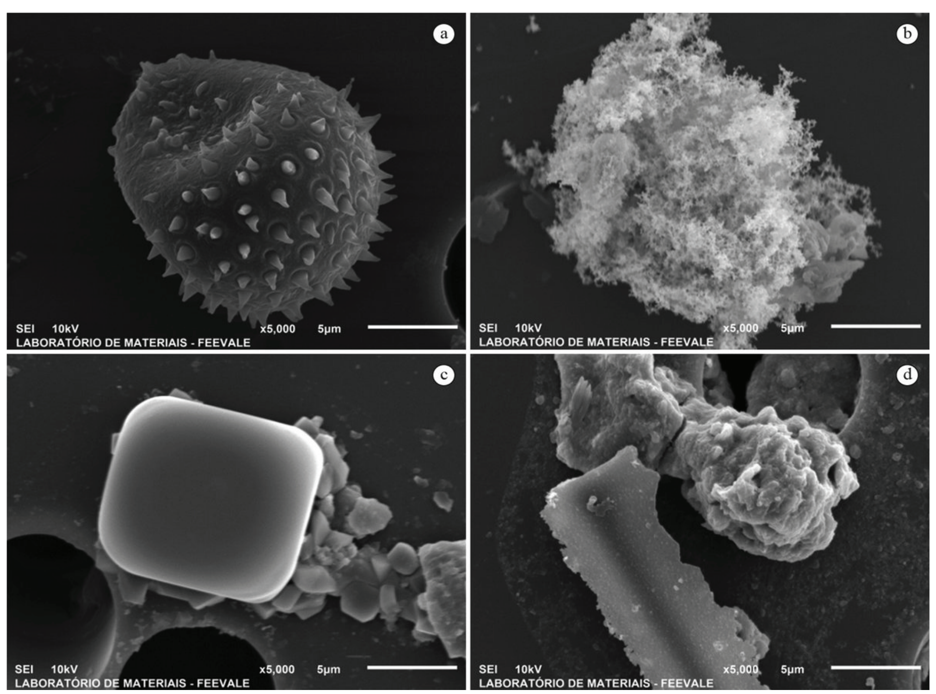
**HOW IS IT CLASSIFIED?**

Particles range in size and composition. Some are large enough to be seen as dust or dirt; others can only be seen with the help of a microscope.[29] Most commonly, measurements focus on two size ranges – particles less than 10 microns in diameter (coarse particles, PM2.5-10) and particles less than 2.5 microns (fine particles, PM2.5). Particles less than 0.1 micron in diameter are called ultrafine particles (UFP), which can be emitted during the process of fuel combustion. The PurpleAir sensors located throughout your community measure both coarse and fine particles (specifically PM10, PM2.5, and PM1.0), but not ultrafine particles. The figure on the following page illustrates the different sizes of PM in comparison to a human hair.[31]

**HOW DOES IT AFFECT HEALTH?**

Fine and coarse particles have different sources, properties, and effects. PM has been shown to cause premature death, heart attacks, stroke, asthma, decreased lung function, and lung cancer.[32] In 2015, an estimated 4.2 million people perished due to PM2.5 exposure, putting it in the top five mortality risk-factors worldwide.[5]

Particle size strongly affects the health impacts of PM. Larger particles, like PM10, impact the upper respiratory tract while smaller particles, like PM2.5 and ultrafine particles, can enter the lower respiratory tract and cross into the bloodstream. Many of the worst health impacts are attributed to fine particles because they can penetrate furthest into the body.[33]




(a) a particle of biological origin in the PM10 size range
(b) soot particle in the PM10 size range
(c) unknown cubic particle in the PM10 size range
(d) suspended soil particle in the PM10 size range

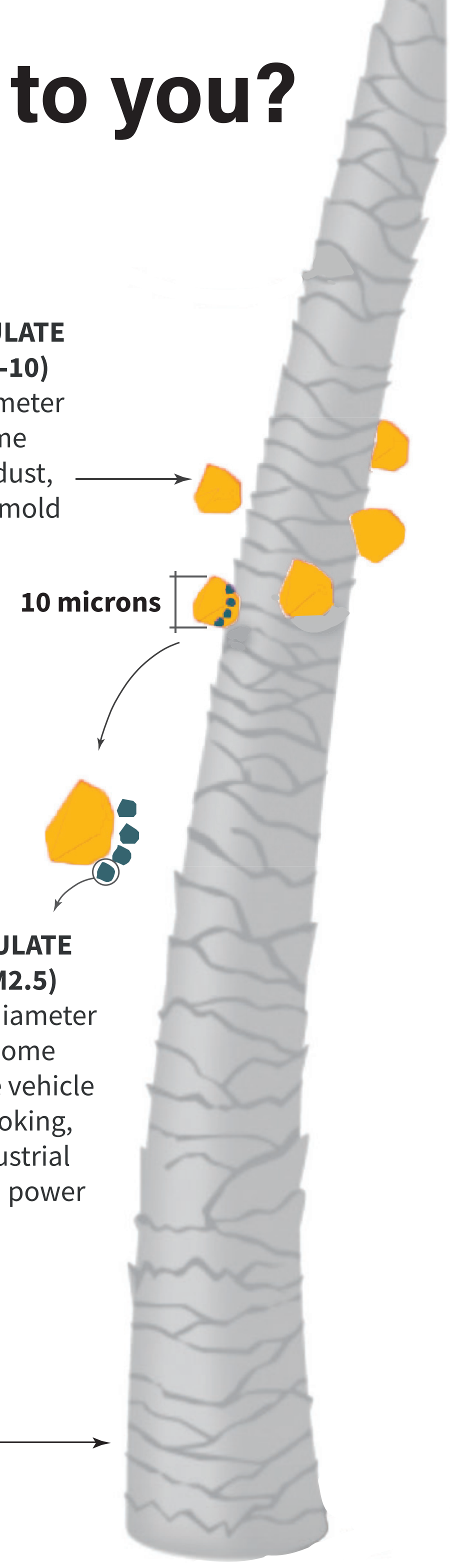
Source: Alves et al. 2015

**WHAT ARE THE REGULATIONS?**

The U.S. Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS) to protect human health. These standards stipulate that the average PM concentration in the outdoor air over a 24-hour and 1-year time-period should not exceed a certain threshold, based on the findings of health and risk assessments. The US standards for PM2.5 and PM10 are shown in the table below, along with the standards adopted by other nations and the World Health Organization.[34] ❑

**PM AIR QUALITY STANDARDS AROUND THE WORLD**

| Country/ Organization | | $PM_{2.5}$ (μg/m³) | $PM_{10}$ (μg/m³) | Time average |
|---|---|---|---|---|
| United States | | 35 | 150 | 24-hour |
| | | 12 | none | 1-year |
| Canada | | 30 | none | 24-hour |
| European Union | | 25 | 40 | 1-year |
| Australia | | 25 | 50 | 24-hour |
| | | 8 | none | 1-year |
| China | rural | 35 | 50 | 24-hour |
| | urban | 75 | 150 | |
| | rural | 15 | 40 | 1-year |
| | urban | 35 | 70 | |
| Mexico | | 45 | 75 | 24-hour |
| | | 12 | 40 | 1-year |
| World Health Organization | | 25 | 25 | 24-hour |
| | | 10 | 10 | 1-year |




Graphic adapted from South China Morning Post

# FREEWAY POLLUTION

## potential health effects of long-term exposure


Graphic adapted from the USC Environmental Health Centers[35]

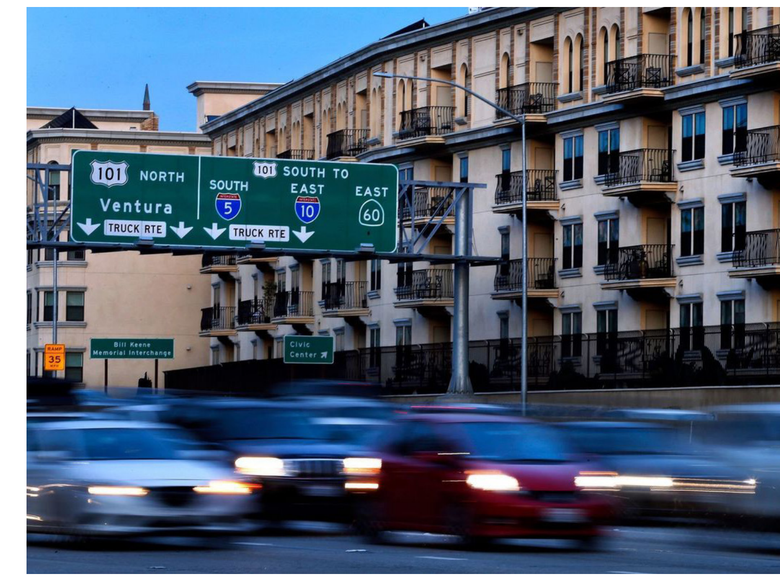


# Protect your health

According to decades of research, the zone within 500 ft of the freeway is most affected by vehicle emissions.[36] Elevated pollutant concentrations are observed within the first 0.2-0.3 mi of the freeway before reaching background levels, though pollutants can travel over a mile before dispersing, depending on conditions.[25,37,38] Despite widespread acceptance of the risks associated with freeway pollutants, 92% of parcels within 500 ft of a freeway are zoned for residential use in LA and thousands of new apartments are built on these parcels each year.[15,36] In Southern California, a majority of the housing in the 500 ft zone is multifamily, with significantly higher proportions of low-income and minority group members living there than in the region overall. As a result, minority and low-income neighborhoods experience 2-2.5 times the traffic volumes of other neighborhoods, which can result in disproportionate exposures to air pollution.[36,39]

In Southern California, vehicles are responsible for 76% of CO, 45% of VOC, and 63% of NOx levels in the region, all of which can harm wellbeing.[39] In the US, approximately 58,000 premature deaths are caused by traffic emissions.[40] In California alone, there are an estimated 21,000 premature deaths due to PM2.5 exposure—the highest in the nation.[40] According to the EPA Cumulative Exposure Project, vehicle emissions are responsible for about 70% of the cancer risk from outdoor air pollutants.[39] Those most vulnerable to health problems from freeway pollutant exposures include pregnant women, children, and the elderly, as well as people with preexisting cardiovascular and respiratory issues.[37] The infographic to the left illustrates some of the known health impacts of living near the freeway throughout the life cycle.[35]

Colloquially, many residents of University Village have reported signs and symptoms of chronic freeway-pollutant exposures, like throat and lung irritation, migraines, and breathing issues. If you have noticed a decline in your health since living near the freeway or you are worried about your exposures, there are steps you can take to protect yourself from freeway pollution both outdoors and in your home. Some examples of ways you can immediately avoid outdoor exposures are shown in the box to the right.[25] See the following page for tips to improve your indoor air quality. ❑




Above: the Da Vinci apartments in Downtown L.A., like University Village, are located immediately next to a major freeway. The number of housing units within 500 ft of the freeways is increasing in L.A., with 1.2 million people and growing living in these high pollution zones.[2] (Image: Mel Melcon/Los Angeles times)[41]

### Avoid outdoor exposures:

- **AVOID OUTDOOR EXERCISE EARLY IN THE MORNING, DURING PEAK HOURS, AND WHEN AQI* IS BAD**
- **CHECK YOUR COMMUNITY AIR SENSORS WHEN PLANNING OUTDOOR PLAY AND ACTIVITIES**
- **STAY INDOORS, CLOSE WINDOWS, & TURN ON YOUR HVAC FAN WHEN AQI IS POOR, LIKE DURING WILDFIRES**
- **MINIMIZE TIME SPENT DRIVING, WHICH ACCOUNTS FOR 33–45% OF TOTAL UFP EXPOSURES FOR ANGELENOS[23]**
- **WHEN DRIVING, CLOSE THE WINDOWS AND USE THE RECIRCULATION SETTING ON AC**
- **SELECT SCHOOLS/DAYCARES FOR CHILDREN THAT ARE AT LEAST 500 FT AWAY FROM THE FREEWAY**

*AQI= Air Quality Index

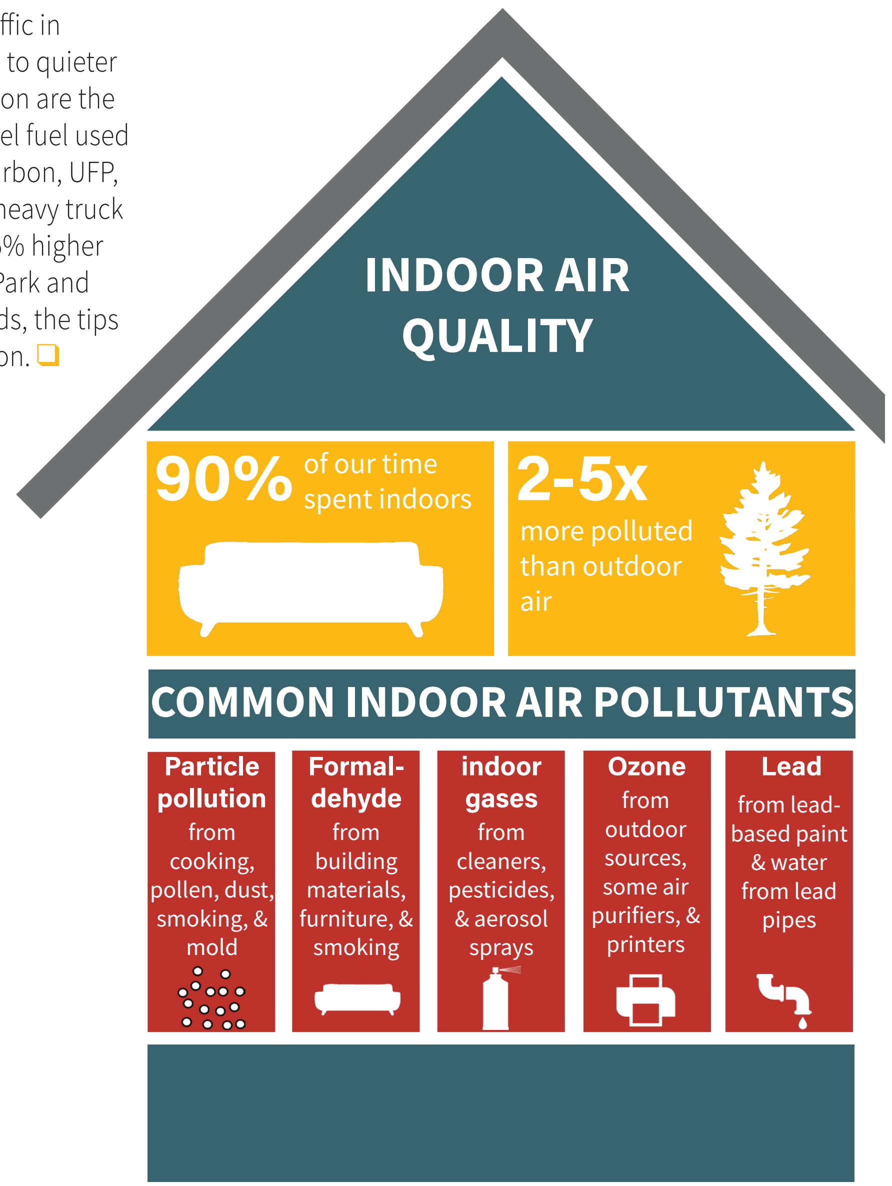
# indoor Air Quality

**It might be hard to believe in a place like LA, but indoor air is often more polluted than outdoor air. Because nearly 90% of our time is spent indoors, having healthy indoor air quality is critical.[1]**

As you plan your future moves, avoid choosing homes within 500 feet of the freeway (further if possible), busy streets (like Wilshire Boulevard), and major interchanges. Congestion and traffic in these areas result in heightened air pollution, compared to quieter neighborhood streets.[25,42] Another important consideration are the locations of ports, rail yards, and freight routes. The diesel fuel used in goods movement results in high levels of PM, black carbon, UFP, and other pollutants.[39,43] For example, in Boyle Heights, heavy truck volumes along I-5 have resulted in UFP levels that are 25% higher than those seen in nearby communities, like University Park and Downtown.[43] In addition to locating away from busy roads, the tips below offer some options for reducing indoor air pollution. ❑

### Ways to improve indoor air:[25,45]

- OPEN WINDOWS IF AQI IS GOOD
- USE VENTS WHEN COOKING
- USE AIR PURIFIERS IN THE HOME
- USE A HEPA-BAGGED VACUUM
- AVOID BURNING CANDLES
- DON'T SMOKE/VAPE INDOORS
- USE NON-TOXIC CLEANERS
- PLACE PLANTS IN YOUR HOME
- DUST HOME OFTEN
- KEEP HUMIDITY LOW
- INSTALL HIGH-EFFICIENCY HVAC FILTER




Graphic adapted from Dr. Jockers[46]

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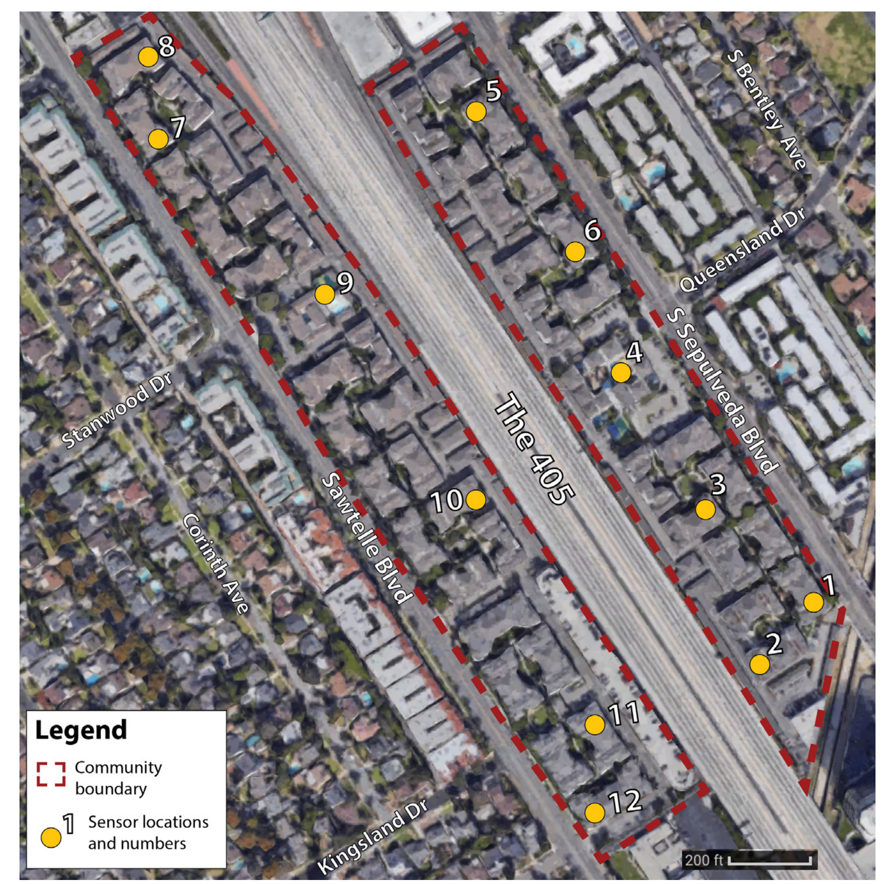
# the project

## Project basics:

- 12 OUTDOOR AIR SENSORS, 6 ON EACH SIDE OF THE 405
- OUTDOOR AIR SENSORS PLACED ON ROOFS THROUGHOUT COMPLEX
- 18 INDOOR AIR SENSORS IN SELECT APARTMENTS
- AIR SENSOR MODEL: PURPLEAIR II
- SENSORS RECORD PM1.0, PM2.5, PM10, TEMPERATURE, AND HUMIDITY
- SENSOR DATA PUBLICLY AVAILABLE IN REAL TIME AT PURPLEAIR.COM
- PROJECT LENGTH: NOVEMBER 2017 - PRESENT




Above: project map with outdoor air sensor locations.

Low-cost air sensors, like the PurpleAir sensor used in this project, present an exciting opportunity to supplement data from EPA monitoring stations to help us better understand local-scale air pollution and to involve citizen scientists and community organizations in the knowledge-making process. This study aims to evaluate how low-cost sensors compare to traditional air monitoring devices, gain a better understanding of how freeway emissions impact the air quality in neighborhoods like yours, and learn more about users' experiences with these devices. Our hope is that these air sensors will become a useful tool for community members by helping residents gain a better understanding of the air quality here, why it is important to their families' wellbeing, and what measures can be taken to protect their health.

For this project, a PM sensor was selected due to the impacts of PM on health and because it is one of the major pollutants associated with vehicles. Testing by the South Coast Air Quality Management District (SCAQMD) indicates that this sensor is ideal for studying air quality near freeways because of its accuracy and ease of use. The sensors are mounted outdoors throughout the community and inside select apartments, transmitting data in real-time. Everyone in the complex, as well as the general public, is able to view the real-time sensor data on the PurpleAir website, helping you become informed about the air quality in your area, plan outdoor activities accordingly, and manage your indoor air quality. The map to the left shows where the outdoor sensors are located. Sensors closest to your home will most accurately reflect the outdoor air quality near your house. ❑

# Outdoor Air Quality results

**PRELIMINARY FINDINGS ON OUTDOOR AIR QUALITY AT UNIVERSITY VILLAGE**

## Here's what one year of outdoor PM data can tell us about air quality at UV:

**BACKGROUND**

The twelve outdoor air sensors at UV are helping residents and researchers gain a better understanding of air quality in neighborhoods near the freeway. While there are important limitations to what these low-cost sensors can tell us, a comparison of the UV sensors to an EPA approved air quality monitor at the nearest SCAQMD station shows that the PA-IIs have tracked ambient PM trends remarkably well (Fig. 1). We also found similar PM levels across the sensors. Combined, this indicates the sensors have been performing with a good level of accuracy and precision.

**RESULTS: TEMPORAL AND SPATIAL TRENDS**

We found that PM levels are highest at night and in the early morning across all days of the week (Fig. 2). This result is supported by several studies on pollution near Los Angeles freeways, which found higher particle counts and concentrations in the late night and early morning due to stable atmospheric conditions and a lack of vertical mixing.[26–28,43,47–49] These researchers have also found that during the night and early morning, pollution from vehicles travel approximately 2km downwind of the freeway, compared to only 150-300 m during the daytime.[26–28] These results are alarming because over 50% of Southern Californian's live within 2km of a freeway and are affected by these elevated nighttime and morning PM levels.[50] Based on these findings, residents should avoid outdoor exercise near the freeway in the early morning and late at night, as increased respiration during exercise leads to greater pollutant exposures.[51]

We also found similar seasonal PM trends to those reported in the literature, with heightened PM levels in the months of October through February (Fig. 3). Colder temperatures in the winter lead to inversion layers in which warm air sits atop cold air, causing stagnant atmospheric conditions that trap pollutants closer to the ground and lead to poor air quality.[17,26,27,47,48]

Spatially, when controlling for wind direction, the PM concentrations on either side of the complex were fairly uniform, indicating that residents on one side of the

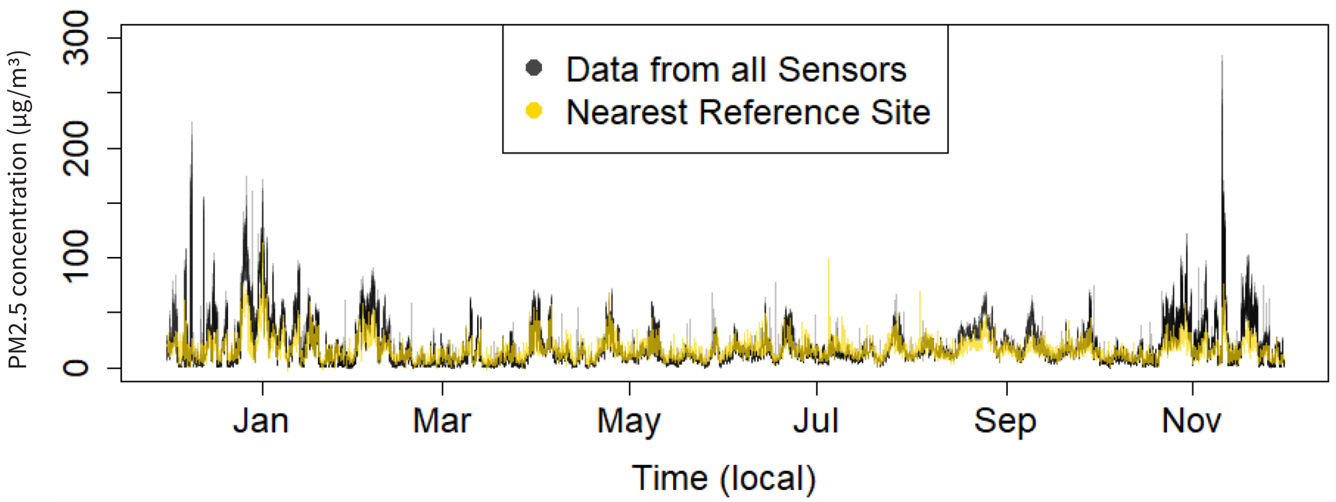



Fig. 1: comparison of UV air sensors' PM2.5 readings and DTLA SCAQMD reference monitor measurements

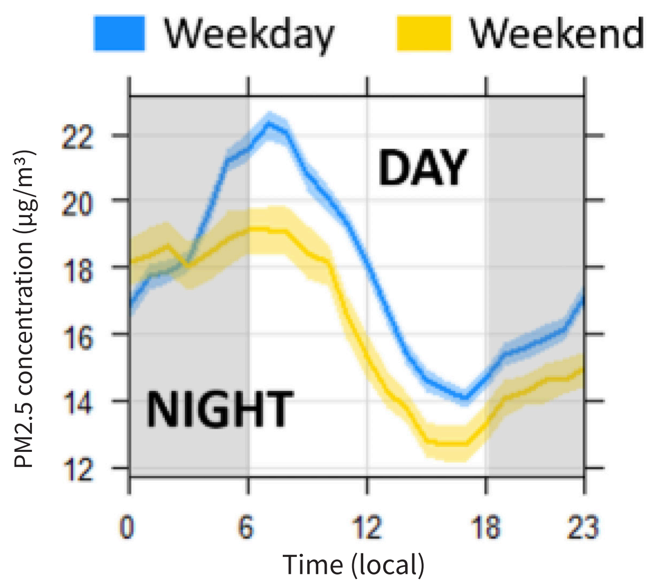



Fig. 2: hourly PM2.5 diurnal trends over one year

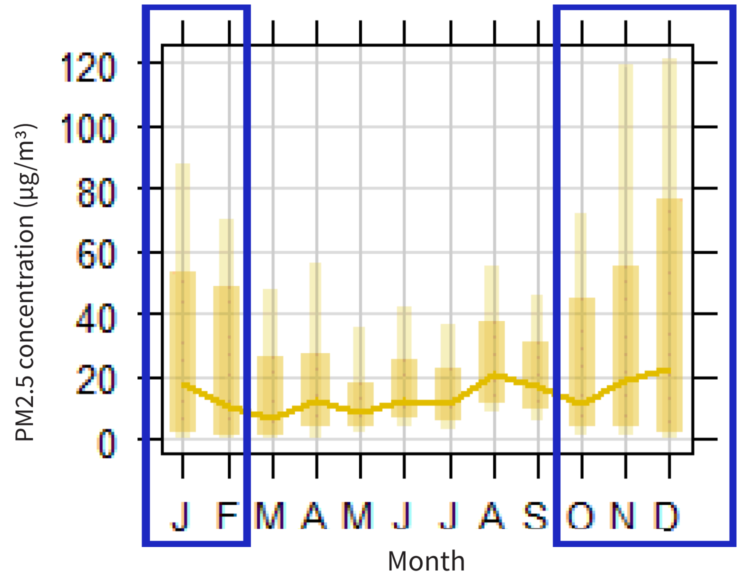



Fig. 3: monthly PM2.5 trends in 2018

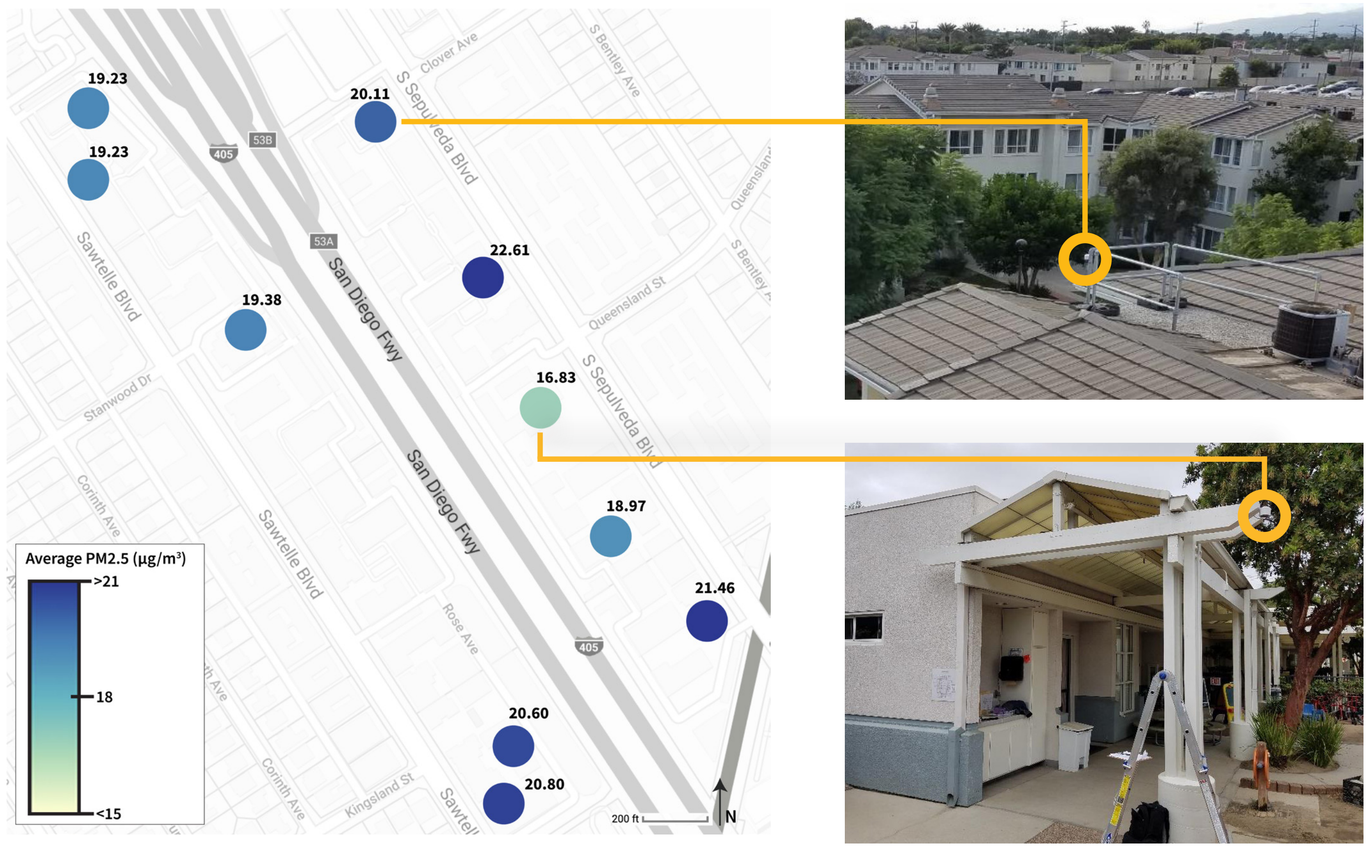



Fig. 4: average PM2.5 concentrations from each outdoor air sensor, controlling for wind direction (top). Sensor 04, located at the Childcare Center had the lowest PM levels, potentially due to sheltering (bottom). Most other outdoor air sensors are located on exposed rooftops (top).

# Outdoor Air Quality results

PRELIMINARY FINDINGS ON OUTDOOR AIR QUALITY AT UNIVERSITY VILLAGE

## Here's what one year of outdoor PM data can tell us about air quality at UV:

Above: downtown Los Angeles on a smoggy day

highway vs. the other are not at a disadvantage when it comes to PM1.0, PM2.5, and PM10 levels (Fig. 4). One unanticipated, positive finding of the spatial analysis is that the PM levels in the playground at the Childcare Center are significantly lower than the other outdoor air sensors on the Sepulveda side of the complex (Fig. 4). For example, in one of the months with the most complete data, October 2018, the PM levels at the Childcare Center were 1.02-3.08 µg/m3 lower, on average, than the other sensors on the Sepulveda side (PM1.0 $t(7488) = -4.03$, $p<0.001$, PM2.5 $t(7488) = -6.12$, $p<0.001$, PM10 $t(7488) = -2.72$, $p<0.005$). The lower PM levels in this location are likely due to the sheltered nature of the playground, which is in a courtyard sheltered on all sides by buildings. There is a well-established literature on the positive impact of barriers like vegetation, sound walls, and buildings on freeway adjacent air quality.[52–56]

**RESULTS: IMPACT OF THE FREEWAY**

As previously mentioned, researchers studying freeway impacts in Los Angeles have found the most pronounced effects during the morning rush hour, when traffic is high and atmospheric mixing is minimized. Based on this, we looked at diurnal PM trends by time of day and day of week and found consistently heightened PM levels between 7:00 am and 9:30 am on weekdays, but not on weekends (Fig. 5).

To further confirm whether heightened morning PM is related to traffic on the freeway, we created polar plots using the smallest size fraction of PM that the PA-IIs are able to collect (0.3µm) along with wind direction and wind speed data. Freshly emitted particles from vehicle exhaust are primarily within the UFP size-range (0.1µm), so the PA-II is only able to pick up a small portion of passenger vehicle exhaust. Despite this limitation, the PM0.3 trends clearly indicated a source of heightened PM coming from the direction of I-405 (Fig. 6). Lastly, we found a moderate correlation between traffic flow and PM in the winter (r=0.53-0.54), but not in summer (r=0.17-0.18).

Further analysis with research-grade equipment can help us better characterize the impacts of the freeway on air quality at University Village. In the upcoming months, the research team plans to bring research equipment that can measure smaller particle sizes to the community to supplement the PA-II data that has been collected thus far.❏

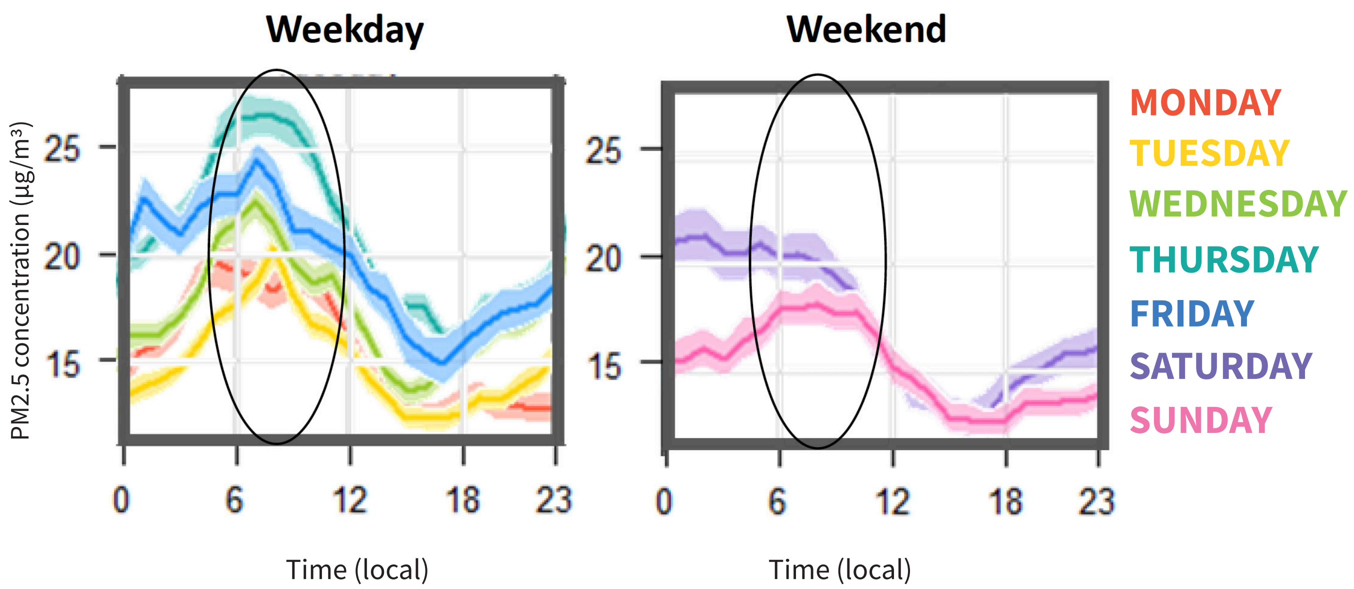



Fig. 5: hourly PM2.5 diurnal trends in Summer 2018. We see elevated concentrations during the morning rush-hour period only on weekdays. Overall, hourly PM2.5 is lower on the weekend than during the week

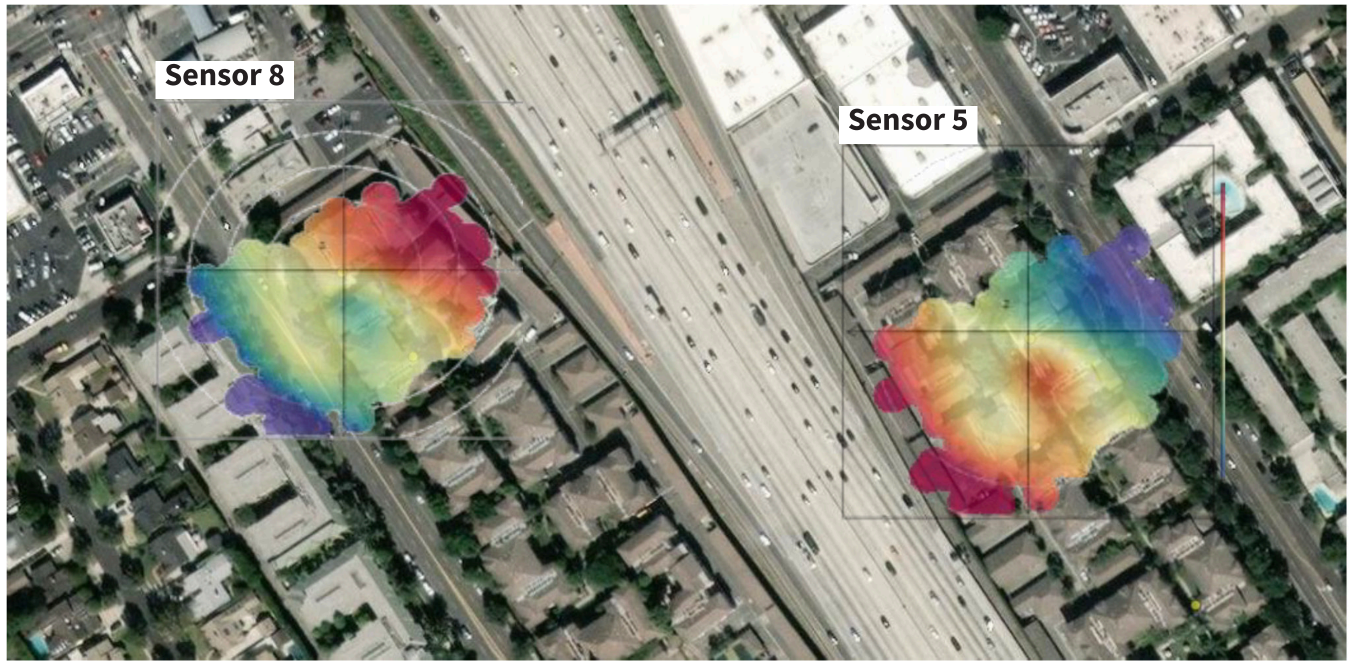



Fig. 6: polar plots of June 2018 weekday morning PM0.3 at Sensor 5 (Sepulveda side) and Sensor 8 (Sawtelle side). Plots were created by subtracting the Sensor 8 PM from Sensor 5 to control for ambient levels and comparing these readings to wind direction and speed recordings. Warmer colors indicate the direction of the emissions source. Here, we can see that PM0.3 is coming from the freeway, and is slightly higher on the Sawtelle side than the Sepulveda side.

# The Woolsey Fire

results

**PRELIMINARY FINDINGS ON OUTDOOR AIR QUALITY AT UNIVERSITY VILLAGE**

## Here's how the Woolsey Fire impacted air quality at University Village:

Above: the Woolsey Fire in Malibu (image: Kyle Grillot/ The Washington Post)

Over the last three years, California has had six of the top ten most destructive wildfires in the state's history, a trend that is expected to continue.[57] Researchers predict that the severity of wildfires across the state will be exacerbated by the effects of climate change.[58–60] During the fires in 2018, PurpleAir monitors throughout the state helped alert communities to the impact of wildfires on air quality and track pollutant plumes.

On November 8, 2018, the Woolsey Fire broke out in Malibu and burned 96,000 acres of land in Los Angeles and Ventura Counties prior to its full containment on November 22, 2018.[61] During the Woolsey Fire, the PurpleAir monitors throughout University Village detected elevated particle pollution during two periods that impacted both outdoor and indoor air quality throughout the community. We found increases in PM1.0, PM2.5, and PM10 during the wildfire. This was especially the case for PM2.5, as wildfires typically generate fine particles.[62]

Outdoor air pollution at University Village peaked on November 11th, three days after the start of the fire, with PM1.0, PM2.5, and PM10 reaching concentrations of 156 µg/m$^3$, 250 µg/m$^3$, and 295 µg/m$^3$, respectively (Fig.1). A second period of elevated PM occurred from November 16-22, 2018 (Fig. 1). Fig. 1 shows that indoor PM levels also increased during these periods, reaching peak levels several hours after the outdoor concentration peaked. It's interesting to note that there are numerous spikes in indoor PM levels throughout the month, indicating that cooking activities can lead to indoor PM levels similar or greater than those seen during the fire (Fig. 1).

The initial peak in PM coincided with a shift in wind patterns, which began to blow from the northwest on November 10th. During the second period of elevated PM, winds were predominantly blowing from the northwest and west (Fig. 2). The plots in Fig. 2 should be read by noting that the direction of the wedge shows the direction from which wind is blowing. The "length" of the wedge shows what percent of the average PM level at University Village came from a given direction. Additionally, the color of the wedge indicates the observed PM level when the wind was coming from that direction. This plot is used to help show the relationship between wind and pollution, by indicating the direction pollution is coming from. In Fig. 2, we can see that prior to the fire, wind was predominantly blowing from the southwest and pollution sources derived from the east of the sensors (likely the freeway) and the west. During the first, and highest, peak in PM, wind blew almost exclusively from the direction of the fire (northwest). During the second peak, wind and pollution sources came from the northwest and west, likely due to the widespread blanketing of smoke by the late stages of the fire.

With the frequency and severity of wildfires expected to increase in the coming years, the PurpleAir sensors in your community can serve as an important resource for minimizing exposure to hazardous pollution levels. In the advent of fires and other unique pollution events, residents can check the online map to see if pollutant levels merit staying indoors and utilizing air purifiers or the HVAC unit to keep the indoor air clean. This is especially important for families with young children or individuals sensitive to air quality.❏

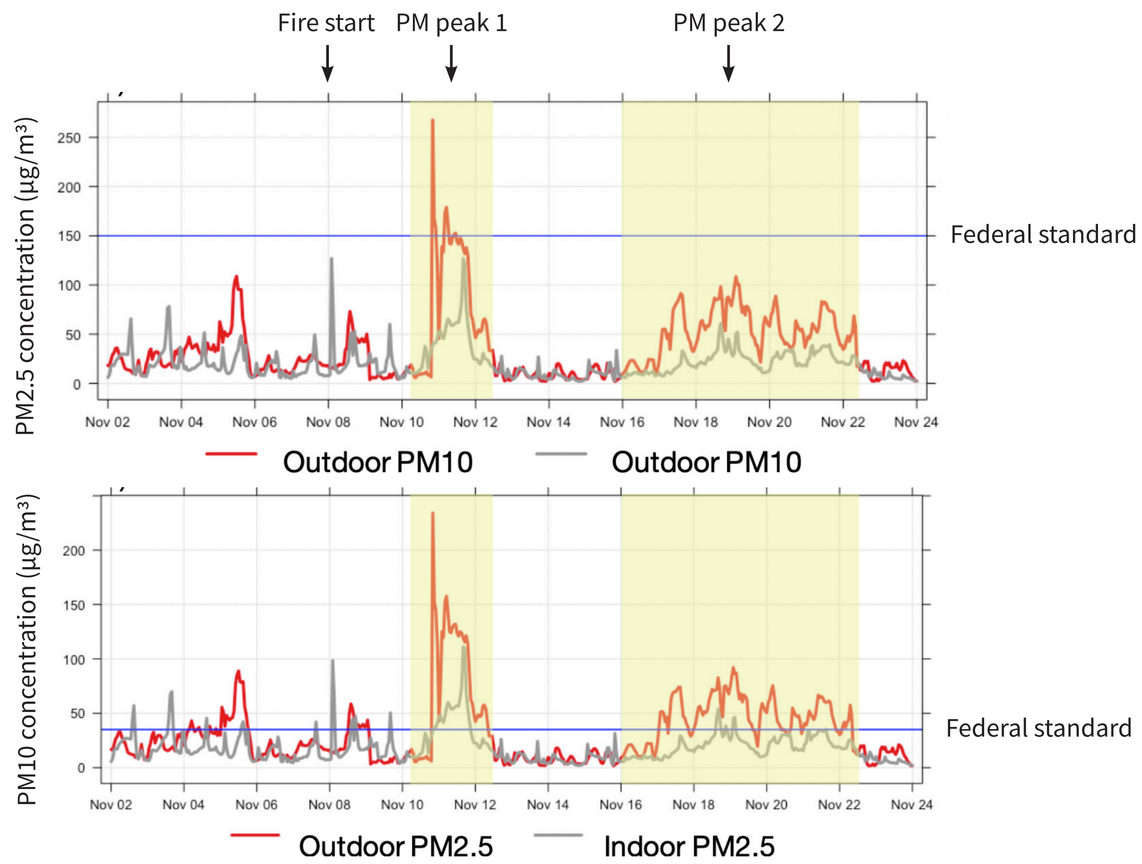



Fig. 1: hourly average outdoor and indoor PM2.5 and PM10 in November 2018. Federal air quality standards are indicated by the blue lines. Standards were exceeded for PM10 only on November 10th and 11th. PM2.5 standards were exceeded several times throughout the month

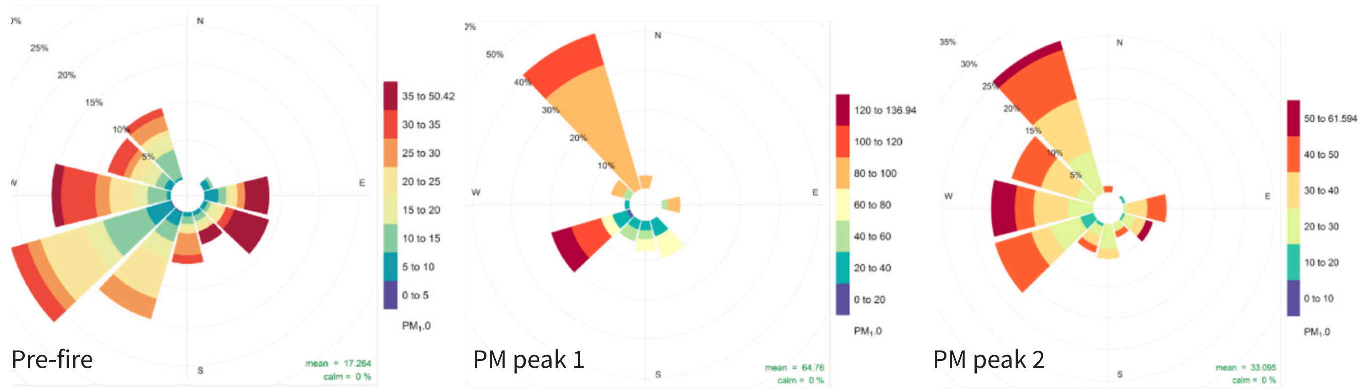
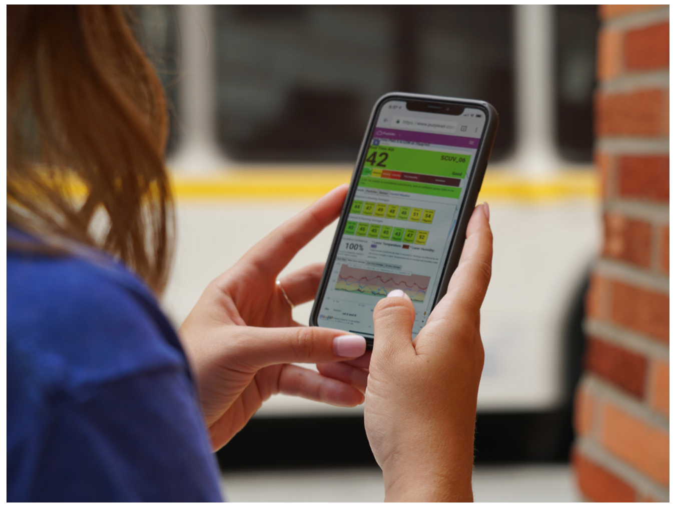



Fig. 2: PollutionRose plots from air sensors on the west side of UV indicating the wind directions and PM1.0 sources in the week before the Woolsey Fire and during the first peak (November 10-12) and second peak (November 16-22) in pollution

# Indoor Air Quality results

**PRELIMINARY FINDINGS ON INDOOR AIR QUALITY AT UNIVERSITY VILLAGE**

## We analyzed data from 18 indoor air sensors. Here's what we learned:



Above: PurpleAir II user viewing air quality readings on a mobile device

### BACKGROUND

Using data from eighteen project participants with indoor air sensors, we have found some interesting preliminary results about indoor air quality, household activities, and the freeway. Participants provided a baseline survey containing questions about home characteristics, cleaning activities, air purifier use, and cooking activities and thirteen also filled out a detailed hourly log containing activities known to impact air quality. This information was compared to the hourly indoor and outdoor PM concentrations recorded by the PurpleAir sensors. A complete explanation of the analysis methods can be found in the supplement section of this report.

### RESULTS: HOUSEHOLD ACTIVITIES

We found clear relationships between certain household activities, like cooking and air purifier use, and indoor PM2.5. Common activities like cooking and vacuuming caused PM concentration spikes, as shown in data taken from Apartment A on the following page (Fig. 1-2). According to the sensor data and resident activity logs, we found that vacuuming increases PM levels by 5 to 10 times. What's more, cooking can increase PM levels 5 to 20-fold, depending on the cooking type (e.g. boiling, frying, grilling). Across all of the apartments, indoor PM of all particle sizes was significantly higher when cooking activities occurred compared to non-cooking hours ($p<0.05$). PM concentration peaks returned to normal levels nearly five times more quickly when the stove fan was used during cooking compared to when it was not used, indicating that ventilation plays an important role in mitigating excess indoor PM generated by cooking (Fig. 1-2).

The hourly PM2.5 indoor/outdoor ratio (I/O ratio) over the month of January 2018 shows clear patterns of heightened indoor PM during typical morning and evening meal hours (Fig. 3). I/O ratios are useful because they help to separate the effects of indoor and outdoor sources on air quality. During periods of inactivity in the home, the indoor and outdoor PM levels are similar, and we see I/O ratios close to or below 1.0. However, during the cooking hours, the I/O ratio dramatically increases, indicating that the heightened indoor PM level is due to an indoor activity rather than an outdoor air quality impact. On average, in both winter and summer, I/O ratios of PM are greater than 1 , indicating that indoor activities drive household PM concentrations.

We also learned that another important contributor to indoor PM levels is candle use. One resident in Apartment B decided to conduct an experiment by burning a candle for one hour to see how it would influence the indoor air quality. During that hour, the

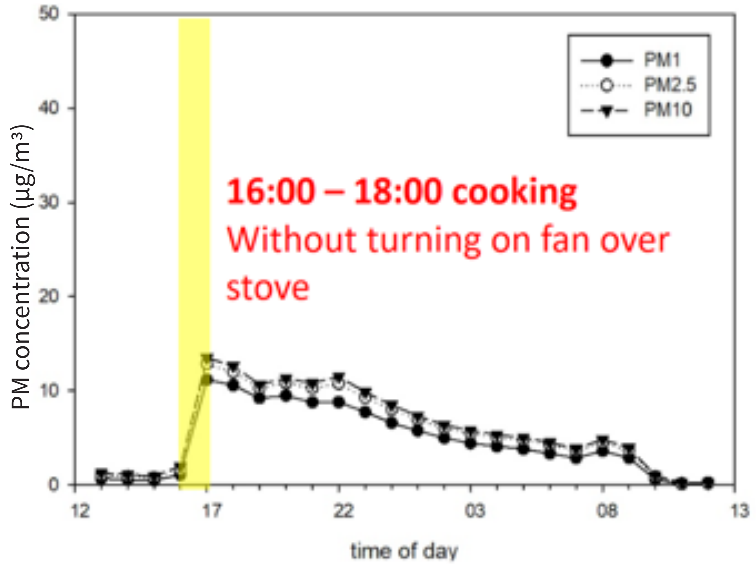



Fig. 1: Hourly PM concentration data of Apartment A over Day 1 of activity log

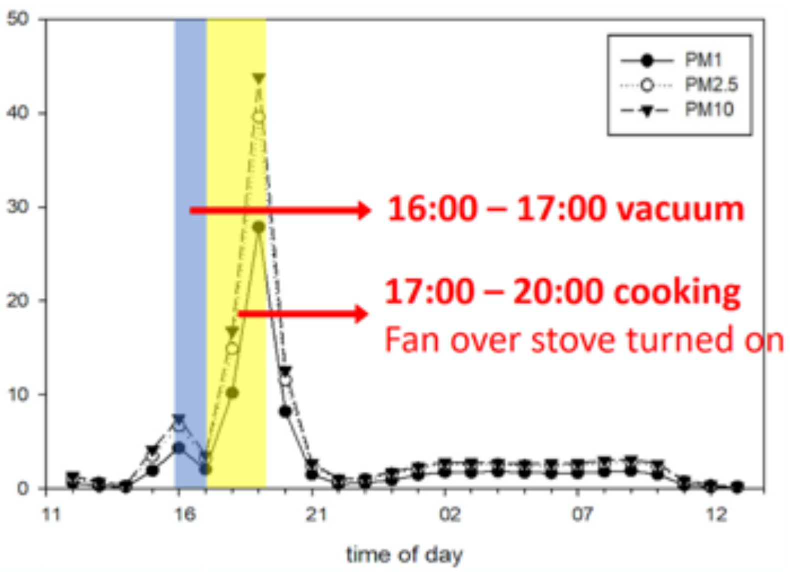



Fig. 2: Hourly PM concentration data of Apartment A over Day 2 of activity log

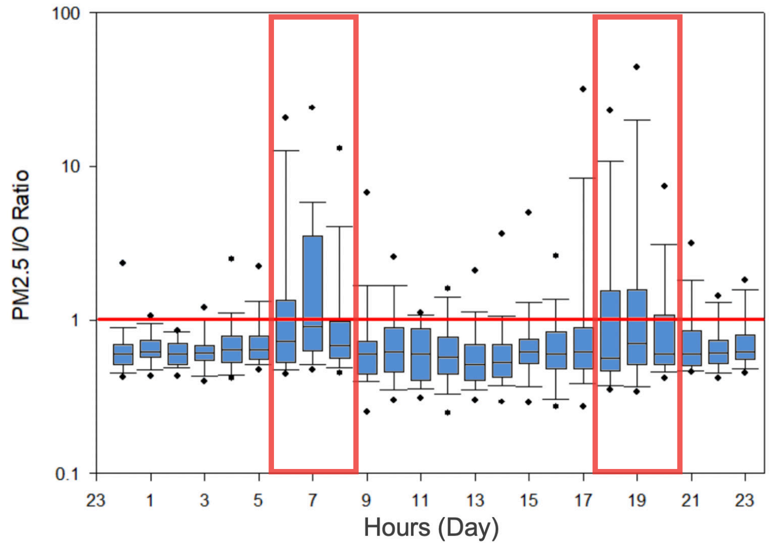



Fig. 3: Hourly PM I/O ratio across 12 apartments in January 2018. Elevated I/O ratios seen between 6-8 am and 6-8pm

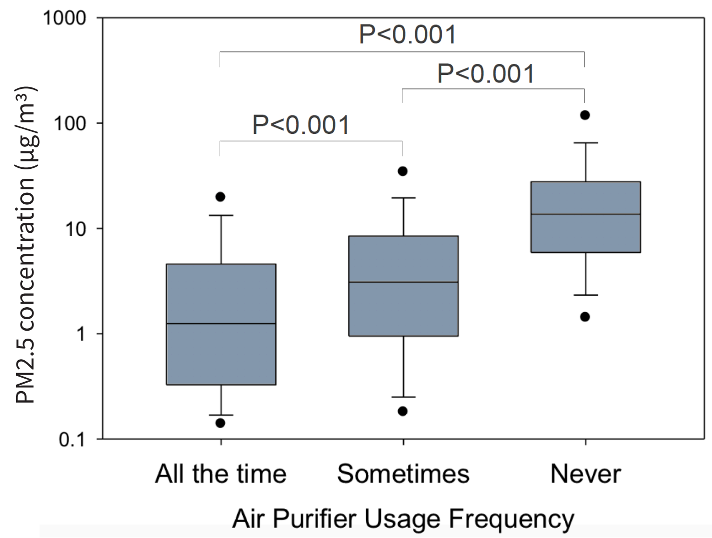



Fig. 4: Boxplots indicating the range, median, and 25th and 75th percentiles of indoor PM by purifier use

# Indoor Air Quality results

**PRELIMINARY FINDINGS ON INDOOR AIR QUALITY AT UNIVERSITY VILLAGE**

## Here's how outdoor PM impacts the indoor air quality:

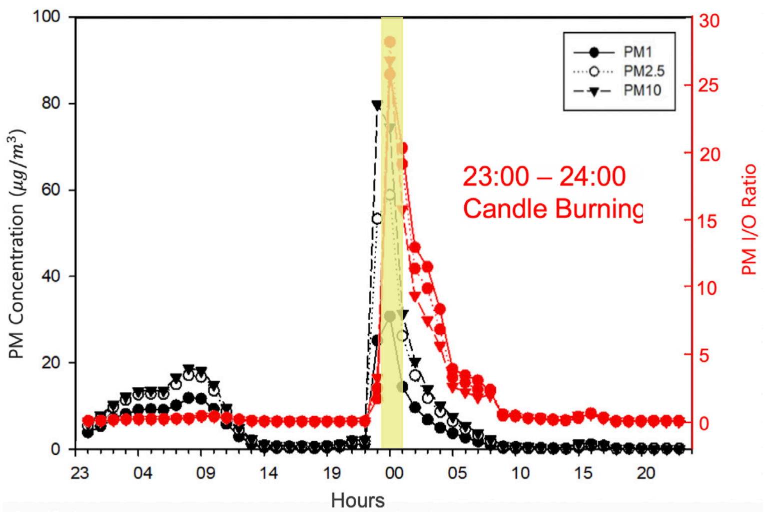



Fig. 5: Hourly PM concentration data of Apartment B over 24-hours (black) and I/O ratio (red)

indoor PM concentrations were 50 times higher than normal and it took approximately seven hours for the air quality to return to the background level (Fig. 5). The good news is that we found that air purifiers play an important role in decreasing indoor PM level. We classified apartments by how often they used an air purifier (all the time, sometimes, and never) and compared this to their indoor PM2.5 concentrations. There were significant differences in PM2.5 concentration between the apartments, with those using air purifiers all the time showing the best indoor air quality ($p<0.001$). For example, apartments that did not use an air purifier had approximately 10 times higher concentrations of PM2.5 than apartments that used an air purifier all day (Fig. 4).

### RESULTS: INFILTRATION OF OUTDOOR AIR

While household activities seem to have the strongest impact on indoor air quality, we found that the outdoor air quality influences the indoor environment too. For example, Figure 5 shows a 33% increase in indoor PM levels in Apartment C from about 7:00 am to 9:30 am, during which the I/O ratio remained constant. This indicates that the increased PM was not due to any indoor activities, but likely a result of the morning rush hour.

Furthermore, when participants were out of town and no activity was happening inside, indoor air quality was closely correlated with outside PM levels and generally contained about 40% the PM concentration as outdoors (Fig. 6). However, when the participants were home and going about typical daily activities in the same seasons, the outdoor PM levels were a poor predictor of indoor air quality (Fig. 7). Table 2 details the correlations between indoor and outdoor air during five periods in which participants were out of town.

To further assess the relative importance of indoor activities and outdoor PM sources, we created a linear regression model with variables for cooking, cleaning, air purifier use, ventilation, and outdoor PM levels (see supplement for further details on methods). We applied the model to the indoor PM data from four households with complete activity logs and found that the outdoor PM concentration, HVAC use, and cooking were significantly associated with indoor PM levels (Table 1). For example, MLR found that HVAC use decreases indoor PM by 2.72 $\mu g/m^3$, all else constant ($t(586)=-5.26$, $p<0.001$). ❑

Table 1. Standardized regression coefficients for each predictor variable across residences (PM2.5)

| Variable | Coefficient | Std Error | t-value | p-value |
|---|---|---|---|---|
| Outdoor PM | 0.59 | 0.04 | 14.87 | <0.001* |
| HVAC | -1.27 | 0.24 | -5.26 | <0.001* |
| Air purifier | -0.68 | 0.44 | -1.55 | 0.12 |
| Candles | 0.84 | 0.48 | 1.74 | 0.08 |
| Vacuuming | -1.09 | 0.68 | -1.61 | 0.11 |
| Cooking | 1.70 | 0.68 | 2.50 | 0.01* |

*significant predictor of indoor air quality

Interested in getting an air purifier for your home? Check out the Supplement for tips!

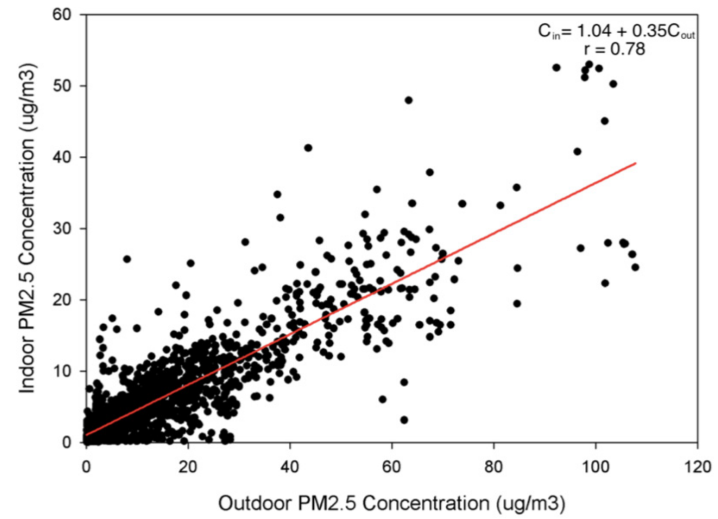



Fig. 6: Correlation between indoor and outdoor hourly PM2.5 over out of town periods in five apartments

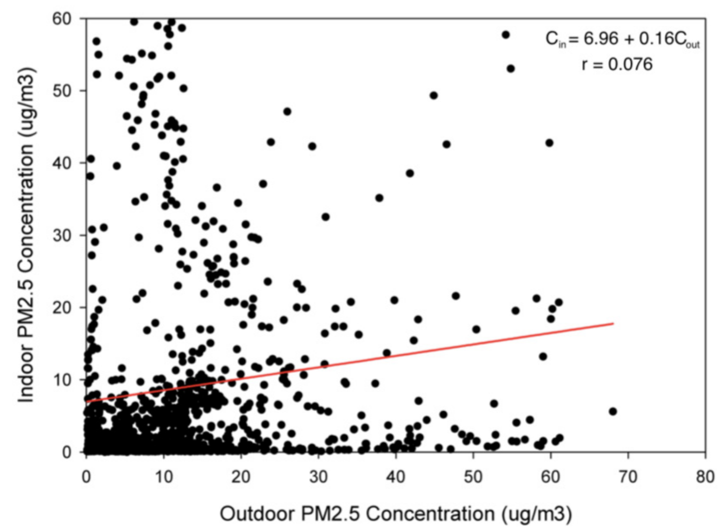



Fig. 7: Correlation between indoor and outdoor hourly PM2.5 in five apartments when residents in town

Table 2. Out of town periods and correlation between 1-hour average outdoor and indoor PM2.5 (µg/m3)

| Apartment | Dates | Correlation Coefficient | p-value |
|---|---|---|---|
| 17 | 2/16/2019-2/19/2019 | 0.04 | <0.001 |
| 18 | 12/7/2018-1/8/2019 | 0.24 | <0.001 |
| 25 | 12/20/2018-1/3/2019 | 0.44 | <0.001 |
| 27 | 12/25/2018-1/3/2019 | 0.48 | <0.001 |
| 29 | 12/25/2018-1/1/2019 | 0.68 | <0.001 |

conclusions

# Key Takeaways

### CONCLUSIONS

These sensors have been collecting data for over a year and reporting the air quality in real-time on an open-source map, providing residents with access to important information about air quality in the neighborhood. Readings from the air sensors, along with additional data sources, have allowed us to explore trends like the impact of the freeway, seasonal changes, and wildfires on the air quality at University Village over the past year. We found evidence for strong seasonal and diurnal (day vs night) variability in air quality and that traffic on the freeway has some impact on outdoor PM levels in the neighborhood.

While we found some evidence of the freeway impacting outdoor PM levels and that this significantly influences the concentration of PM indoors, the observed effect is modest. Though there are many other pollutants associated with traffic, including the smallest particles, that we were not able to measure, the relatively minor impact of I-405 on indoor PM2.5 is good news for the entire community given that PM2.5 is a pollutant of top concern for health and that most people spend approximate 90% of their time indoors.[1,5] The strongest predictors of indoor air quality are the activities that happen within the home. For example, candle burning, cooking, and cleaning can temporarily contribute to poor indoor air quality.

These findings on the major factors influencing indoor air quality are similar to those reported in the literature.[63-68] For example, in one study of the indoor and outdoor concentrations of PM and BC in Pittsburgh, researchers found that outdoor PM explained only 10%-43% of indoor PM variability, while indoor activities like smoking and cooking had the strongest impact on indoor air quality.[63] Likewise, Chao and Cheng (2002) determined that approximately 62% and 32% of indoor PM2.5 was due to cooking and infiltration of outdoor PM, respectively.[64] This is supported by a number of other studies which have found that cooking is the single largest source of PM in peoples' homes.[66] Furthermore, Corsi et al. (2008) found that vacuuming with a non-HEPA filtered vacuum caused significant increases in PM10 above the background level.[67] Similarly, Lewis et al. (2018) found that vacuuming with a HEPA-filtered vacuum causes the resuspension of PM, but that the HEPA filter on the vacuum then helped to filter this out of the air, resulting in lower overall PM levels after vacuuming.[68]

We know that for most families, these are necessary activities. So, we are excited to say that our preliminary results indicate some simple measures families can take to improve their indoor air quality and protect their health. We found that taking steps like using the over-stove vent, opening windows, and using the HVAC system (even just on fan mode) while cooking and cleaning can help to quickly reduce the PM levels in your apartment. Likewise, keeping your air purifier turned on for most of the day is another great way to improve indoor air quality. As we collect more data and conduct further analysis, we will look for more ways that people can improve their indoor air quality at University Village.

Lastly, through this project, we learned that the PA-II is a great resource for informing individuals about their indoor air quality and general outdoor ambient air quality trends, wildfire impacts, and other unique events (like weekend barbeques in the common areas), but that it is not the ideal device for studying fine-scale freeway impacts due to inaccuracy of estimating the smallest PM sizes. This project is one of the first to use a low-cost sensor to study freeway impacts, so these new understandings of the strengths and limitations of the PA-II will help communities and researchers select the most useful sensors for their needs. ❑

## Based on the outdoor and indoor analysis:

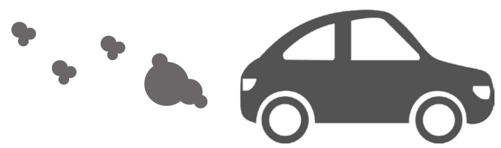
### OUTDOOR AIR KEY FINDINGS:

- PM LEVELS ARE HIGHEST IN THE WINTER DUE TO LOWER ATMOSPHERIC BOUNDARY LAYER THAT TRAPS POLLUTION & LESS ATMOSPHERIC MIXING
- AVOID OUTDOOR EXERCISE IN EARLY MORNING & LATE NIGHT: PM LEVELS ARE HIGHEST AT THESE TIMES DUE TO A LOWERING OF THE ATMOSPHERIC BOUNDARY LAYER AFTER SUNDOWN
- LOCATIONS SHELTERED FROM THE FREEWAY BY STRUCTURES HAVE LOWER PM LEVELS THAN NON-SHELTERED ONES ($P<0.05$)
- THERE'S A MODERATE CORRELATION BETWEEN TRAFFIC FLOW AND PM IN WINTER ($R=0.53$-$0.54$), BUT NOT IN SUMMER ($R=0.17$-$0.18$)
- ON WEEKDAY MORNINGS DURING RUSH HOUR PM LEVELS PEAK AND TRAFFIC IS A LIKELY CAUSE
- DURING MORNING RUSH HOUR, THE SOURCE OF PM0.3 (CLOSEST SIZE PARTICLE TO TYPICAL TAILPIPE EMISSIONS DETECTABLE BY PA-II) ON EACH SIDE OF UV IS THE FREEWAY

### INDOOR AIR KEY FINDINGS:

- THE MORE YOU USE YOUR AIR PURIFIER, THE BETTER THE INDOOR AIR QUALITY
- COOKING SIGNIFICANTLY WORSENS INDOOR AIR QUALITY, CAUSING PM LEVELS 5-20X NORMAL
- USING THE FAN AND OPENING WINDOWS DURING & AFTER COOKING HELPS QUICKLY DECREASE INDOOR PM
- CANDLE BURNING CAN INCREASE INDOOR PM UP TO 50X THE NORMAL LEVELS
- INDOOR PM IS SLIGHTLY ELEVATED DURING TIMES OF HEAVY TRAFFIC, ESPECIALLY IN THE MORNING
- INDOOR ACTIVITIES HAVE A LARGER IMPACT ON INDOOR AIR QUALITY THAN OUTDOOR PM
- IN THE ABSENCE OF INDOOR ACTIVITY, INDOOR PM LEVELS ARE ABOUT HALF OF THOSE OUTDOORS

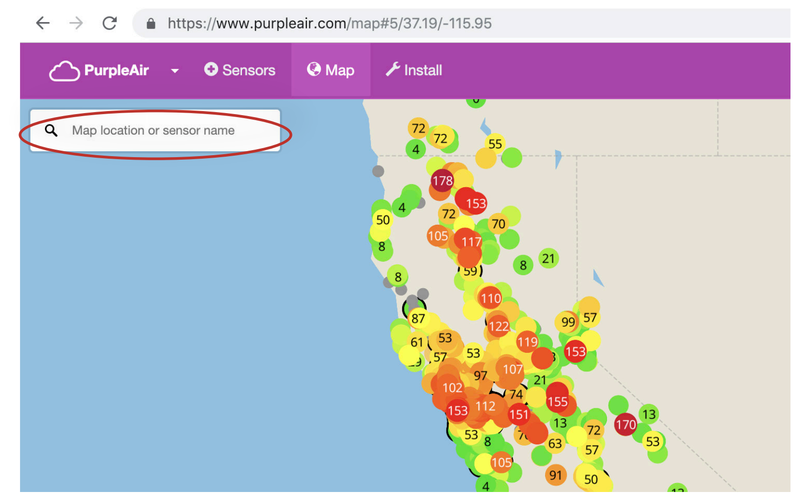

Left: residents, SCAQMD air quality specialists, and UCLA researchers attended an air quality workshop in February 2019 at the University Village community center. Project results were discussed and community members shared some of their experiences with using the air sensors



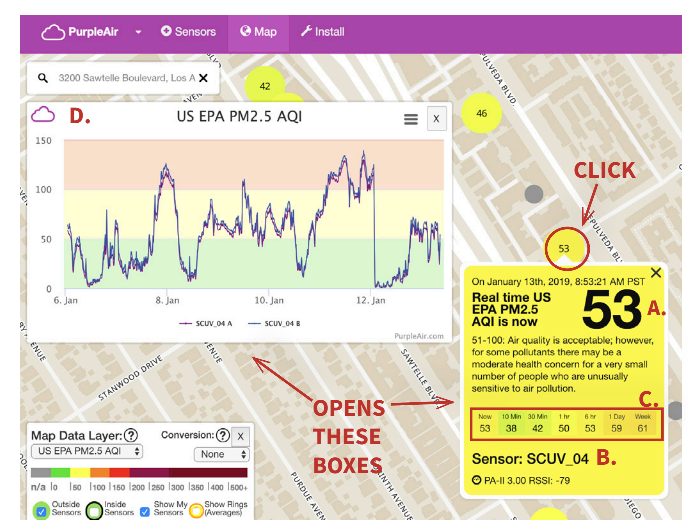
# supplement

## Interested in viewing the data?

To view the data from the air sensors located throughout your apartment complex, take the following steps:
1. Go to www.purpleair.com/map
2. Type in your address in the search bar in the upper left corner of the map as circled below:




3. Click on the dot for the sensor you are interested in viewing (dots without a black outline indicatee outdoor sensors, dots with a black outline are indoor sensors):




4. Description of information in boxes:
   A. Near the top of the yellow box, you will see a number (in this case "51") that indicates the real-time AQI. The AQI is measurement based on the EPA's national outdoor air quality standards. The AQI will give you information about how clean the air is and whether certain susceptible people (e.g. people with asthma, cardiovascular disease, or other respiratory issues) should avoid being outside at a given moment.

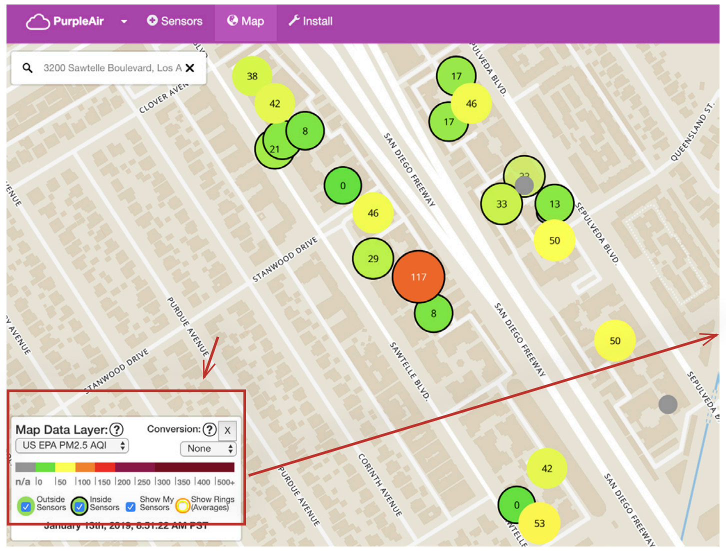
instructions

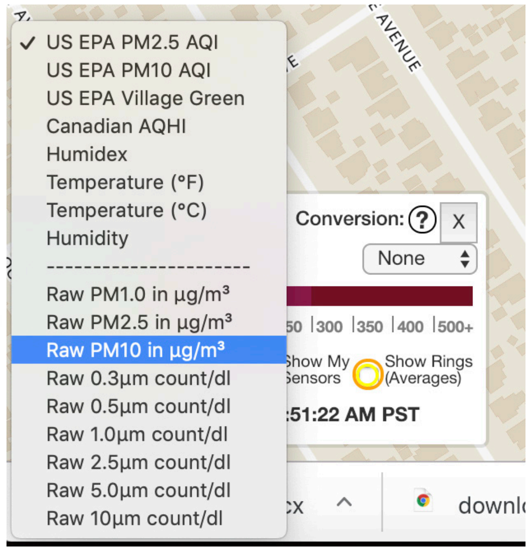
# Data viewing

## Continued from pg. 15:

B. SCUV_04 is the name/label of the sensor
C. The numbers labeled above as "C" show the real time, 10-minute, 30-minute, 1-hour, 6-hour, 24-hour, and 1-week average $PM_{2.5}$ AQIs
D. The graph shows one week of the $PM_{2.5}$ AQIs as a time series

6. In the box at the bottom-left of the page, you can switch the map setting to view $PM_{10}$, $PM_{1.0}$, temperature, humidity, and more. You can also set your map to show only outdoor or only indoor sensors:




If you would like to download the sensor data to see longer-term information, you can do the following:

1. Go to https://www.purpleair.com/sensorlist.
2. At the top, choose your date range for the data you would like.
3. Then find the sensor you want information from (use ctrl F or command F on a mac to search) and select the sensor by checking the box next to it.
   a. Sensors are titled "SCUV_##". The exact number depends on which sensor you are interested in.
   b. Note: You will see an "a" and "b" option for your sensor. This is because each sensor contains two identical laser particle counters, each reporting similar, but potentially slightly different values. For more information about the sensor specifications visit https://www.purpleair.com/sensors
4. Click Download Selected at the top right of the page. Download will start CSV file download.



# Selecting an air purifier

As our preliminary results have shown, using an air purifier in your home can drastically help to improve the indoor air quality. In the infographic below, we provide low, moderate, and higher cost options for air purifiers that can be purchased online (prices as of September 2018). All of the air purifiers shown below have been tested and certified by the California Air Resources Board (CARB) and are effective for use in rooms that are the typical size of the open floor plan living room and kitchen found in the University Village apartments. If you plan to place an air purifier in your bedroom, visit http://www.ahamdir.com/aham_cm/site/pages/search_airCleaners.html and search for options that are effective in a room greater than or equal to the square footage of the room in question.

## AIR PURIFIERS

### California Certified Air Cleaning Devices available online

**$**

- Honeywell 50250-S True HEPA Air Purifier: $130.99
- Winix 5300-2: $139.99
- Winix 5500-2: $150.99
- 50250-S True HEPA Air Purifier: $195.91
- Honeywell HPA300 True HEPA Allergen Remover: $199.99

**$$**

- Whirlpool WP1000: $239.69
- Whirlpool WP500: $239.96
- Blue Pure 211+: $249.35
- Electrolux ELA P40D8PW PureOxygen Allergy HEPA: $289.63
- Blueair 403 HepaSilent Air-Purification System: $399.99

**$$$**

- Sharp KC-860U: $421.99
- Blueair Classic 405 HepaSilent: $549.95
- Cuckoo CAH-4011FW: $600.00
- Philips Air AC5659/40 5000i: $699.99
- Atmosphere 10176: $888.88
- Oransi EJ120: $899.00

# methods

## The details on how we obtained our results

The analysis presented in this report focuses on assessing particulate matter (PM) at University Village to gain an understanding of how the freeway influences air quality in the neighborhood and how residents can limit their exposures to air pollution. The primary research topics addressed are as follows:

Research Topic 1: What are the outdoor air quality characteristics in the community and which factors influence them?

Research Topic 2: What factors influence indoor air quality at University Village?

To explore these questions, we utilized PM data from air sensors located throughout the community, meteorological data from the nearest SCAQMD monitoring station, activity logs from participating residents, and traffic data from the Caltrans Performance Measurement System (PeMS).

### PRIMARY DATA COLLECTION

As discussed in prior sections of the report, PM is one of the major pollutants associated with vehicle emissions and causes a suite of negative health impacts, thus a PM sensor was a good choice for use in this near-freeway community. The PurpleAir II (PA-II) sensor was selected for this project due to several strengths. First, SCAQMD testing indicates that it is the highest performing low-cost PM sensor of all 36 sensors tested by SCAQMD. Second, the PA-II measures multiple size classes of PM (PM10, PM2.5, PM1.0, PM0.5, PM0.3), whereas many others only measure PM2.5. Furthermore, its relatively low cost makes it possible to deploy a dense outdoor and indoor network of sensors to cover the entire community. Lastly, the PA-II is simple to use and allows residents to view the air quality in real-time on an easily interpretable online map.

Between November 2017 and January 2018, we installed twelve PA-II air sensors outdoors at University Village, six on each side of the freeway. The locations were chosen with the help of residents to capture air quality along the length of the freeway, as well as moving away from it. When feasible, sensors were located near outdoor play areas and other key communal spaces, like the childcare center, playgrounds, and pool. We also placed eighteen air sensors inside apartments, selected randomly from residents that responded to a survey indicating interest in participating. We asked participants with indoor air sensors to keep detailed activity logs in order to assess the indoor air quality trends in the complex. This involved completing a seven-day log indicating whether activities known to impact indoor air quality occurred in a given hour (e.g. cooking, air purifier use, vacuuming, etc). A sample of the indoor activity log is provided in the Supplement. PM readings were compared to each other and to the nearest SCAQMD monitoring station, located in Downtown Los Angeles, to identify any signs of sensor malfunction and erroneous data prior to analysis.

### SECONDARY DATA COLLECTION

Secondary sources of data utilized in this project include meteorological data, EPA reference monitor PM data, and traffic counts. High quality meteorological data for the study time-period was provided by SCAQMD, including wind direction, wind speed, temperature, and humidity. The weather data is from the nearest monitoring station to the community, located at the Veterans Affairs Hospital near the intersection of Wilshire Boulevard and Sawtelle Boulevard. Like University Village, this site is situated near I-405 and is expected to have similar wind patterns to the community. Ambient PM data from the nearest EPA monitoring station, located in Downtown Los Angeles, was provided by SCAQMD. Traffic counts and speeds were downloaded from PeMS which utilizes real-time measurements from in-lane vehicle detectors on state highways. This is the most rigorous traffic data available for the area and allows us to compare changes in traffic at the 5-minute scale to the readings from the air monitor. Basic QA/QC procedures were applied to secondary data sources to remove any clearly erroneous values. For example, sensor failures in PeMS result in 0 values for traffic counts; recordings from faulty sensors were discarded.

### DATA ANALYSIS

The primary and secondary data were analyzed using a combination of Microsoft Excel, R, SigmaPlot, and Stata software. To assess the outdoor air quality characteristics in the community (Research Topic 1), we conducted basic summary statistics and used the R OpenAir package to visualize the spatiotemporal PM trends in the community, along with student's t-tests to assess significance (significance established if two-tailed p-value<0.05). Building upon this, we checked for correlations between meteorological, traffic flow, and PM data to further study the influence of these factors on air quality (Research Topic 1). Using the wind direction and speed data, along with the PM readings from the sensors, we created bivariate polar plots in OpenAir to map potential sources of pollution near the community.

To assess the indoor quality in the community (Research Topic 2), we utilized the PM readings from indoor and outdoor air sensors and activity logs to determine which activities worsen indoor air quality, the effectiveness of mitigation measures, and the impact of outdoor air quality on participants' homes. We conducted qualitative analysis using PM timeseries and information from the activity logs to identify general patterns in the indoor air quality at University Village. We also calculated the indoor-outdoor ratios (I/O ratios) of PM to study the relative importance of the outdoor air quality on indoor PM levels. This was supplemented basic statistical tests (e.g. student's t-test, correlations) to determine which factors (e.g. cooking, air purifier use, outdoor PM, etc) affect indoor air quality. Significance was established if two-tailed p-value<0.05. Lastly, to assess the relative importance of indoor activities and outdoor air quality on indoor PM levels, we created a multiple linear regression using data from four indoor air sensors (SCUV_24, SCUV_25, SCUV_26, and SCUV 29), activity logs, and one outdoor air sensor (SCUV_06) in which:

$$\ln(PMi)= \ln(X0)\beta 0 + \beta 1X1 + \beta 2X2 \ldots + \beta iXi + \beta aSa + \beta bSb + \beta cSc + \varepsilon$$

where:

PMi is the indoor PM concentration

X0 is the outdoor PM concentration

βiXi are the indoor activities recorded in activity logs

βaSa, βbSb, and βcSc are the indicator variables for the apartments where the sensors are located

ε is the error constant

The natural log was used to normalize the distribution of PM data and a collinearity test was used to ensure collinearity did not occur. A stepwise regression method was also utilized to eliminate variables that did not contribute to the explanatory power of the model.

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# THANK YOU FOR READING

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