Chesapeake Community Research Symposium 2026

Session 14: Low-Cost Physical Environmental Monitoring Systems

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Understanding Spatiotemporalal Variation in Air Quality Using Purple Air Sensors

Air quality has long been a concern to residents of Baltimore, due to the city's role as an extensive and ongoing industrial hub. Baltimore City is a hotspot for childhood asthma and other health impacts exacerbated by air pollution exposure. Air quality monitoring is an important tool for informing and empowering communities with knowledge regarding unsafe conditions, informing air quality regulations, and identifying changes over space and time.

Despite a clear need for distributed air quality data, there is only one regulatory monitor in Baltimore, located in the north, away from many pollutant sources in the south. Although it measures daily pollutant concentrations, it may be inadequate for characterizing air quality across the entire city. Purple Air sensors are a popular tool for bolstering air quality observations in areas with few regulatory observations. These low-cost sensors measure fine particulate matter and can be used to create hyper-local monitoring networks that observe air quality on a finer spatial scale than extant government installations.

Daily average PM2.5 concentration data from March 2022 to August 2023 were collected from six Purple Air sensors in Baltimore City to analyze spatiotemporal variation in air quality. Observed data was corrected to more closely match the regulatory monitor to assess evidence for unmeasured variation in air quality and to understand whether a singular regulatory monitor represented this spatial variability. We found that daily average air pollution differed among sensors, and that only some nearby Purple Air sensors matched observations from the regulatory monitor when they were very close by. The findings suggest that substantial spatial and temporal variation in air quality exists in Baltimore. This variation is not represented by the current regulatory monitor, indicating a need for the development of a more robust air quality monitoring network to better capture pollution exposure across the city.

Tiberias Okanga (University of Maryland, College Park)

Advancing Community Air Quality Monitoring Through Low-Cost Sensors in the Baltimore–Washington Corridor

Air pollution remains a significant environmental justice concern, disproportionately impacting vulnerable communities in the Baltimore–Washington Corridor (BWC). High traffic, industrial activities, and proximity to the coastline contribute to the emission, transport, and formation of particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), ozone (O3), and volatile organic compounds (VOCs) in the BWC. These pollutants exacerbate respiratory illnesses and health disparities, necessitating comprehensive air quality monitoring. Following community guidance, we deploy low-cost community air quality sensors, including Purple Air, Modulair, SPODS, and C-12, to address this issue and monitor pollutant levels in burdened communities. PM emissions are further characterized using carbon sticky tapes analyzed by Scanning Electron Microscopy (SEM) to determine elemental composition and morphological properties. Our preliminary findings indicate the presence of mineral dust, metals, organic compounds, and coal dust, highlighting contributions from both natural and anthropogenic sources. By integrating real-time sensor data with compositional analysis, our research provides a holistic understanding of air pollution patterns. This community-based monitoring approach empowers residents with localized air quality data and informs targeted policy interventions. The results will support strategies to mitigate pollutant exposure, enhance public health, and advance environmental justice in Maryland's most impacted communities.

Katie Lehman (Department of Atmospheric and Oceanic Science, University of Maryland, College Park), Ava Puschnigg

Mesoterps: Building a Resilient Campus With High-Resolution Environmental Monitoring

The University of Maryland (UMD) has expanded its campus-wide micronet, initially deployed to monitor microclimate variations and enhance campus safety. The network, consisting of low-cost automated weather stations, aims to increase the number of observational sites strategically placed to capture high-resolution data on temperature, dew point, atmospheric pressure, wind speed, direction, rain rate, and heat stress indicators. These stations, powered by Raspberry Pi units running WeeWX software, provide continuous, real-time data that are publicly accessible through the website weather.umd.edu.

As of February 2026, seven observation stations have been deployed, and by May 2026, at least three additional stations are expected to be operational. These new stations will increase spatial coverage and improve data granularity.

Recent projects have involved implementing automated alert systems to enhance campus safety. These systems trigger threshold-based alerts sent directly to relevant campus stakeholders. For instance, when rain rate exceeds predefined thresholds, real-time alerts are sent to facility personnel to mitigate flash-flooding risks. Similarly, high-wind or heat stress conditions activate notifications to ensure prompt response to hazardous weather.

Tim Canty (University of Maryland, College Park), Michael Maddox, Louis Uccellini, Ava Puschnigg

Addressing Adaptation Challenges Facing the Chesapeake Bay Through Low-Cost Monitoring Supporting Impact-Based Decision Support Services

The Chesapeake Bay faces growing threats from sea level rise, coastal erosion, habitat loss, inland flooding, extreme weather, nutrient pollution, harmful biological activity, and air pollution. These challenges highlight the urgent need for state and local action on climate change while ensuring that all communities are supported equitably in the process.

Efforts proposed by the Maryland Climate Adaptation and Resilience Plan include improved environmental observations on land and along the coast, enhanced coordination and real-time access to weather, water, and climate data, improved predictions based on Earth system science approaches, and better connections between environmental data and decision makers at all levels of government.

Our team is deploying a real-time observation network of low-cost water level sensors in areas prioritized by local partners, with a focus on underrepresented, high flood-risk communities that lack monitoring. We are identifying and filling gaps in existing networks to better warn communities of flood events, especially those related to storm surge on top of rising Bay levels. These observations also provide boundary conditions for predictive models and help assess model performance. The resulting data can improve forecasts in an economically important region with a complex shoreline and support mitigation of near-term impacts from increasingly extreme weather, water, and climate events through Impact-Based Decision Support Services (IDSS).

Tori Tomiczek (United States Naval Academy), Liliana Velasquez Montoya, Jasmine Wilding, Alexis Rider, Kevin Colbeck, Lucia Samaras, Belle Neset

Monitoring Local Coastal Backflow in Storm Drains Using Low-Cost Accelerometers: Flood Frequency and Duration in Annapolis, MD Using Low-Cost Accelerometers

Chronic, wind- and tidally-driven flood events are occurring more frequently in Annapolis, MD, causing challenges for residents and local businesses. Low-cost accelerometers deployed in storm drains or stormwater outfalls allow flood data (frequency and duration) to be collected at high spatial resolution to inform adaptation decision-making. The buoyant accelerometers record instances when a storm drain is flooded as floodwaters cause changes in their orientation.

From June 30, 2025 to the present, four accelerometers have been deployed at the corner of Chester Drive and 4th Street in the Eastport neighborhood of Annapolis, MD. Three sensors are located in storm drains, and one is in the stormwater outfall in George Washington Davis Memorial Park. A pressure logger was also deployed in the outfall to record local water levels relative to the roadway and correlate these measurements with the nearby NOAA Station 8575512.

Analysis of flood data from June 30 to October 22, 2025 indicates that the three storm drains triangulating the intersection flooded at different frequencies. The percentage of hours flooded ranged from 4% to 10%, and the number of flood occurrences ranged from 17–26 between June 30 and August 11, 2025. More frequent and longer flooding occurred during the second deployment period from August 11 to October 22. The presentation will discuss these observations along with ongoing deployments, including the October 30, 2025 event that reached 3.46 ft relative to NAVD88 at the NOAA station. These data provide a hyper-local assessment of flooding that affects residents and businesses and support data-driven mitigation planning.

Megan Curtiss (University of Maryland, Baltimore County)

Cities as Climate Labs: Measuring Tree Growth Responses Across Urban Stress Gradients With Dendrometer Bands

Urban landscape structure fundamentally reshapes the environmental conditions in which trees grow, increasing the likelihood of thermal and water stress. To quantify the effects of different landscape contexts on tree growth in urban environments, a long-term tree growth study using dendrometer bands was conducted on the University of Maryland, Baltimore County campus. Dendrometer bands were selected as a durable, low-cost monitoring tool to capture fine-scale radial stem diameter changes across a large and spatially distributed urban tree sample.

Study trees included both native and non-native species distributed across surrounding land uses such as forest interiors, forest edges, lawns, and parking lots to represent an urbanization gradient. Topography and soil moisture variables were derived from high-resolution terrain analysis and characterized within a 15-meter buffer around each study tree. Percent change in diameter at breast height (DBH) from 2023 and 2024 growth data was analyzed in relation to these landscape variables.

Species identity explained variation in growth, but the magnitude and ranking of growth rates shifted dramatically between forest and non-forest settings. Trees in non-forest areas grew substantially faster than those in forested areas (5.4% vs. 2.4% annually), suggesting that urban land-use intensification alters species performance. Within forests, soil moisture availability and landform type were key drivers of growth, while non-forest growth responses reflected more complex interactions among species identity, impervious surface cover, and topographic position.

Urban landscape structure does not uniformly constrain tree growth; instead, it restructures species competition and the relative importance of environmental gradients. Urban environments serve as accessible living laboratories for understanding how heat and water stress may affect tree growth under future climate conditions. Examining shifts in species performance hierarchies provides insight into potential compositional changes and helps identify species and microhabitats most resilient to anticipated stress gradients.
