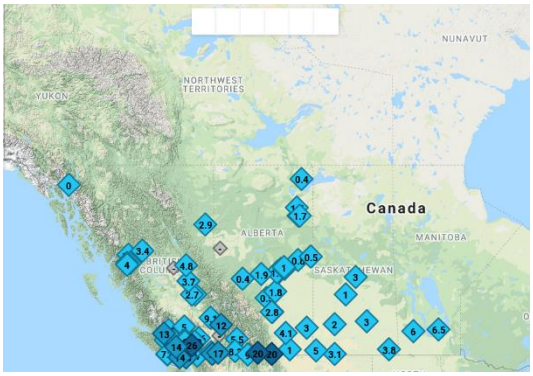
Small Low-Cost Air Quality PM Sensor Pilot Project

Collaborator Information

Overview:

The low-cost air quality sensor pilot project is being under-taken by the Meteorological Services of Canada (MSC), a branch within Environment and Climate Change Canada (ECCC), to investigate the benefit of using emerging low-cost sensor technologies to measure Particulate Matter (PM) to partner with governments, institutions and interested stakeholders to augment current air quality (AQ) monitoring networks. The aim is NOT to replace existing networks but to expand and increase spatial coverage of air quality measurements in areas that the current networks do not cover. The project started in Western and Atlantic Canada and will expand to Central Canada in the coming year.

Why do we need to augment the existing AQ network?



Location of Traditional Monitoring Network in Western Canada

The National Air Pollution Surveillance (NAPS) network, a collaborative effort between ECCC, the provinces, territories and some municipalities, has a long history of providing high quality air quality monitoring data in urban communities across Canada. This data is used to inform compliance with Air Quality Objectives and Standards and to track trends in ambient data. NAPS sites provide the observations that are used to generate the Air Quality Health Index (AQHI) and forecasting products. The AQHI is a communication tool that informs Canadians about the acute health effects of current air pollutants using a 1 to 10+ scale. While the spatial coverage of the NAPS network is representative of the larger population centers and reaches approximately ~80% of the Canadian population, it does not extend into many rural and remote areas. As a result, its measurements do not reflect the high spatial variability of PM2.5 observed during high impact pollution events, such as smoke from forest fires. This leaves ~20% of Canadians, who occupy the remaining ~70% of land area, with no air quality monitoring or AQHI forecast during high impact air pollution events, such as when smoke from forest fires inundates communities. By using low-cost sensors to provide real-time AQ data in these areas, communities will be better able to make informed decisions to protect their health during air pollution events.

What are the benefits for ECCC with the augmented network?

The MSC is responsible for forecasting the Air Quality Health Index (AQHI) within Canada and provides current and 2-day AQHI forecasts and health messaging for Canadians to make informed decisions. The AQHI calculation is based on the concentrations of Ozone, Nitrogen Dioxide and $PM_{2.5}$. The $PM_{2.5}$ measurements made possible by low-cost sensors in the augmented network will be used by the MSC in the following way:

- Real-time PM AQ data will be made available to remote, northern or Indigenous areas. These data will supplement information provided by our air quality forecast models and will be used by MSC forecasters to provide the best possible synopsis of current and future air

quality conditions to Canadians and partners. This is particularly important during high impact AQ events, such as wildfire smoke events, when PM concentrations can be highly variable in scale, both spatially and temporally.
- Data will be used to improve air quality dissemination products (such as web map applications) as well as air quality and smoke forecast models and nowcasting tools,.
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What benefit does the hosting community/agency get from the augmented network?

Hosting a sensor within a community as part of this augmented network can benefit the community in the following ways:

- Real-time $PM_{2.5}$ data would be available to the community via a map product: (https://cyclone.unbc.ca/aqmap).
    - The map product includes sensor and agency concentrations of $PM_{2.5}$ as well as the health messaging that is associated with that concentration based on the AQHI+ $PM_{2.5}$ calculation.
    - Time series graphs per location by clicking on the map show the current PM concentration and how it relates to that of previous days. This can provide answers to inquiries, such as, "Is the concentration higher or lower than yesterday?"
    - The data can be used by the community to make informed decisions about their health, such as whether to participate in outdoor activities
    - The product can be used in real-time for public outreach and social media to educate Canadians on the use of AQHI during extreme events, such as acute wildfire smoke impacts.
- The PM sensor technology can be used as an educational tool in schools and the community to increase awareness of activities that cause air pollution events and to discuss actions to reduce these impacts. Students and Canadians can track data using the tools available on the UNBC sensor network web site.

What role does ECCC play in this augmented network?

During this pilot project, the Air Quality Science units within the MSC are coordinating this augmented network and will be responsible for the following:

- Testing low-cost sensors to understand their capabilities and limits
- Providing the low-cost sensors to collaborators
- Providing instructions on the siting and installation of the low-cost sensors
- Providing expertise for questions regarding sensor technology, the map product, sensor installation, etc.
- Providing a mapping tool in collaboration with the University of Northern British Columbia (UNBC), which can be accessed by the public https://cyclone.unbc.ca/aqmap
- Providing automated corrections to the data following the determination of regionally specific correction factors, if applicable. This correction factor is currently being updated by collocating low-cost PM sensors with the higher quality monitoring instrumentation traditionally used in the NAPS network.
- Providing automated basic quality control (QC) of the data that is reported to the mapping tool, e.g. ensuring that the sensor is reading values typical of outdoor air vs. indoor air and ensuring that the two sensors within each sensor package match.

- Providing any repairs or replacements of sensors during the pilot project

What role does the sensor host play in this augmented network?

The sensor host has the following responsibilities in this augmented network.

- Receiving and installing the sensor according to the instructions provided by ECCC. The installation is simple and should take less than 30 minutes.
- Providing the power for the low-cost sensor.
- Providing the WIFI for the low-cost sensor.
- Performing occasional simple trouble-shooting such as power cycling the sensor (turn off and on)
- Shipping sensors back to ECCC if they fail.

Which communities or regions is ECCC looking to collaborate with during this pilot project?

The focus areas for this pilot project are as follows:

1. Communities that do not have or are not near a traditional NAPS or Provincial/Territorial AQ monitoring site.

2. Communities that have in the past been impacted by smoke from wild fires or local residential wood smoke.

3. Communities that are interested in installing Air Quality PM sensors at a school to examine the feasibility of incorporating air quality education into a school curriculum.

4. Indigenous communities that are interested in air quality monitoring in their communities.

Frequently Asked Questions:

How much power does the PurpleAir sensor use?

The power usage is small. The power supply is a 5V at a max of 1.5 A, or 7.5 W.

How much data does the PurpleAir use?

Sent messages will be less than 180 bytes per message, with 4 messages every 2 minutes for a total upload of around 518 KB/day (~15 MB/month).

Why can they not just expand the current network into my community?

Obtaining the high quality data associated with traditional networks is expensive. Initial setup of a monitoring site can cost hundreds of thousands of dollars or more, when land acquisition, a shelter and instrumentation are included. Operating costs are also substantial, as it takes trained technicians to maintain a monitoring site. Therefore, it is not feasible or possible to expand the existing network to every community. However, using low-cost sensors in under-served areas can help to provide additional information about local air quality conditions and help inform air

quality network managers about whether enhancing the monitoring capabilities in certain areas may be warranted.

Will they remove existing monitoring in my community if we use these low-cost sensors?

No. The goal is not to replace the existing network but to expand into areas that do not have existing monitoring or sufficient spatial coverage with existing monitoring.

If I look on the map and see a difference between our low-cost monitor and the traditional monitoring network which one should I believe?

They both could be correct, however, the traditional monitoring network has higher quality measuring equipment and will likely be more accurate. This may not necessarily mean that the low-cost sensor is incorrect, as in some cases it may be picking up local effects such as traffic, a smoke plume or a car idling nearby.

Is the password for the network encrypted?

According to PurpleAir, the WiFi details on the microchip within the sensor (ESP8266) are not stored encrypted. You would need physical access to the device and the know how to flash it with your own firmware to extract the password. For more information regarding the PurpleAir security features please visit their website: https://docs.google.com/document/d/1mUPywHk59i3kTP_8h0w--vMQejEl1we47PPUilXJG1M/edit

There are many low-cost sensors on the market. Why is ECCC only using the Purple Air sensor?

ECCC has assessed numerous low-cost PM sensors. The PurpleAir sensor was chosen for this stage of the pilot project for the following reasons:

- Cost – of the sensors assessed by ECCC; the PurpleAir is one of the least expensive sensors that had reasonable correlation with the higher quality monitors in the traditional network.
- Ease of Data retrieval – the data are easily incorporated into the UNBC mapping tool
- Availability of Citizen based monitors – numerous Purple air sensors have been purchased by the public and can add to this collaborative network

ECCC is continually assessing other low-cost sensors, and although PurpleAir are currently the only low cost sensor data displayed on the mapping tool, other low-cost sensor data may be added in the future.

Note: Low-cost sensor data on the mapping tool are provided by PurpleAir and are subject to the capabilities and limitations of these instruments. Use of any data provider or system does not constitute endorsement or recommendation of that system. Mention of trade names or commercial products does not constitute ECCC endorsement or recommendation for use.

How accurate and reliable is the data from low-cost sensors such as the Purple Air compared to traditional monitoring technology?

While low-cost sensor data are useful for providing information about air quality, the sensor data are not as accurate as that produced by the traditional monitoring network. The PurpleAir sensors may overestimate or underestimate the actual concentrations but do tend to follow the trend of the particulate matter concentrations. ECCC does not use the data from the low-cost sensors for regulatory purposes.

The PurpleAir sensor data displayed on the UNBC map (https://cyclone.unbc.ca/aqmap) includes a correction factor to improve the data accuracy. The correction factor was developed using available data from collocated Purple Air and traditional regulatory monitors across North America. Collocation studies have found that when corrected data from the PurpleAir monitors is compared to traditional monitors, the AQHI was found to be within 1 AQHI unit, approximately 95 percent of the time. Work by ECCC scientists is on-going to further investigate the correction factor using the most recent data from across Canada and North America, and the mapping tool will be updated to include a new correction factor, if necessary, as this work progresses.

Traditional monitors are located at long-term sites that had to meet rigorous siting conditions, while low-cost sensors do not follow such procedures. This may result in low-cost PM sensors being place near local sources, such as BBQs or idling cars, which could affect their measurements. Therefore, comparing sensor data with other nearby sensors or regulatory monitors, if possible, may be helpful in determining if a particular sensor is picking up contamination by a local source.

The data from the sensors is also available on the Purple Air website. How is that different from the UNBC map product?

The PurpleAir map (https://www.purpleair.com/) and the UNBC map (https://cyclone.unbc.ca/aqmap/) both display data from the host sensors and both can provide information.

The PurpleAir map:

- covers the entire world
- displays only low-cost sensor data
- data can be displayed using a variety of correction factors determined throughout the USA.
- The default for color coding is in line with that of the US AQI index
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The UNBC map:

- utilizes a correction factor that was developed using Canadian $PM_{2.5}$ collocation data.
- currently only displays data in western Canada and bordering regions, such as Alaska and Washington
- displays data from both the regulatory grade monitors and the PurpleAir sensors

- displays additional information, such as the ECCC Firework $PM_{2.5}$ forecast, NRCan active fire locations and fire danger ratings, satellite data, as well as other meteorological parameters of interest.
- displays messaging and colour coding in line with the Canadian AQHI
- includes preliminary quality control of the data

The AQHI is calculated from concentrations of $PM_{2.5}$, NO_2 and O_3. Why is ECCC only measuring PM2.5 in this low-cost sensor network?

The low-cost sensor pilot project is currently focused on $PM_{2.5}$ alone for the following reasons:

- The current technology for the low-cost $PM_{2.5}$ sensors show good correlation with traditional monitoring methods.
- The current technology employed in low cost sensors does not yield NO_2 and O_3 data that are well correlated with traditional measurements. As small sensor technology is rapidly changing, ECCC plans to continue evaluating new sensors, as they become available, and incorporate them into this network.
- $PM_{2.5}$ is the major contributor to poor air quality in communities impacted by smoke from forest fires.

What will happen at the end of the pilot project? Will this augmented sensor network continue to be supported by ECCC in the long term?

The purpose of this pilot project is to assess the benefit of using low-cost sensor technologies to provide additional air quality information in areas that lack traditional monitoring. Findings from this pilot will help to determine the next steps for the project.

Whom should I contact if I have any other questions?

You can contact the following for any further information.

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