Purple Air network in Alaska to monitor wildfire smoke

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Group website: https://atmoschem.community.uaf.edu/
Project website: https://akair.community.uaf.edu

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Outline

- Introduction to boreal forest fires
- Develop a network with low-cost sensors
- Next steps

Introduction to boreal forest fires

Boreal wildfires are very unique (1)

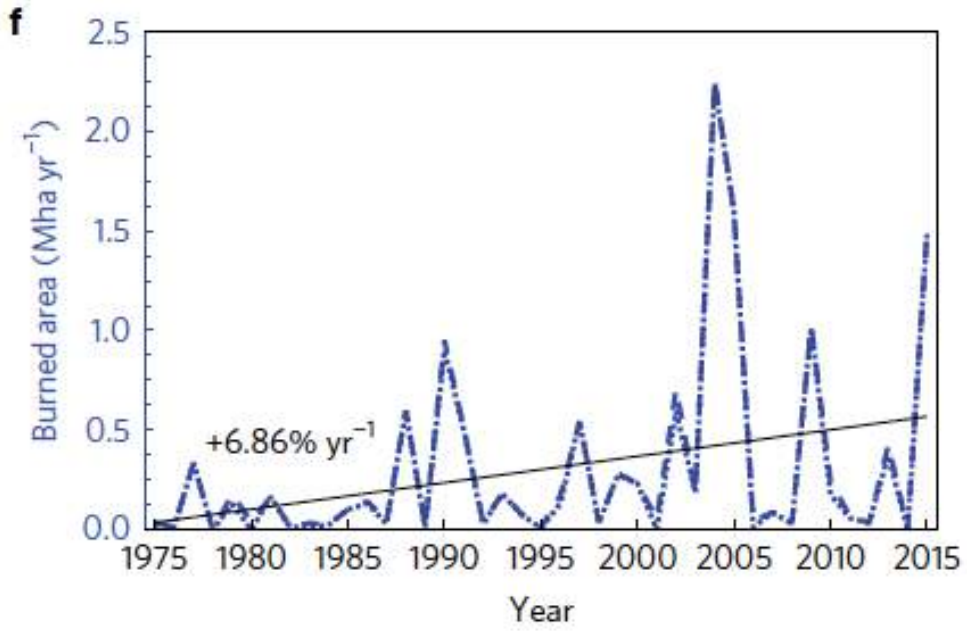
- Boreal forest fires are mainly set by lightning, not people.

(Veraverbeke et al., 2017, Nature Climate Change)

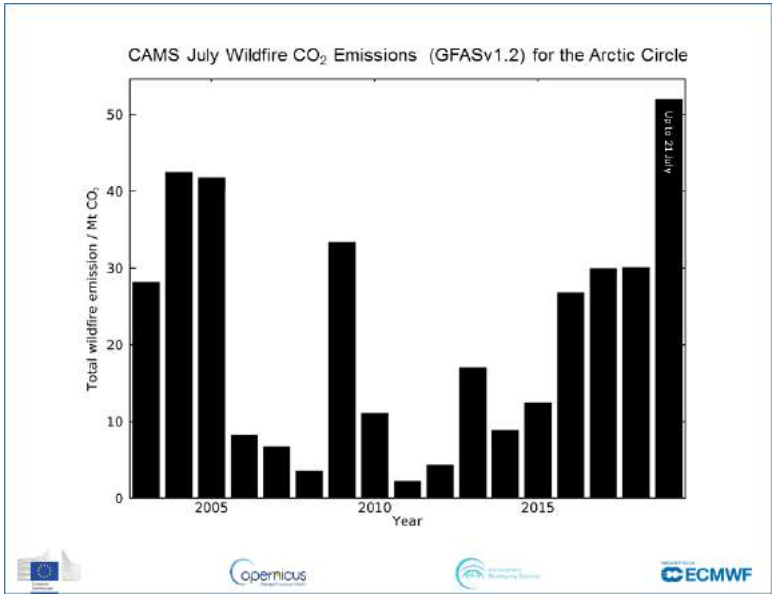
Boreal wildfires are very unique (2)

- Increasing trend of boreal forest fires
- New normal?

Burning area in Alaska from 1975-2015



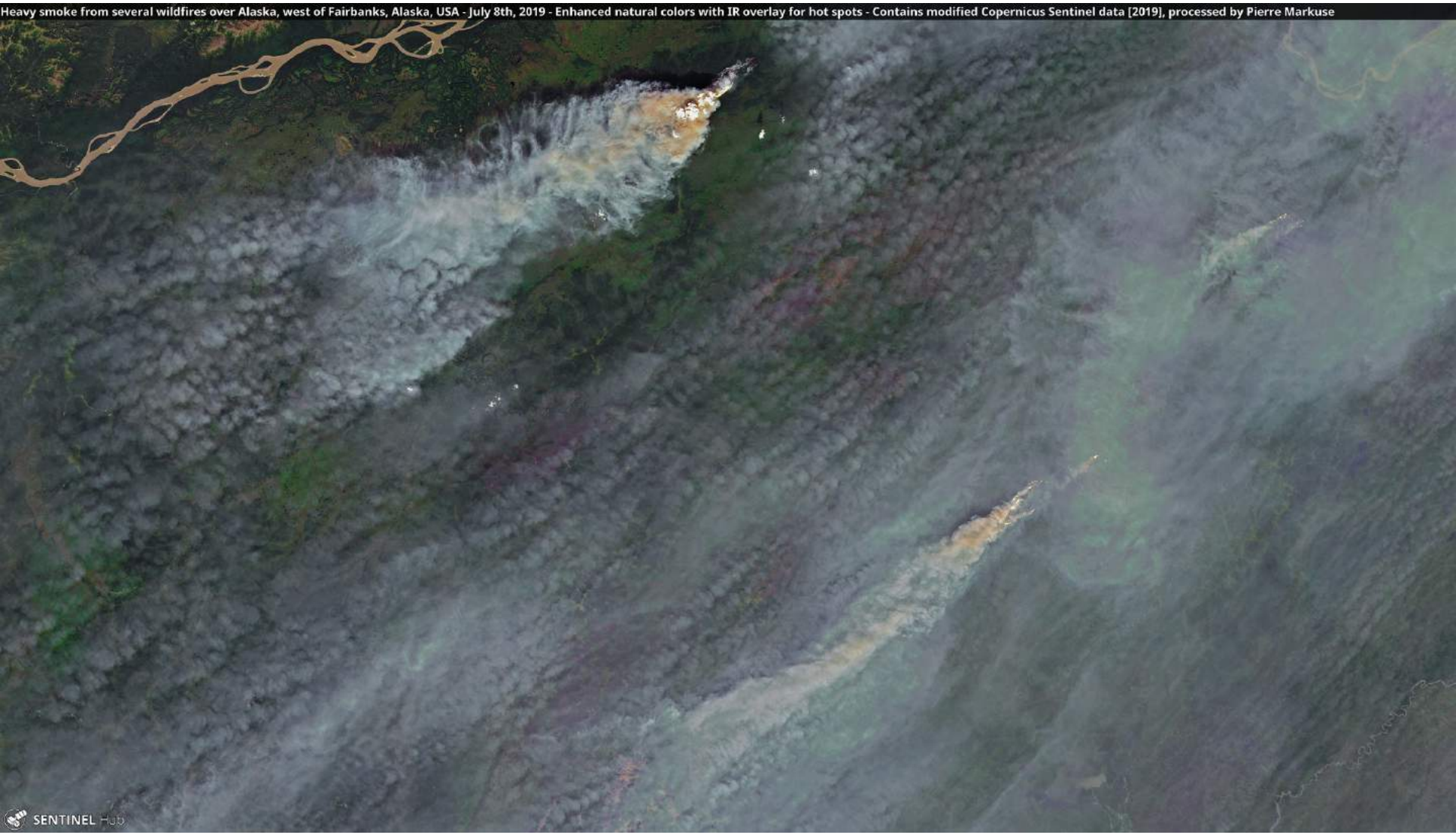
2018 is even higher



(Veraverbeke et al., 2017, Nature Climate Change)

(Credit: Mark Parrington)

You can see it from satellite



(Credit: Pierre Markuse)

You can also see it from NASA satellite

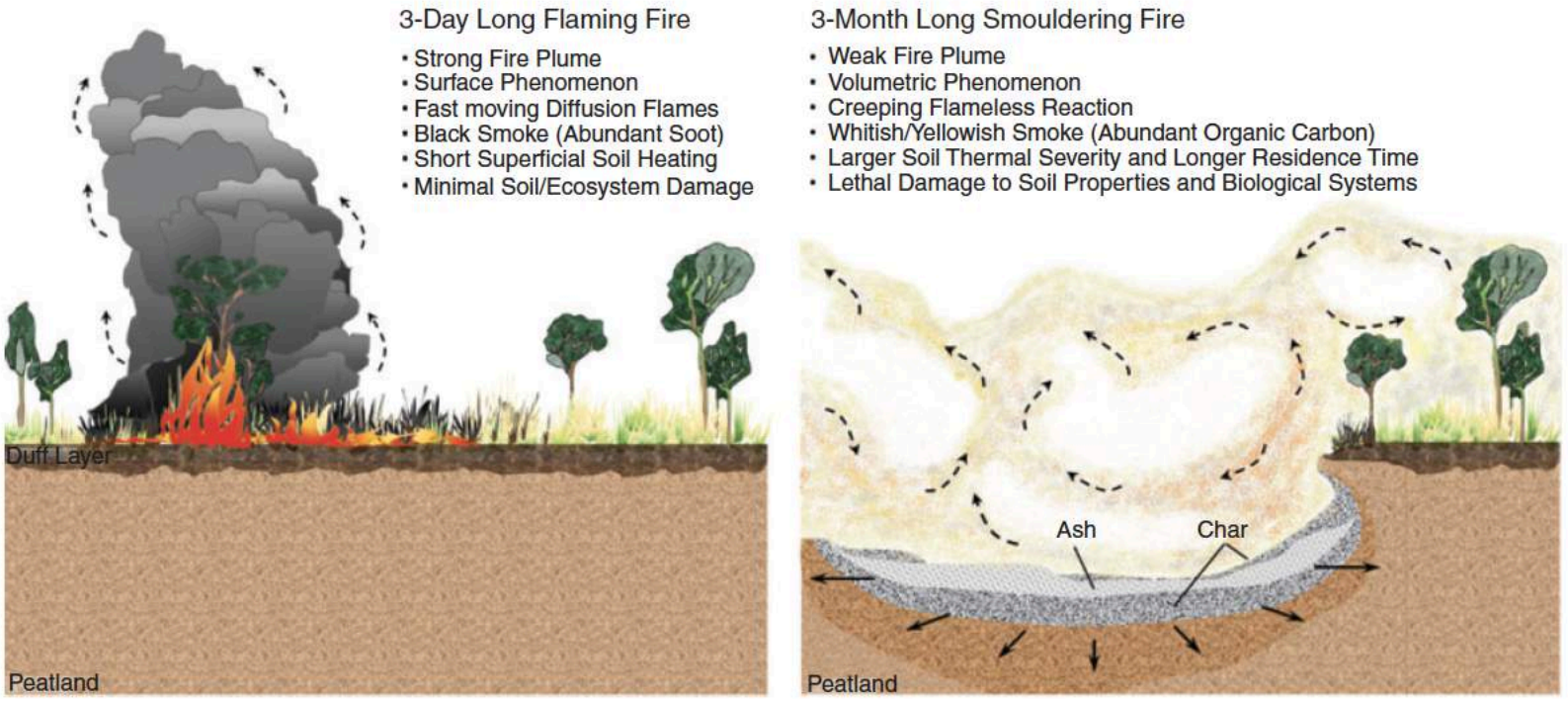
NASA Aqua satellite on July 8, 2019

Boreal wildfires are very unique (3)

Arctic wildfires are often fueled by duff layer smoldering

The duff layer is the organic material layer between the A-horizon (or uppermost soil mineral horizon) and the litter layer.
It is actually the primary carrier of fire in black spruce forest and often supports smoldering combustion.

Boreal forest fires last longer



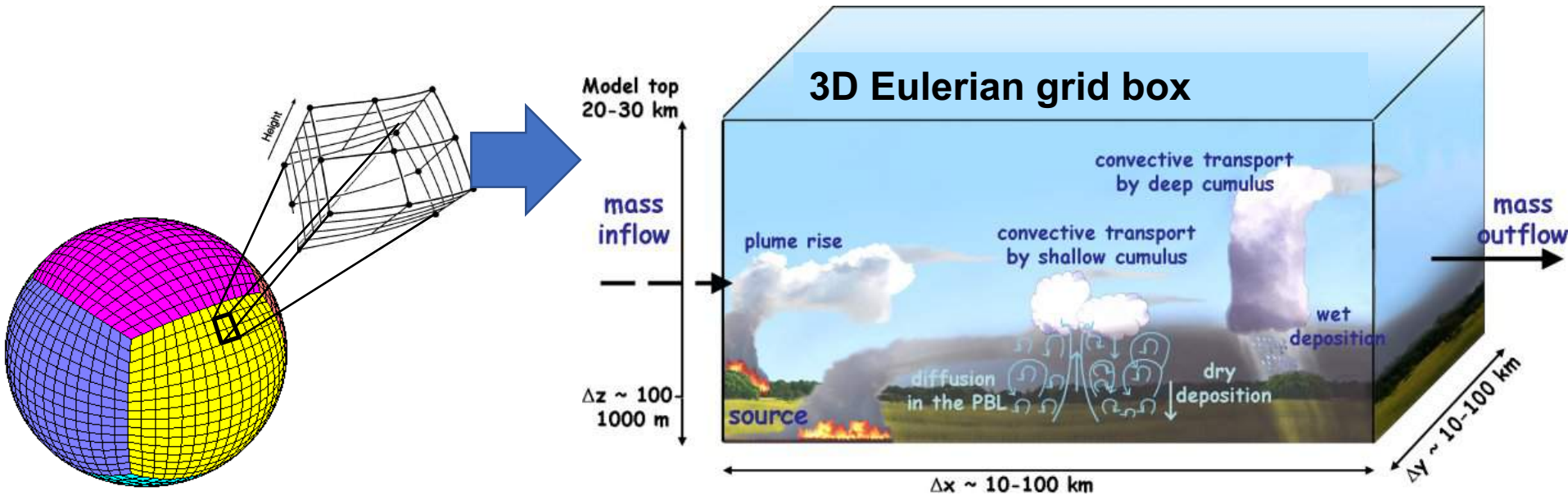
- 60-90% of fuel consumption comes from carbon in boreal soils (Peat, duff burning).
- Fires burning in the lower 48 U.S. states are often put out as quickly as possible, to avoid damage to property and human lives.
- In the Arctic, where the population is sparser, fires are often allowed to burn and often grow massive.

Boreal wildfires are very unique

- Mainly smoldering with little flaming [Akagi et al., 2011]
  - Aerosol emissions dominated by organic aerosols (OA) including brown carbon (BrC)
  - Relatively little black carbon (BC) [Chakrabarty et al., 2011]

Global Modeling of biomass burning

Solve continuity equation for chemical mixing ratios $C_i(x, t)$



Standard global chemistry-climate model (200 km x 200 km) has ~660,000 grid boxes.

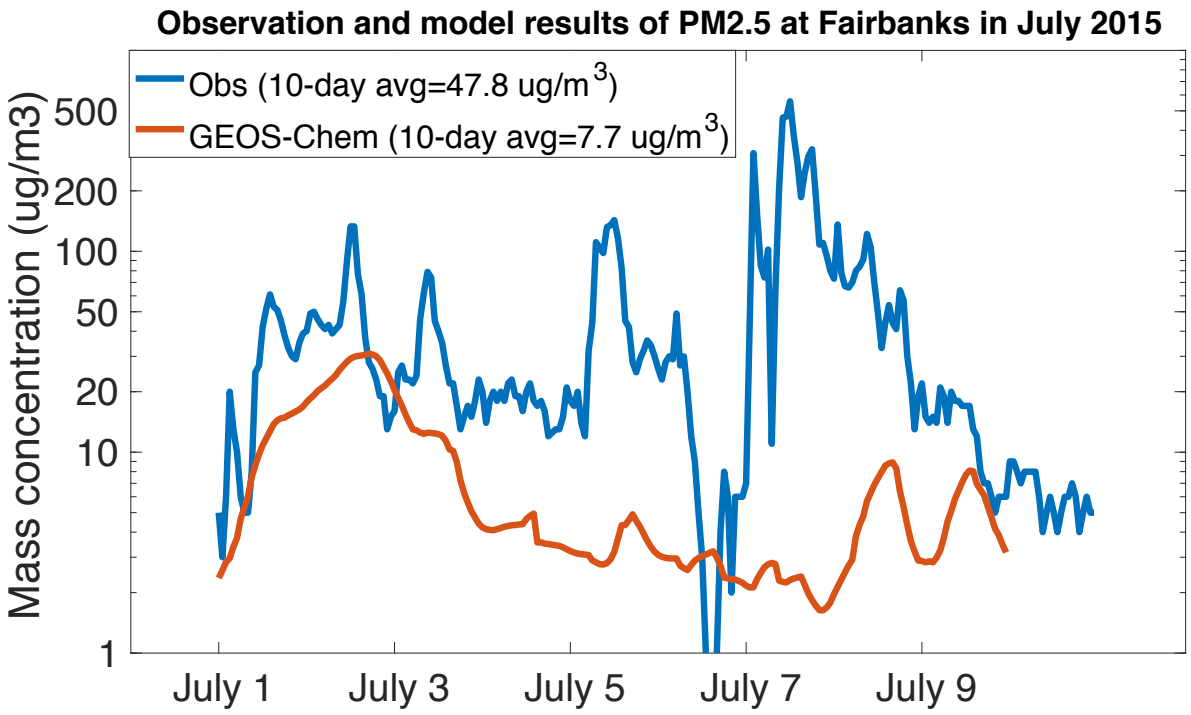
Biomass burning emission is driven by GFED4 daily emissions.

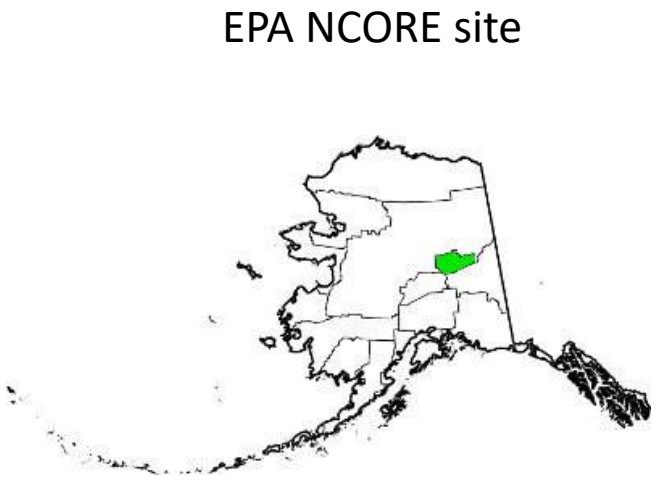
$$\frac{\partial C_i}{\partial t} = -\nabla(U \bullet C_i) + P_i - L_i$$

C_i = "mixing ratio"
U = wind vector
P_i = local source of chemical *i*
L_i = local sink

Observed and modeled PM2.5 during a fire event

Modeled $PM_{2.5}$ is too low by a factor of ~6 in 2015



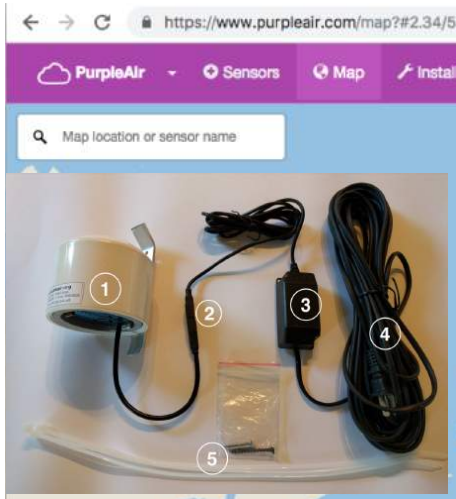


A challenge for satellite fire detection due to low intensity fires

- 45% fires undetected by MODIS in Alaska in 2016 [Waigl et al., 2017].
- Underestimation of aerosol emissions in current emission inventories, mainly derived from satellites.

2. Develop a network with low-cost sensors

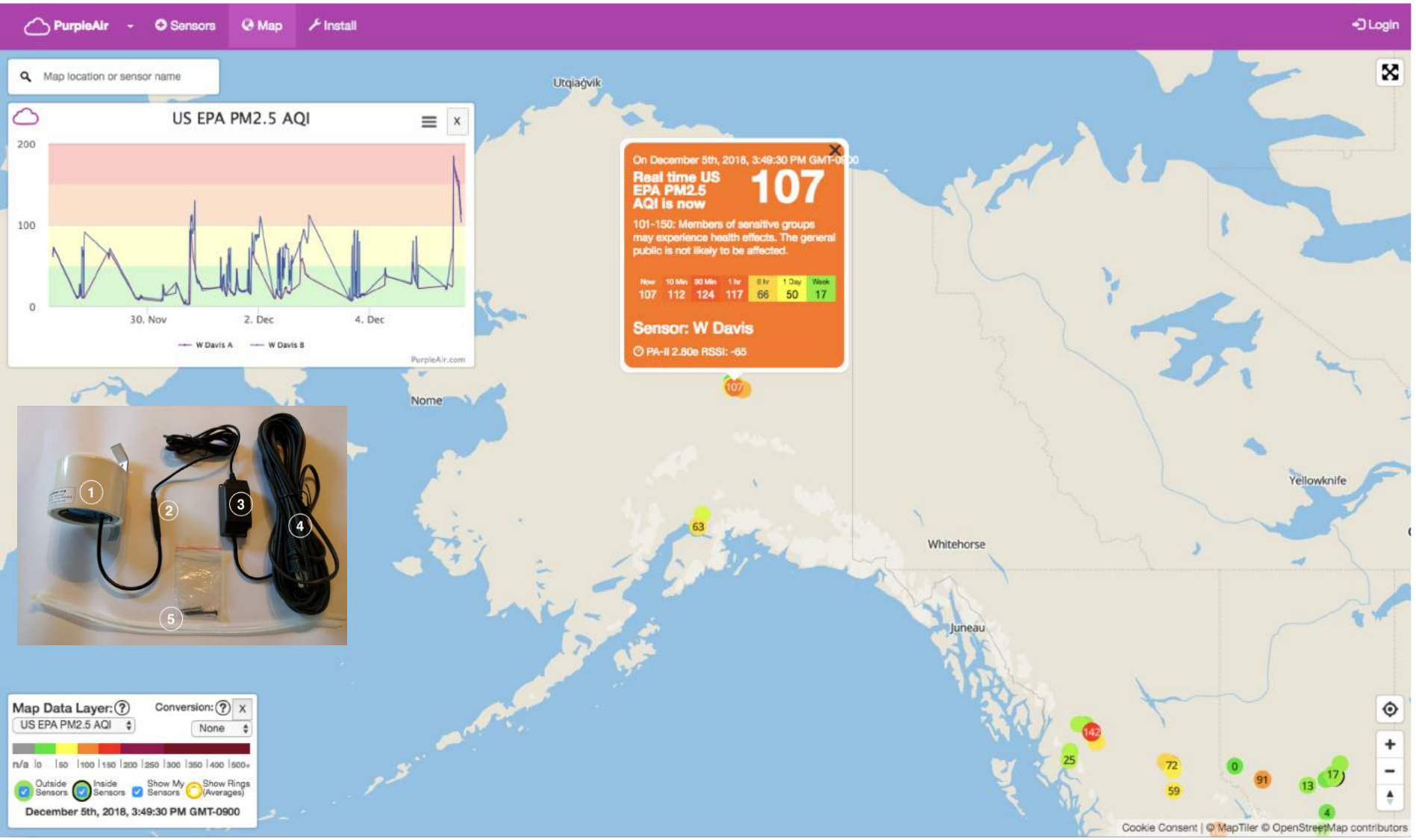
Strong need for real-time monitoring on air pollution

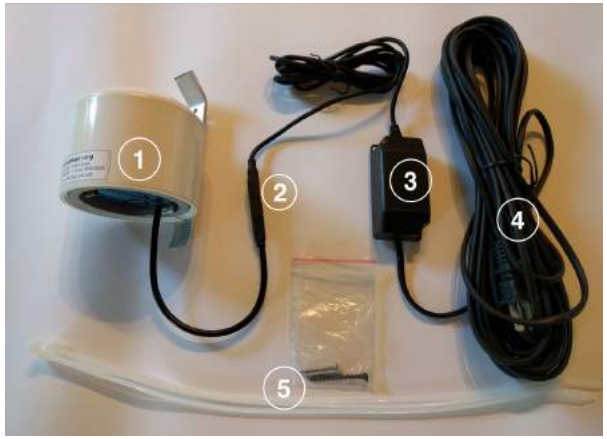


Why do we need this?

- Air quality in rural Alaska can reach alarmingly bad levels due to extreme wildfires and excessive road dust.
- We actually don't know how bad the air quality is in rural Alaska during wildfire seasons.
- Providing real time data for communities can provide a tool to help protect their citizens and understand health implications.
- Without knowledge of air quality, people are left guessing and uninformed to the dangers that they face when spending time outside.

Each sensor provides real time PM2.5, PM10, temperature humidity data, and data can be accessed by clicking the map.

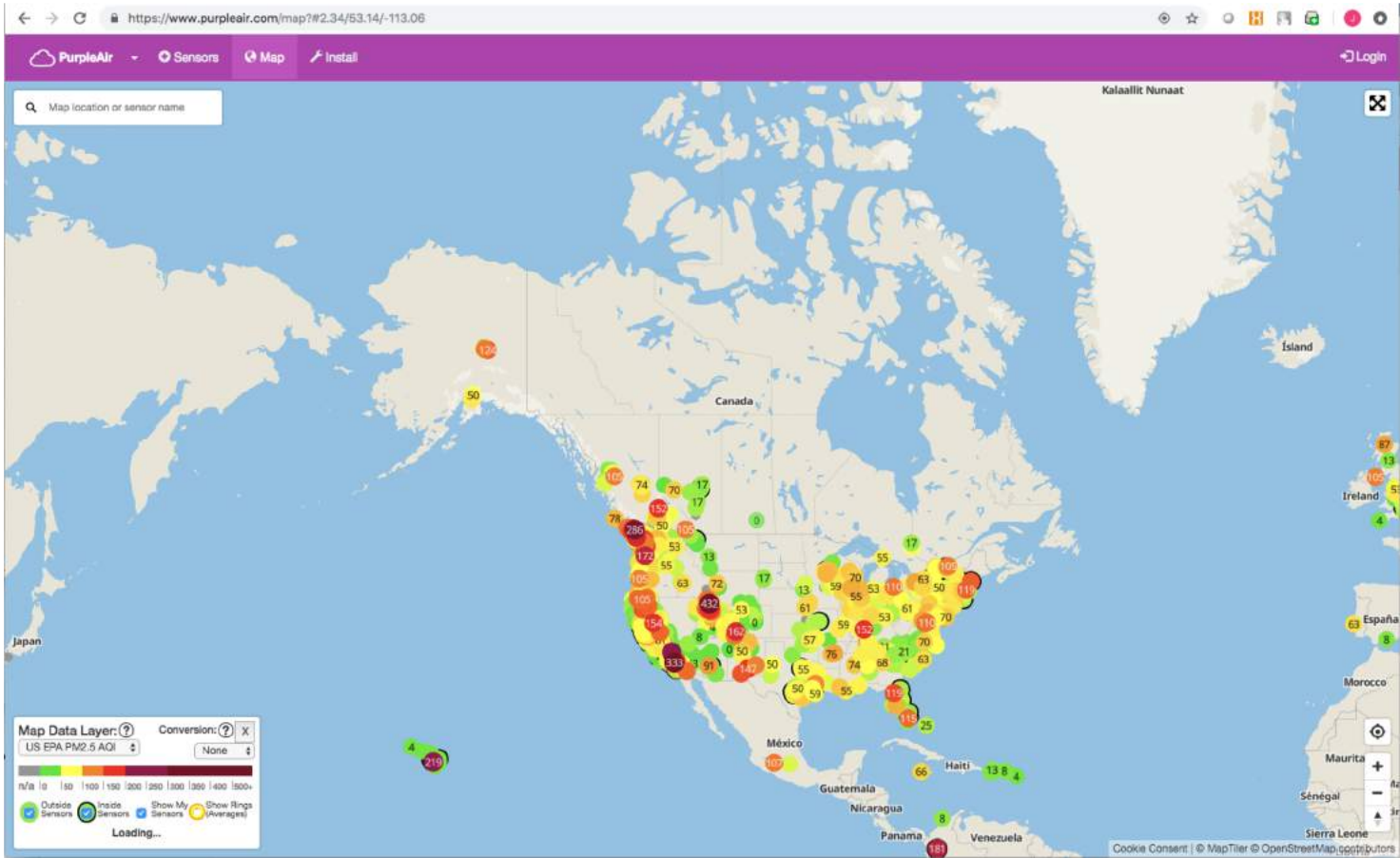




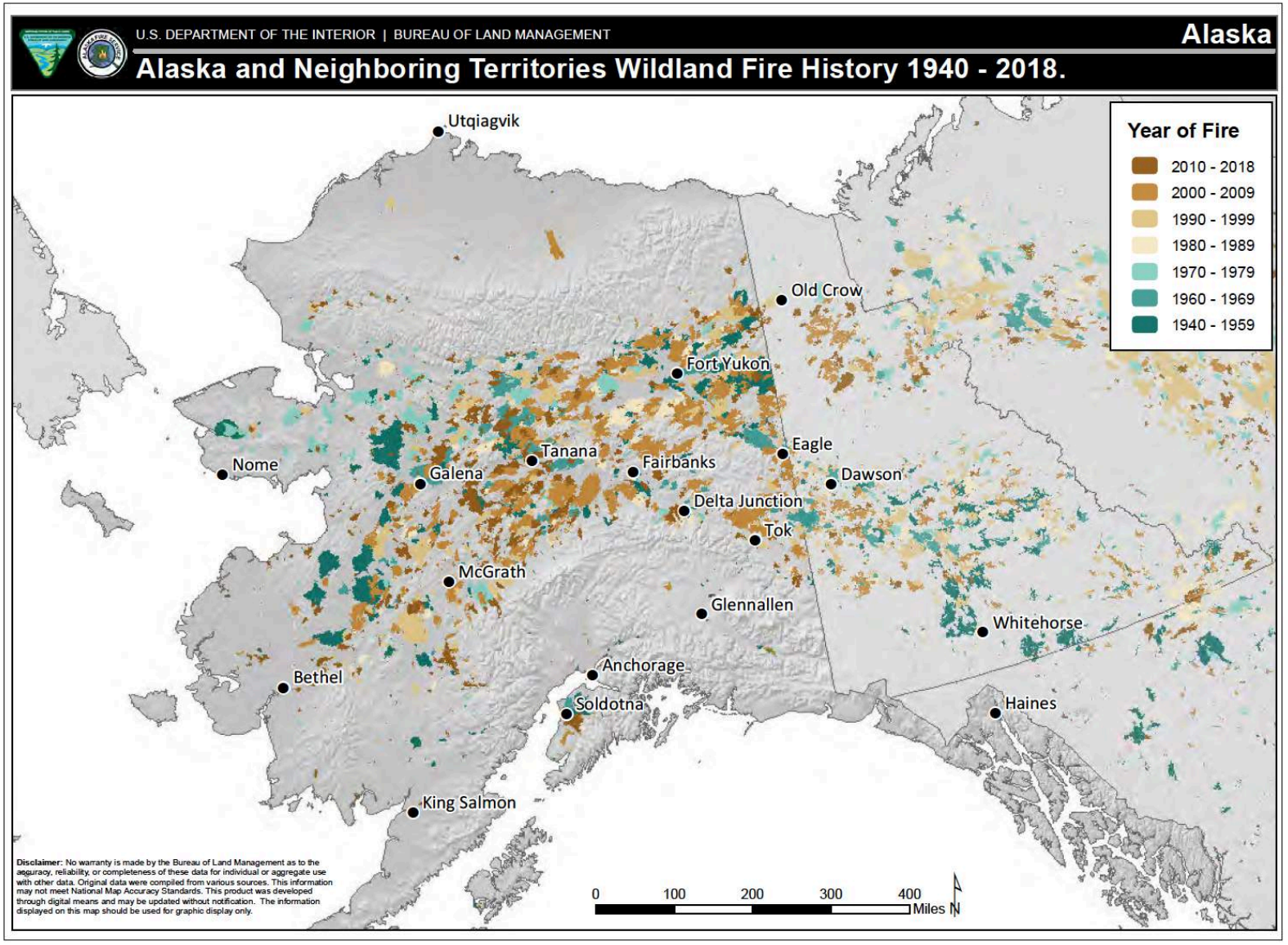
Vert few sensors in rural Alaska.

Where to put them?

($200)



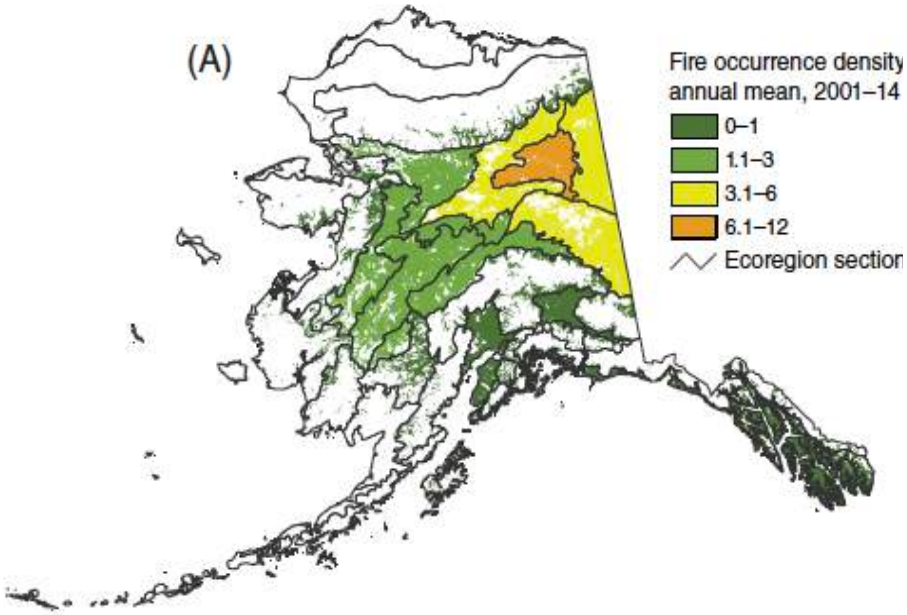
Fire history



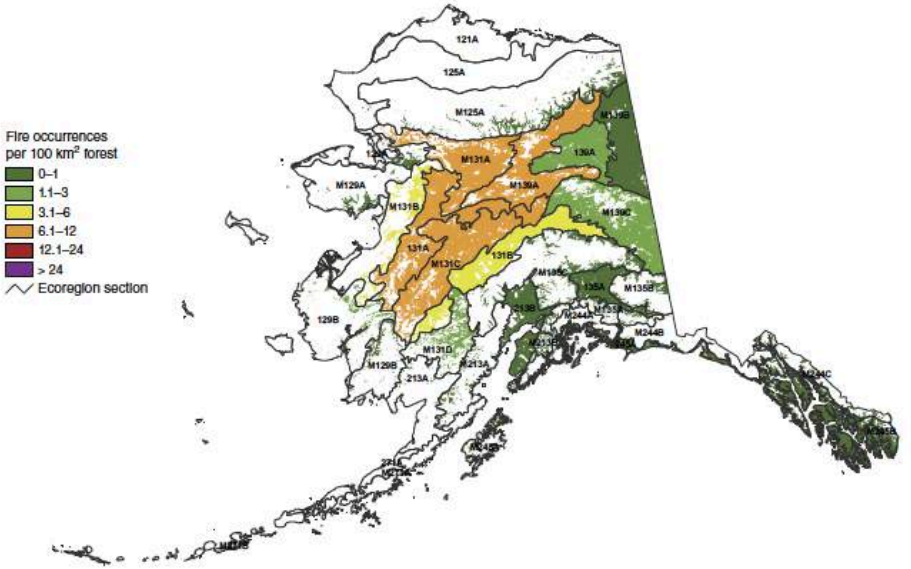
data source https://fire.ak.blm.gov/predsvcs/maps.php

Fire frequency

2001-2014



2015



Mean number of forest fire occurrences, per 100 km^2 (10 000 ha) of forested area for 2001 to 2014, by ecoregion section within Alaska (adopted from Potter, K.M., & Conkling, B.L. (2017)

This sensor can be deployed both outdoor and indoor.
If no internet available, data can be stored on microSD card.

PA-II: Dual Laser Air Sensor

1) Built in WiFi for logging to "the cloud".
2) Dual laser counters provide reliable particulate readings.
3) BME280 temperature, humidity and pressure sensor.
4) Automatic updates: Your sensor will update over WiFi when new firmware is available.

In The Box

1) PA-II Dual Laser Sensor.
2) Micro USB connector.
3) 5V 2A USB Outdoor Power Supply.
4) 17 foot power cable.
5) Zip Ties for mounting.

PA-II-SD: With microSD

Includes:
1) Everything included with the PA-II Dual Laser Sensor.
2) Built in 16Gb microSD Card (Good to store two years of data).
3) Built in Real Time Clock for offline logging.
Please note: The SD version may take longer to ship. The SD version is only intended for locations where WiFi is not available. We encourage the use of the standard PA-II where WiFi is available.

PA-I-Indoor:

A limited edition, 3D printed sensor with a single laser counter and BME280 temperature / pressure /

PurpleAir sensors use a fan to draw air past a laser, causing reflections from any particles in the air. These reflections are used to count particles in six sizes between 0.3µm and 10µm diameter.

Using one second particle counts, estimated total mass for PM1.0, PM2.5 and PM10 is averaged by the PurpleAir Internet of Things (IOT) control board.

Readings are then uploaded to the cloud every 80 seconds or so where they are stored for download and display on the PurpleAir map.

Item	Quantity	Each	Totals
PA-II		$0.00	$0.00
PA-II-SD		$0.00	$0.00
PA-I-Indoor		$0.00	$0.00

Please note: The SD version may take longer to ship.
The SD version is only intended for locations where WiFi is not available.
We encourage the use of the standard PA-II where WiFi is available.

NOTE: Your purchase places you in the shipping queue.
Currently, shipping time may be several weeks or more unless there is current stock.
Orders outside of the US may be subject to customs charges in your country.

Total: $0.00

Buy Now

Quantity	PA-II	PA-II-SD	PA-I-Indoor
1-2	$229	$259	$179
3-8	$219	$249	$169
9-25	$199	$229	$149
26+	$189	$219	$139

Technical Specifications

Power Supply

Outdoor power supply with 17 foot leads:
Output Voltage: 5 Volt (V)
Output Current: 2 Amps (A)

Julia joined us as a summer intern, sponsored by ITEP.

Speedbumps I have encountered along the way –

Lack of outside outlets
Lack of strong Wifi
Finding a place to mount sensors
Lack of communication to council or no response to inquiries
Bears

Location selection was based on using past data of wildfire activity and hot zones. Initially I identified the communities who are the most likely to have wildfire in their vicinities. After I saturated that area, I kept moving west and south dependent on accessibility and also influence in that area. Not only have I embarked on multiple road trips but have also flown into many communities that have agreed to be part of the study.

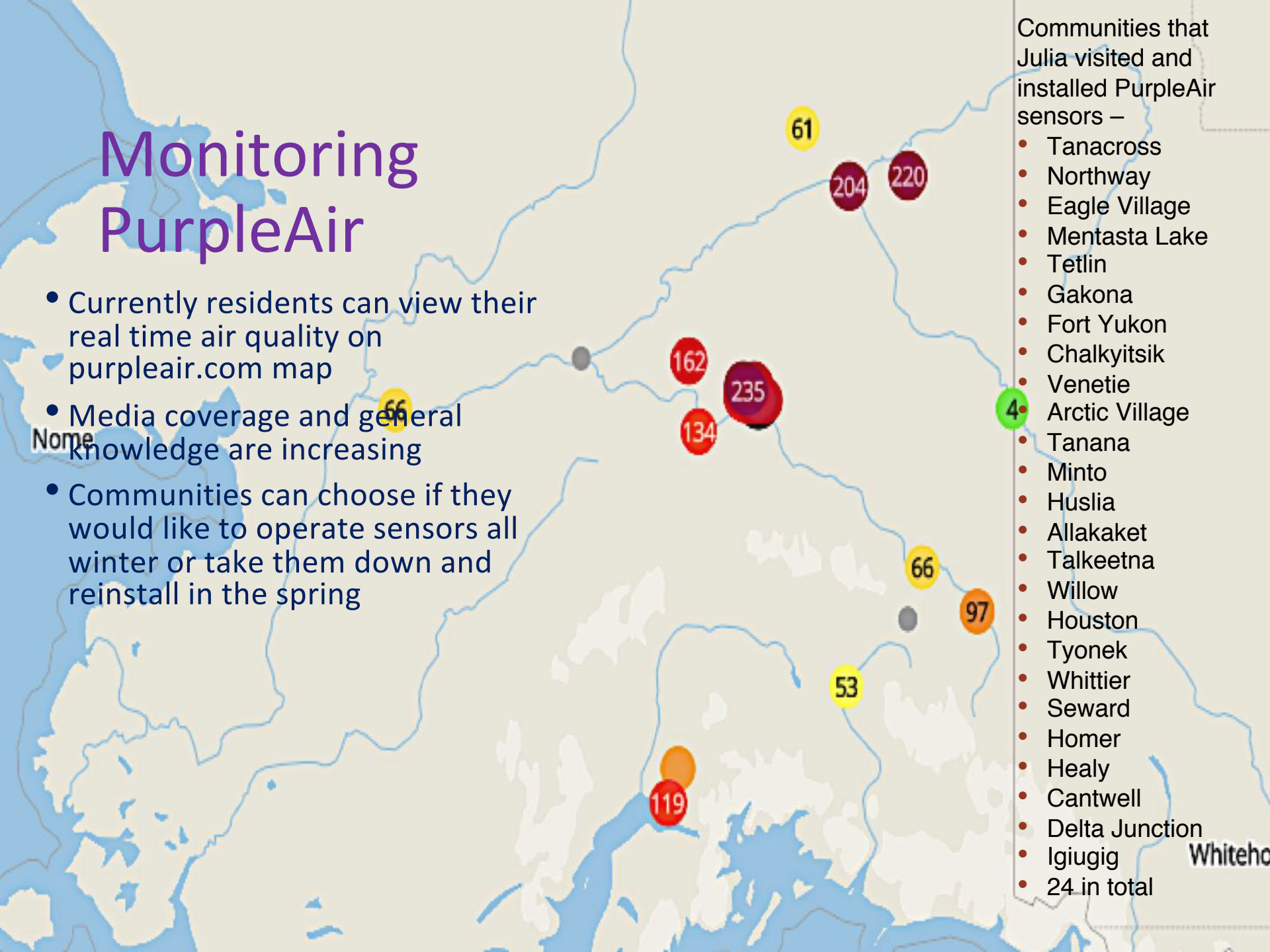
Installation Requirements

Outside power outlet (or ability to wire through the building) and strong WiFi signal. Cost to run a PurpleAir sensor, $0.88 per year and 20mb of data a month. Mounted with one or two screws or can be ziptied to poles.

Often times in rural communities patience and creative thinking are necessary components of finding the right spot to mount the sensor.

Monitoring PurpleAir

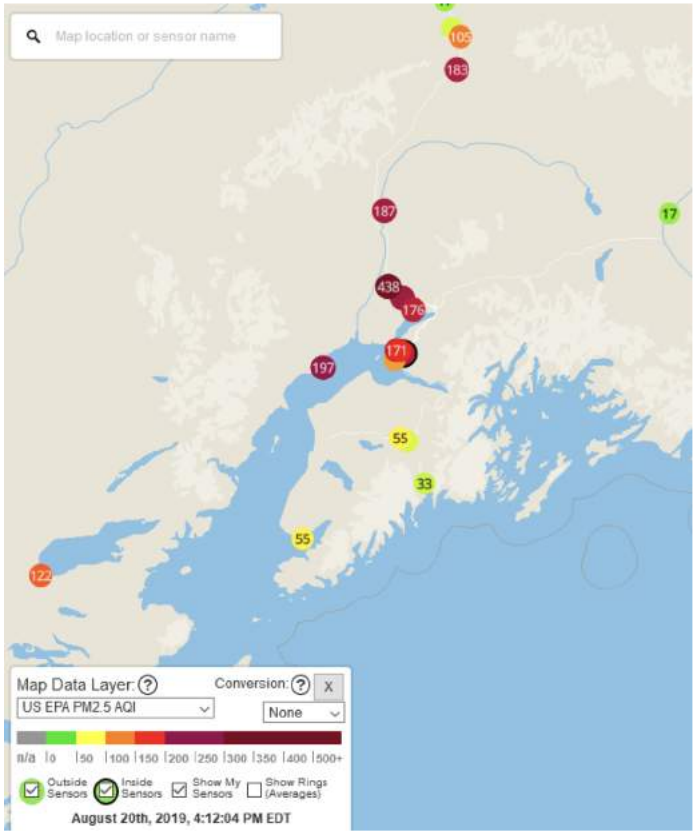
- Currently residents can view their real time air quality on purpleair.com map
- Media coverage and general knowledge are increasing
- Communities can choose if they would like to operate sensors all winter or take them down and reinstall in the spring

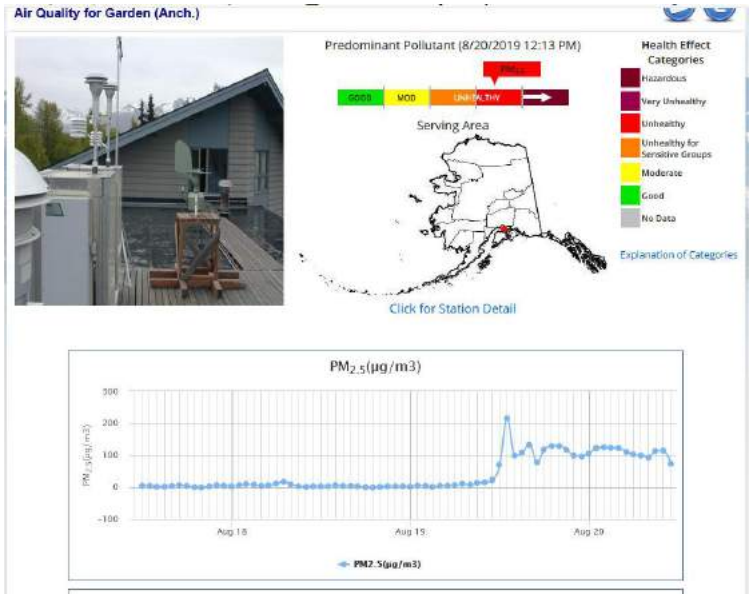


Communities that Julia visited and installed PurpleAir sensors –

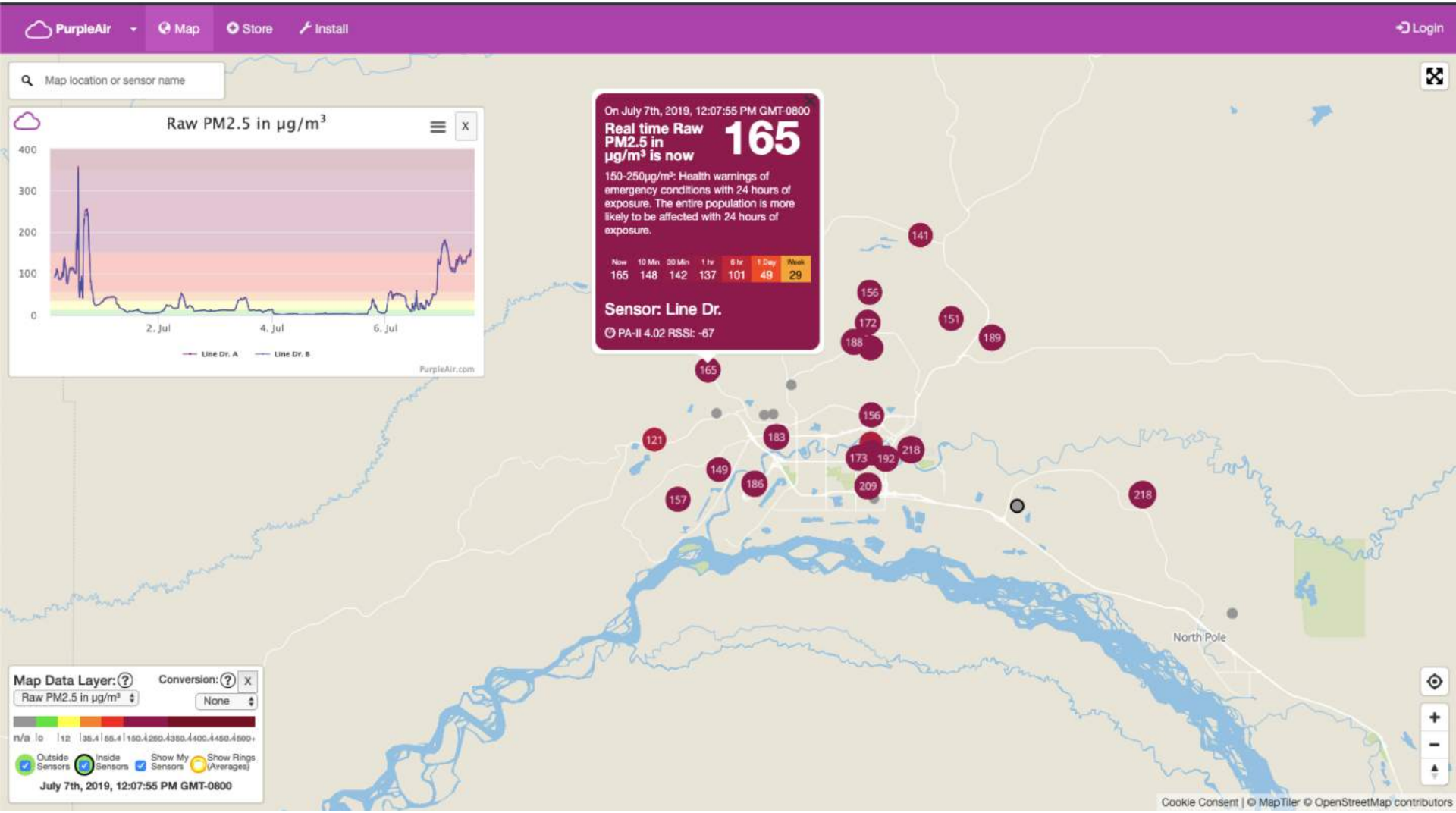
- Tanacross
- Northway
- Eagle Village
- Mentasta Lake
- Tetlin
- Gakona
- Fort Yukon
- Chalkyitsik
- Venetie
- Arctic Village
- Tanana
- Minto
- Huslia
- Allakaket
- Talkeetna
- Willow
- Houston
- Tyonek
- Whittier
- Seward
- Homer
- Healy
- Cantwell
- Delta Junction
- Igiugig
- 24 in total

Kenai fires


Map location or sensor name
105
183
187
17
438
176
171
197
55
33
55
122
Map Data Layer:
US EPA PM2.5 AQI
Conversion:
None
n/a 0 50 100 150 200 250 300 350 400 500+
Outside Sensors
Inside Sensors
Show My Sensors
Show Rings (Averages)
August 20th, 2019, 4:12:04 PM EDT

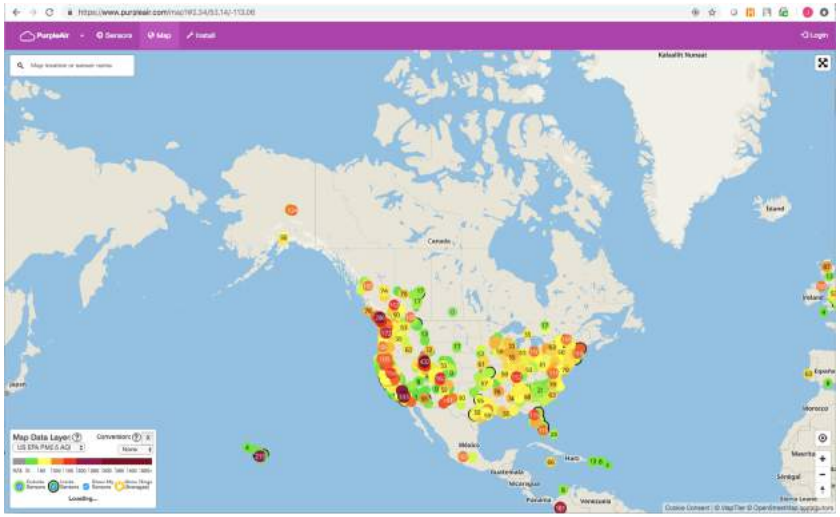

Air Quality for Garden (Anch.)
Predominant Pollutant (8/20/2019 12:13 PM)
PM2.5
GOOD
MOD
UNHEALTHY
Serving Area
Health Effect Categories
Hazardous
Very Unhealthy
Unhealthy
Unhealthy for Sensitive Groups
Moderate
Good
No Data
Explanation of Categories
Click for Station Detail
PM2.5(µg/m3)
300
200
100
0
-100
Aug 18
Aug 19
Aug 20
PM2.5(µg/m3)

Purple Air network provides critical information for air quality forecast, emission validation and many other things.

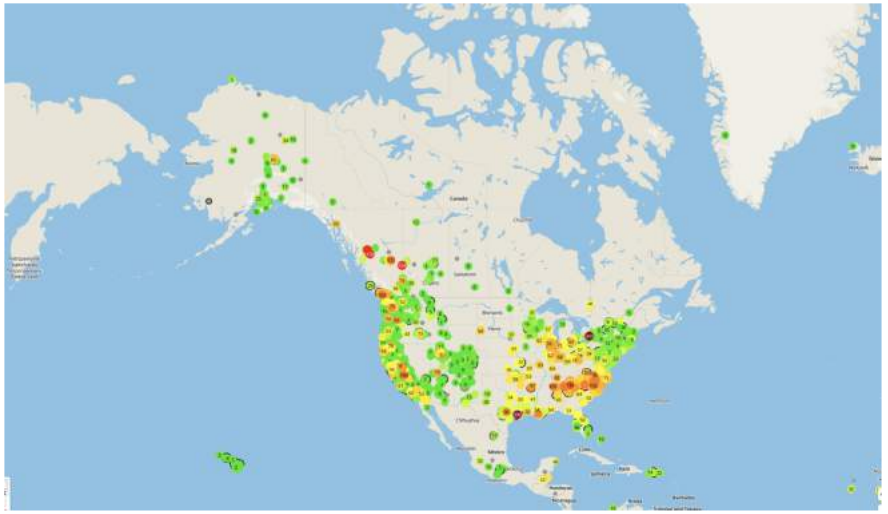


We have installed ~30 sensors in Alaska

2018



2019 and counting

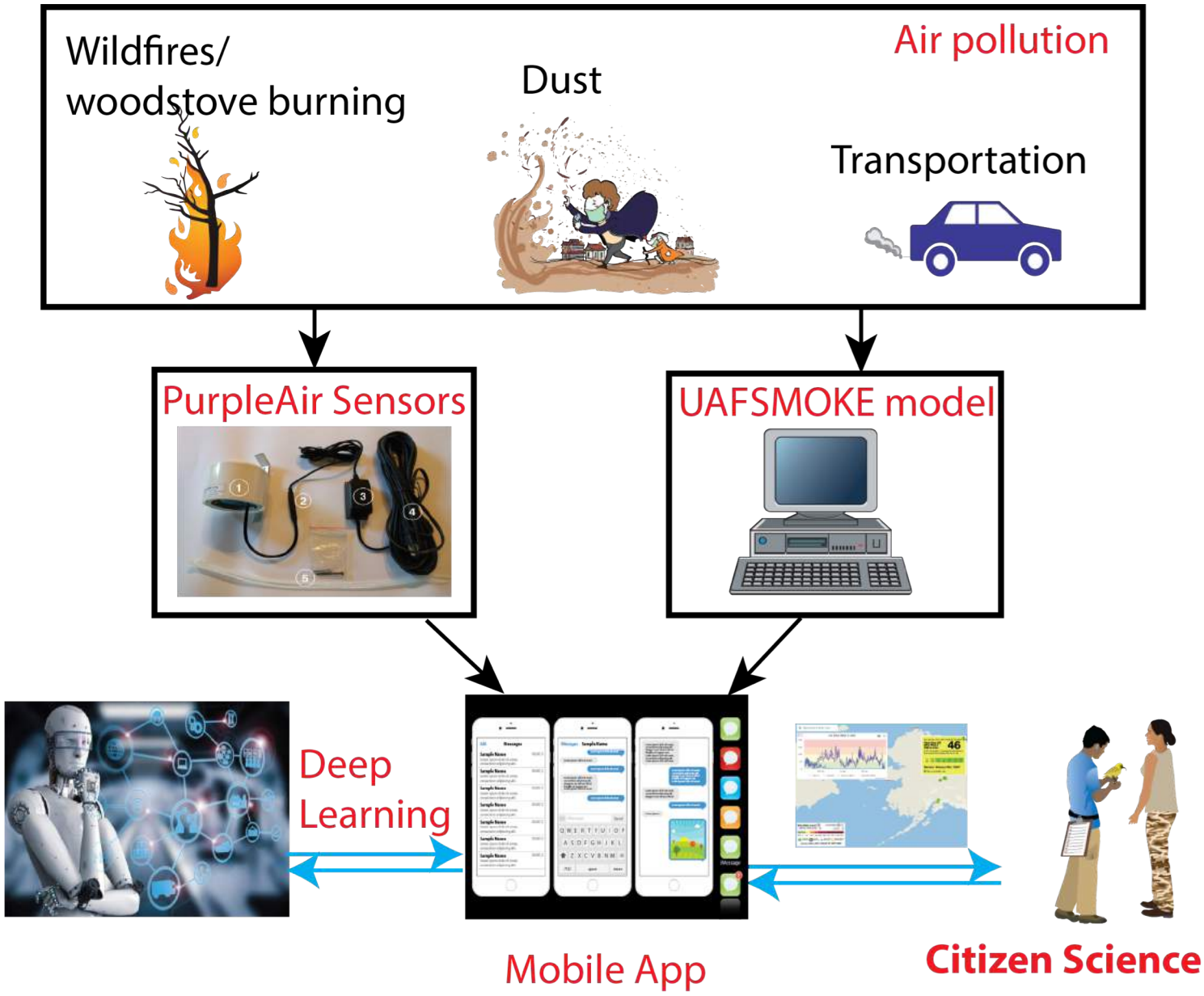


3. Next steps

The future of the PurpleAir project

- Once critical mass is reached we hope that communities in Alaska will seek out these sensors and install them independent of this program.
- Clinics and Schools around the state will see the health education possibilities and choose to install monitors on site.
- Development of school curriculum to learn about impacts of worldwide air quality (Julia is working on this!).
- Communities are able to use the data to seek funding for air quality grants and projects.
- Wildfires data sets will grow and evolve.
- Calibrations.

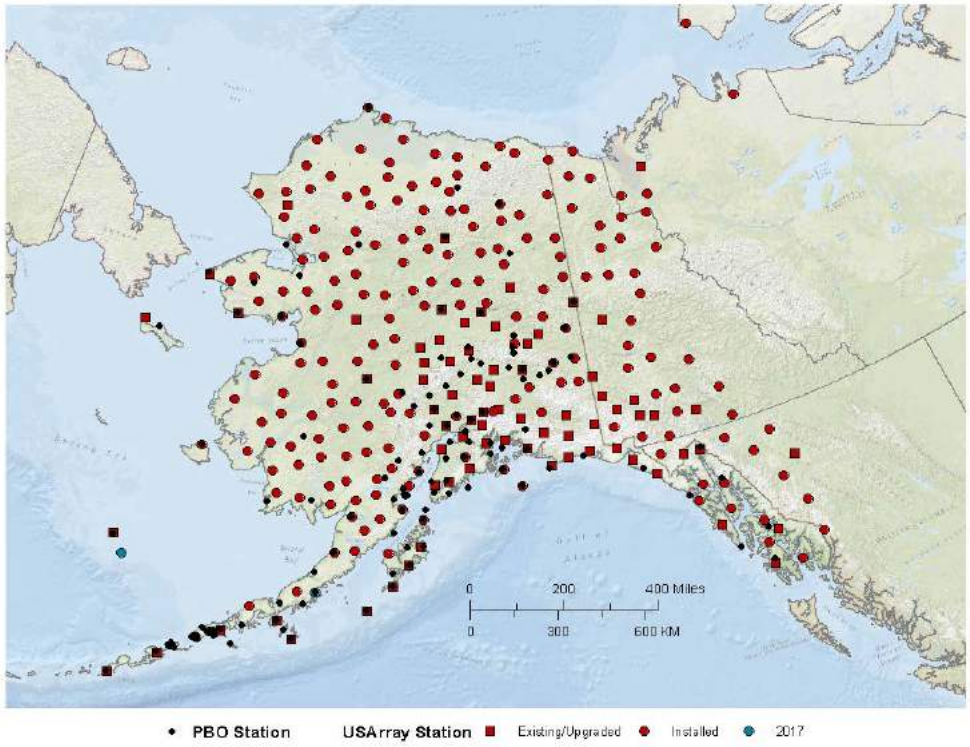
Mobile App for Air Quality (In collaboration with Martin Stufer, Jonathan Metzgar at UAF)



Step 1:
Install 20-30 sensors in rural Alaska, including high schools and elementary schools.

Step 2:
Develop cell phone APP for data access.

Step 3:
Include more sensors, similar to EarthScope map (100 sensors only cost $20,000).



Future work

- Detailed comparison between model and PurpleAir sensors.
- Validating model emission inventory with PurpleAir sensor network.
- Improving model prediction with 3-d model.
- Improving prediction with machine learning ???

References

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