AQ&U: An instrument to measure, understand and reason about $PM_{2.5}$ exposure in the Salt Lake Valley

Pascal Goffin[1], Tom Becnel[2], Kyle Tingey[2], Aspen Hopkins[1], Amir Biglari[3], Tofigh Sahay[4], Ross Whitaker[3], Kerry Kelly[4], Pierre-Emmanuel Gaillardon[2], Miriah Meyer[3]

[1]Scientific Computing and Imaging Institute, University of Utah
[2]Department of Electrical and Computer Engineering, University of Utah
[3]School of Computing, University of Utah
[4]Department of Chemical Engineering, University of Utah

The Salt Lake Valley periodically experiences some of the worst short-term PM2.5 pollution episodes in the country. To better understand and reason about these pollution episodes and simultaneously engage and inform the general public we build and deployed the AQ&U instrument. This open-source instrument provides temporally and spatially dense $PM_{2.5}$ concentrations collected by an interconnected network of custom-built low-cost pollution monitors throughout the Salt Lake Valley. This not only allows citizens to view fine-grained localized information about their $PM_{2.5}$ exposure but also enables them to analyze and manipulate the dataset as a citizen science effort. Moreover, it helps climate researchers to capture acute and temporary pollution events, such as inversions or rush hour along major highways. The benefit of having a low-cost and open-source instrument is that it can be easily transferred and deployed wherever air quality has an impact on the live of its citizens to provide real-time and localized $PM_{2.5}$ exposure.

The instrument consists of five distinct layers: physical sensing nodes, a backend, a regression model, a visualization framework and the citizens. The sensing nodes periodically gather the $PM_{2.5}$ measurements from a fixed location and upload them to the backend. One type of sensor nodes are our own AirU Pollution Monitors (AirU) but we also support other sensor nodes such as the ones from Purple Air, Mesowest and the gold standard of air quality: the DAQ sensors. The AirUs act as single network nodes, contributing a temporally dense dataset of airborne $PM_{2.5}$ concentrations and the supporting climate data (humidity, temperature) to the backend, at a fraction of the cost of current federal and local pollution monitoring stations, such as the DAQ sensors. The wireless connectivity of the monitors provide multiple advantages. Each device's data is immediately available and comparable to the public. Moreover, the communication between devices allows for robust calibration and error correction techniques in order to maintain a reliable backend. The backend stores all these raw measurements and provides access to it through an API. The regression model integrates the captured data to estimate $PM_{2.5}$ concentration at the neighborhood scale. The visualization framework provides citizens with visual tools to better understand and reason about their $PM_{2.5}$ exposure. And finally the citizens themselves are also part of the AQ&U instrument as they host and maintain the sensors and are crucial for an appropriate spatial distribution throughout the valley. We are currently refining and deploying the first instance of this instrument in the Salt Lake Valley, with around 50 physical AirU sensors currently deployed.