Universidad Autónoma de Ciudad Juarez Climate and Air Quality Network

Texas-New Mexico-Chihuahua Regional Workgroup

For the past two decades the Universidad Autónoma de Ciudad Juarez has been working on building and expanding a meteorological monitoring network in Ciudad Juarez, Chihuahua, which currently is comprised of nine stations. In the past 5 years, some of these stations, located throughout the city (Figure 1), have been expanded to include sensors to help measure CO, Ozone, NOx, SO2 and PM. These monitors are in addition to monitors the Municipality of Juarez already operates. All the monitors put in place by the University and the City is part of a binational effort to understand the air basin and educate the public on air quality in the region. However, some of the challenges faced by both entities over the years, include operation and maintenance costs but more importantly, consistent communication between the monitors and computer systems that analyze the data and power for the stations, much of this, is in part due to the geographic location of the stations.

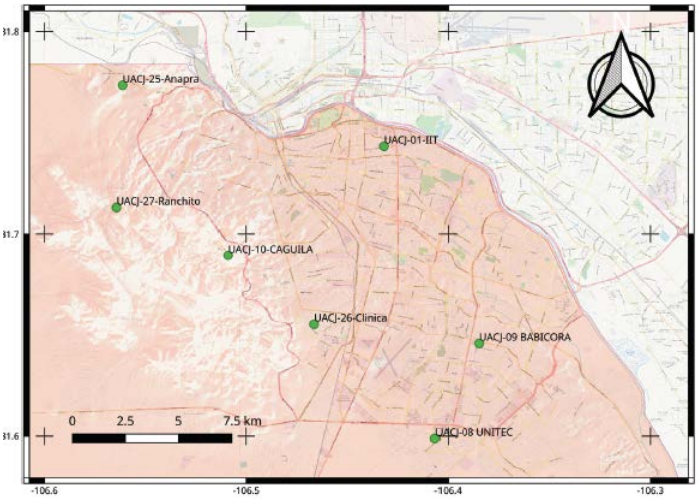

Figure 1. Location of seven of the nine stations, UACJ operates throughout Ciudad Juarez, Chihuahua.

In late 2017, UACJ received a Border Program grant to evaluate and build a prototype low cost air quality sensor as an alternative method to obtain air quality data and share information with the public more quickly. Another objective of the grant was for the University to help make real-time data publicly available from its existing UACJ network, as well as, historical meteorological data, onto a web-based platform. Low-cost sensors are not meant to replace official air quality networks to meet regulatory mandates, however, they offer a more affordable alternative to provide real-time air quality and meteorological data with acceptable performance to the public.

The project was broken into three separate phases. During the first phase, the project team worked on building and programming the software on three protype sensors that would be placed in the community (Figure 2). The sensors would measure ozone, particulate matter, carbon monoxide, temperature and relative humidity.

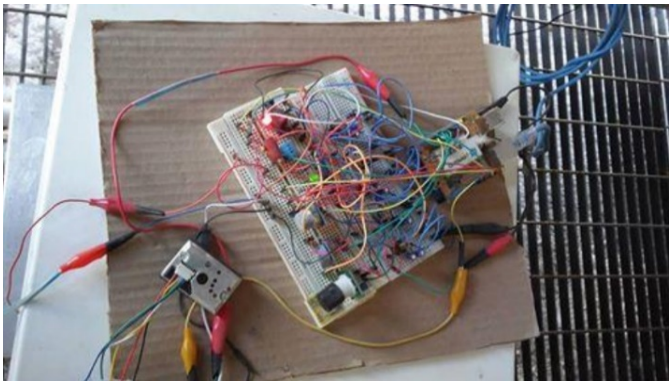

Figure 2. Built protype of functioning low-cost sensor.

The second phase, which took place April 2019, included the placement of the protypes. Two sensors were placed on two different university properties, one location is known as Station llT-1 (Figure 3) and the second as Clínica de Nutrición. The final sensor was placed at Fire Station No.9 en Rancho Anapra. The goal during this phase was to gain an understanding on what type of hardware, software and communication is needed to successfully operate a low-cost sensor long term in order to get useful data that is beneficial to share with the public.

Figure 3. Low cost sensor at UACJ Station llT-1.

The final phase of the project was the development of a webpage, within UACJ's existing webpage platform, that

would visually demonstrate the station readings, not only from the three prototypes built, but existing UACJ network stations, Figure 4. The webpage developed can be found at: (http://cecatev.uacj.mx/).

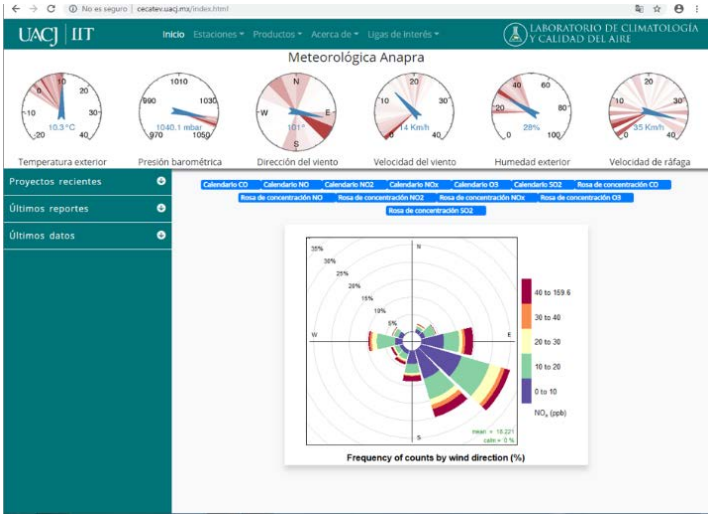

Figure 4. Webpage showing meteorological station data in Ciudad Juarez, Chihuahua.

While field testing the sensors in April and May 2019, the project team discovered that there are challenges to utilizing the university's webpage to communicate with the stations and sensors, such as webpage security protocols that prevented the sensors to truly communicate real-time data to the webpage. Other problems were the lack of consistent internet signal and power to the sensors. Because of these challenges, the project team had to physically download each sensor data back at the lab. However, one thing to note, the team did anticipate that communication might be an issue, and in anticipation of this, a redundant system was placed at the sensor to capture the data to a local hard drive that would then be taken back to the lab to obtain the sensor data.

In terms of how the sensors performed, Figures 5 shows how each of the sensors performed compared to the existing station located at UACJ that already is measuring ozone and PM2.5 for the months of November. From the data that was collected, the project team observed that the sensors need to be adjusted by a multivariate linear regression formula, which uses temperature and relative humidity to make data corrections.

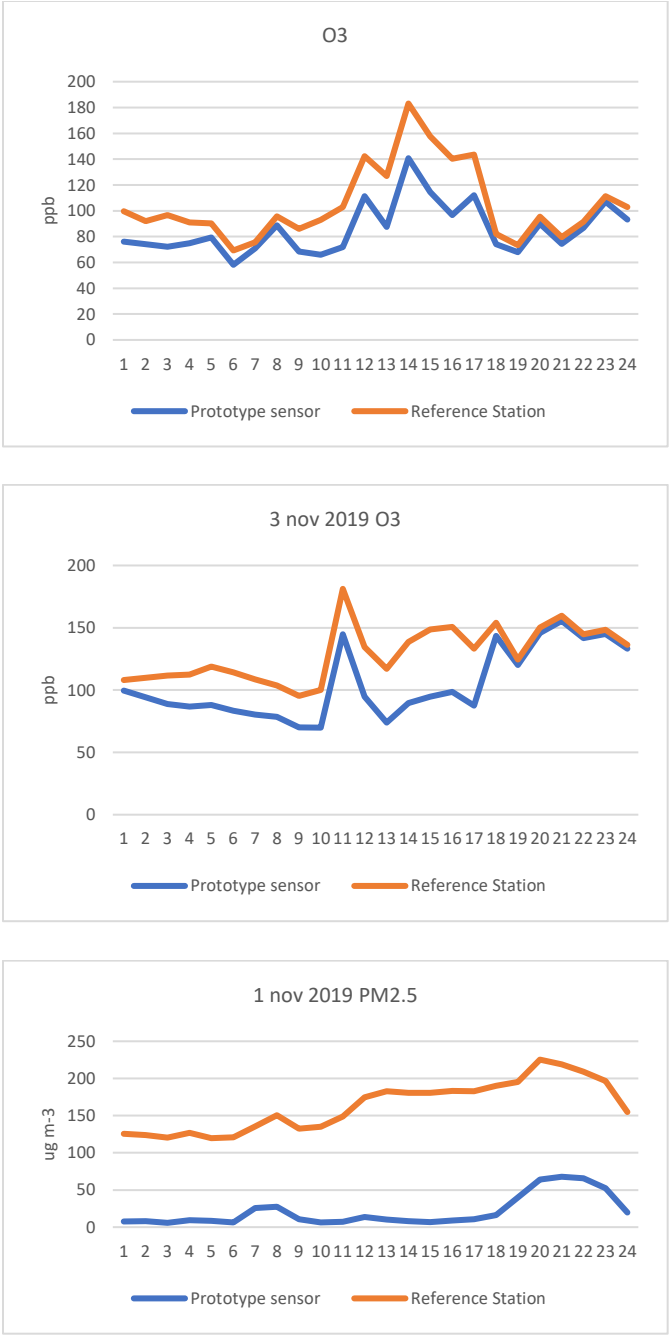

Figure 5. Comparison measurements between prototype sensor and reference stations in November. (Top) UACJ Teledyne Station ozone measurement, (Middle) Anapra Prototype ozone measurement, (Bottom) UACJ Teledyne PM 2.5 measurement.

Another objective of the project was to archive existing meteroligical data from the nine stations UACJ operates and make this data publically available. The project team utilized the university's existing webpage to house this data. The archived data for the nine stations is located at: (http://erecursos.uacj.mx/handle/20.500.11961/4199).

By creating the webpage and uploading historical meteorological data, this is the first time that meteorological data from different decades for the City of Juarez, is available to academic users.

Throughout the course of the project, over 11 university students from three separate programs were able to contribute at different phases of it, whether it was collection of the data, programming the sensor software or webpages, building the sensors or collection and archiving of historical meteorological data. Of the 11 students, three of them were able to fulfill their master's thesis and one of them their undergrad project.

Figure 6. Team photo of project students.

In the end, the Project Team was able to build a low-cost air quality sensor between $400-500. In addition, by getting a better understanding of the existing challenges, with these sensors for use in the city, the team is continuing towards developing a second, more improved and robust low-cost air quality sensor. In addition, they are looking at ways in which the sensor can be continuous, while being able to have a solid communication to a web-based system, as well as, continuous power supply. The project team learned that in order to overcome this challenge, a standalone webpage or system, not utilizing the university platform, would greatly improve the communication issues. In addition, it is important to have a person dedicated to the software programming of these sensors to continue to improve them. If the sensors can be implemented into the community (Figure 7), in public spaces, allowing data to be easily, visually, and readily accessible through a mobile application, this will go a long way towards educating the public on air quality to make better and more informed decisions on their daily activities.

Figure 7. Rendering of a low-cost air quality sensor in public space.