Small Sensors to Augment Future Air Quality Services

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Team Members

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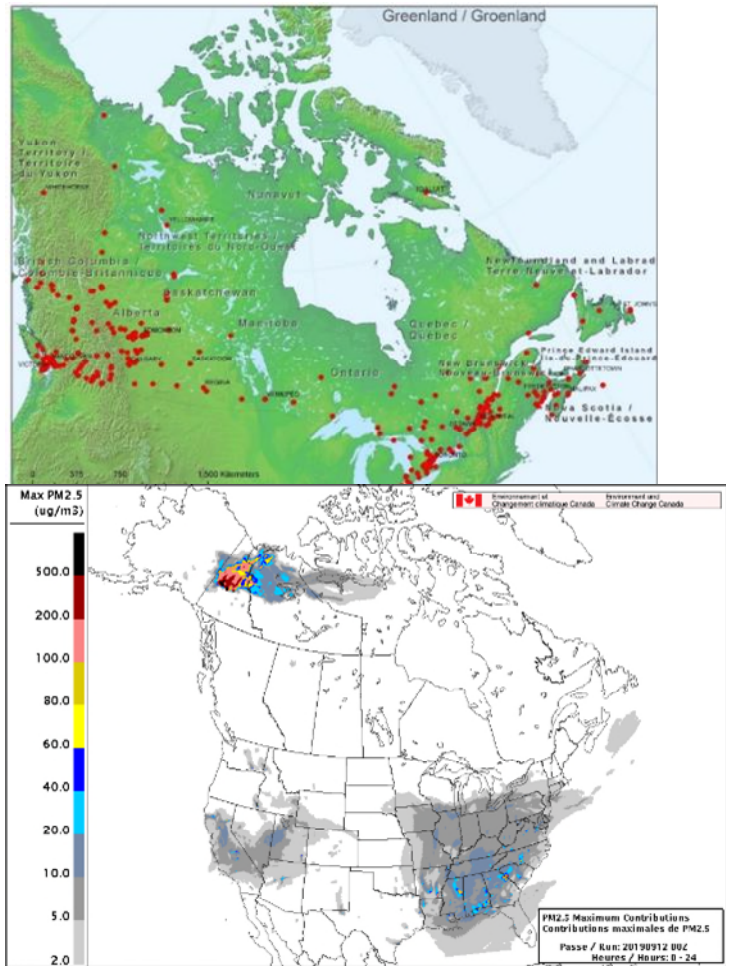
Prediction Needs for Air Quality Data



- Air quality concentration data are fed to ECCC's forecasting models (e.g., *GEM-MACH and Firework*) to provide AQHI forecast products to the public.
- Significant portions of the country are lacking AQ monitoring data.
- Monitoring gaps are most apparent when trying to predict wildfire smoke.

Service Needs for Air Quality Data

Emergency Management

- Data informs decision makers for evacuations due to wildfire smoke in remote communities.

Health Agencies

- To prepare for increased hospital visits and pharmacy dispensations.

Communities and the Public

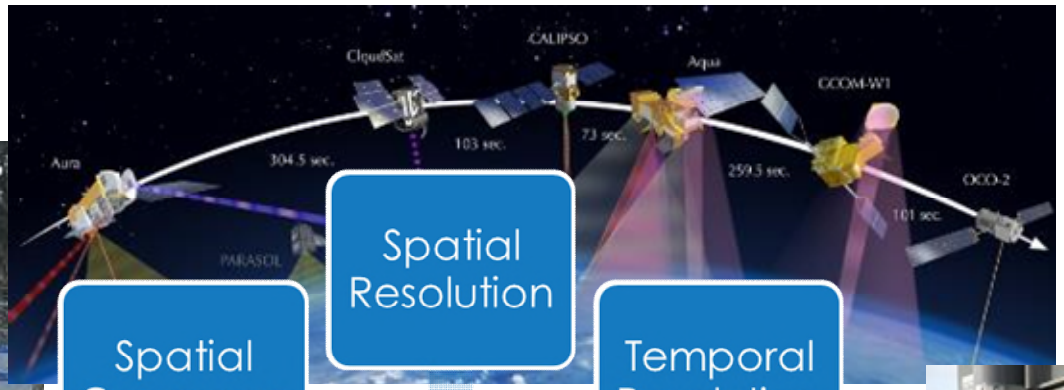
- To inform during smoke events to protect vulnerable populations.
- Advice to modify activity (e.g., cancel kids sports), stay indoors, or seek clean air shelters.

Traditional Air Quality Monitoring

- Reliable, high quality data from Federal Equivalence Method (FEM) instrumentation;
- Set at representative locations for compliance and regulatory purposes;
- Costly to set up and operate;
- Large footprint.

New Air Quality Monitoring Methods

- Emerging technologies in small air quality sensors can **augment** existing technologies to reach higher spatial resolution in real-time.



Spatial Resolution

Spatial Coverage

Temporal Resolution

Accuracy

AQ Data

Cost

Low-cost sensors

Advantages

- Low Cost
- Small footprint
- Ease of use

Disadvantages

- Lower accuracy and precision
- Limited calibration capabilities
- Unknown reliability
- Distrust by scientific community

Understanding restrictions and limitations can ensure a fit-for-purpose that still takes advantage of new opportunities enabled by low-cost sensors for air quality monitoring

Low-cost sensor evaluations

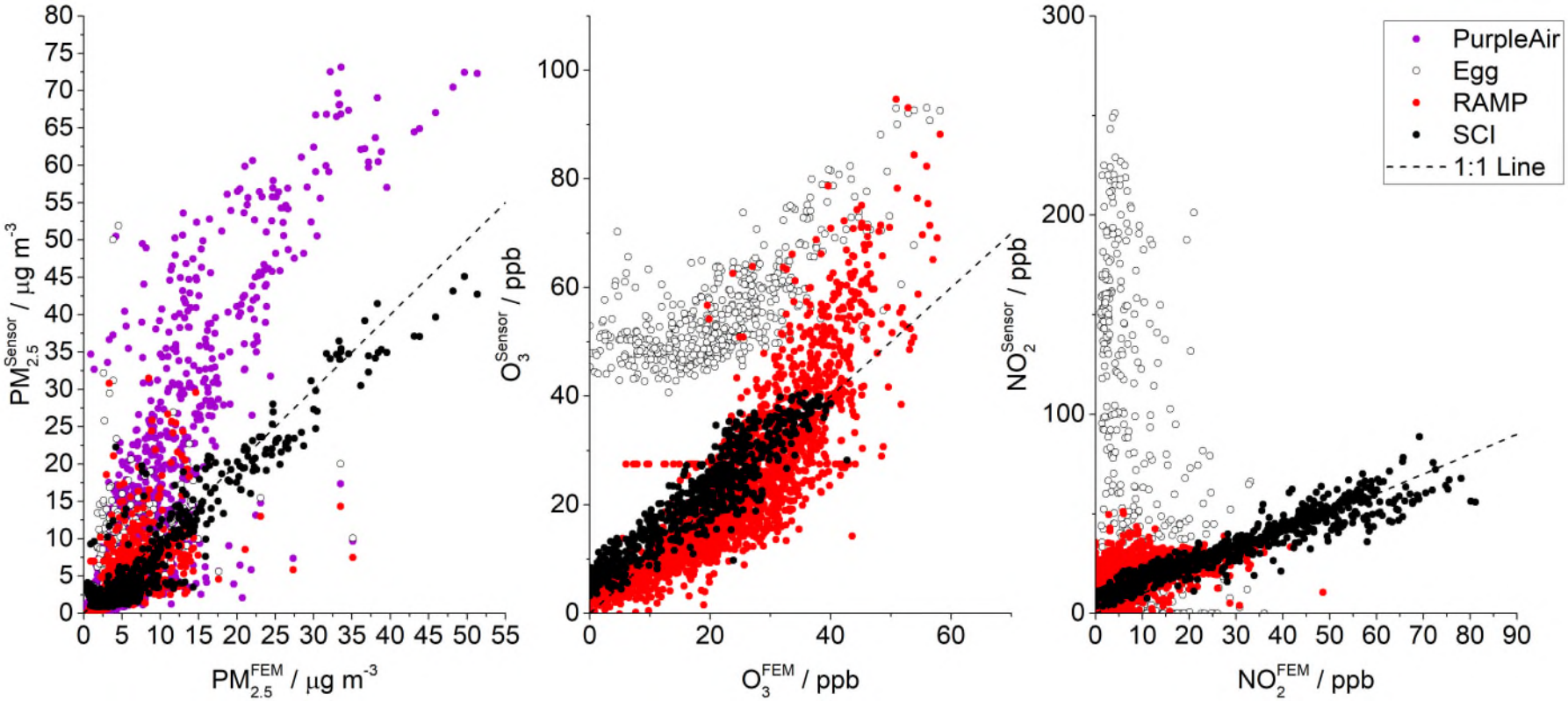
Sensor	Parameters	Purchase Cost	Other Costs	Quantity
Low-Cost Sensors				
PurpleAir PAII	PM	$250		155
Air Quality Egg	PM, O_3, NO_2	$400		6
TSI Blue Sky	PM, O_3, NO_2	$400		0
Moderate-Cost Sensors – "Near FEM" Sensors				
AeroQual AQY	PM, NO_2, O_3	$2500	$500/s/y	2
RAMP	PM, O_3, NO_2, NO, CO_2, CO	$3000		6
SCI-608	PM, O_3, NO_2, CO, SO_2	$5905	$850/s/y	2
2B 106-L	O_3 (FEM)	$5000		6
Vaisala AQT	PM, O_3, NO_2, SO_2	$8000	$1000*	4
Ecotech - AQMesh	PM, O_3, NO_2	$6900	$480/s/y	0

* Maintenance requires a return to the vendor with a minimum $1000 fee

Collocation Comparisons

Primary sites: Edmonton, Vancouver, Halifax

Collocation Comparisons

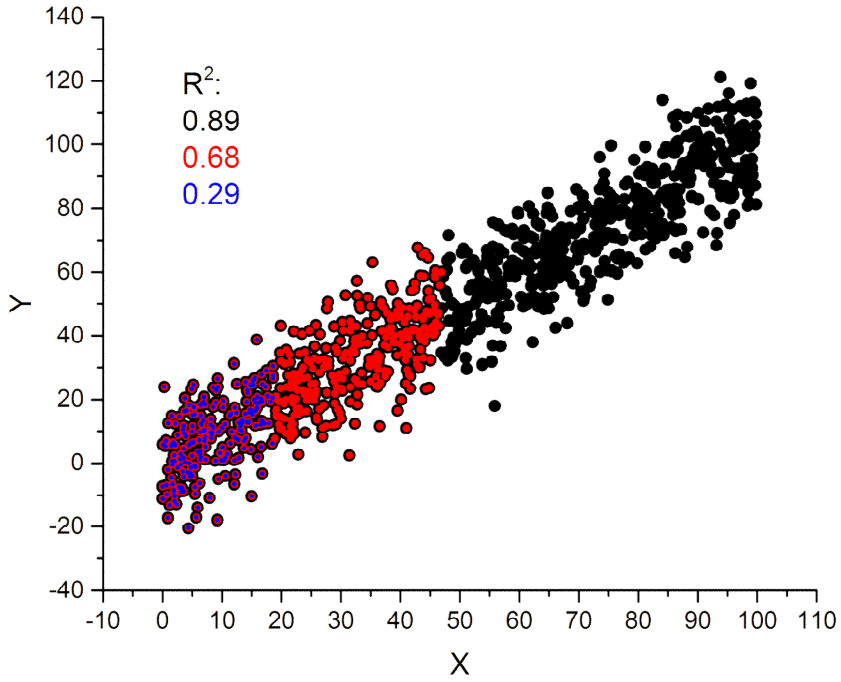


Performance Results (R^2)

Sensor	$PM_{2.5}$ Correlation		O_3 Correlation		NO_2 Correlation	
	ECCC	AQ-SPEC	ECCC	AQ-SPEC	ECCC	AQ-SPEC
PurpleAir PAII	>0.9	>0.93	N/A	N/A	N/A	N/A
AQEgg	0.21	>0.85	0.52	<0.2	0.07	0
Aeroqual AQY	0.52 – 0.89	0.78	0.11 – 0.84	>0.98	0	0.68 – 0.83
Sensit RAMP	0.39	--	0.73	--	0.18	--
SCI-608	0.89	--	0.91	--	0.91	--
Vaisala AQT	0.89; 0	--	0.77	0.66 – 0.82	0.85; 0.32	0.44 – 0.63

(Air Quality Sensor Performance Evaluation Center: www.aqmd.gov/aq-spec)

Limitations to comparing R^2 values



- R^2 can vary significantly depending on concentration ranges.
- Bland-Altman analyses can be more effective when considering differences between methods to determine fit-for-purpose.

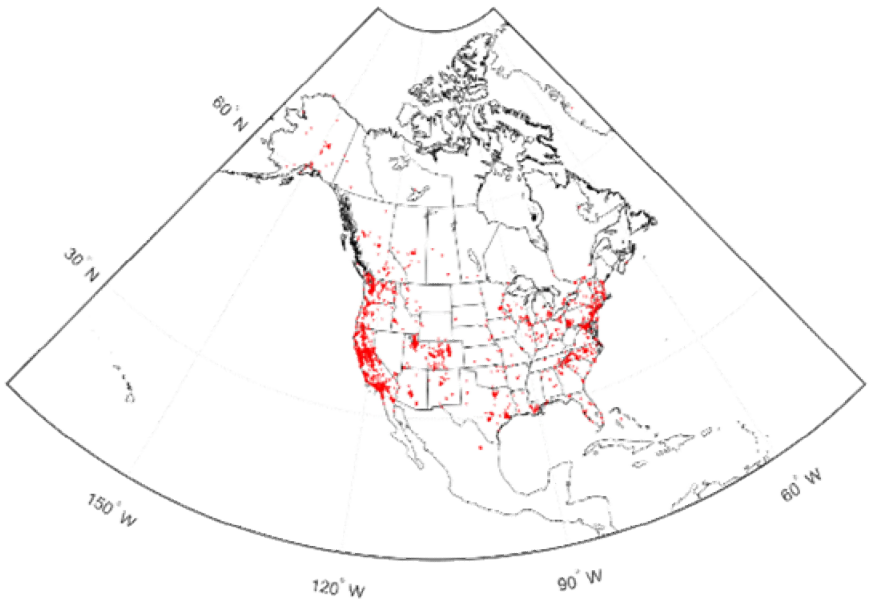
Low-Cost Sensor Summary

- O_3
  - Aeroqual, SCI, and RAMP sensors showed linear responses
  - The cost associated make these sensors mid-range ($1000's) rather than low cost ($100's) instruments.
  - Sensors have the potential to work in the near future given appropriate corrections
- NO_2
  - Only the SCI NO_2 had good agreement with the FEM sensor
  - Often has interferences and short lifetimes following large events
  - Not feasible at this time but will closely monitor emerging technologies
- PM2.5
  - shows a linear response in all instruments
  - Has the potential to currently contribute to the AQHI
  - The PurpleAir is currently used due to its low cost, ease of use, reliability, **ease of data retrieval**

Data Corrections and QC

- Currently using the correction developed by Dr. Peter Jackson at UNBC
- Quality Control:
  - Understand how to automatically detect bad data
- Ongoing effort:
  - Using larger data sets (North America) to examine other variability in the correction factor
  - Considering T/RH effects on PurpleAir
  - Comparisons with US EPA and other correction algorithms
  - Looking into Machine Learning to develop better corrections and QC

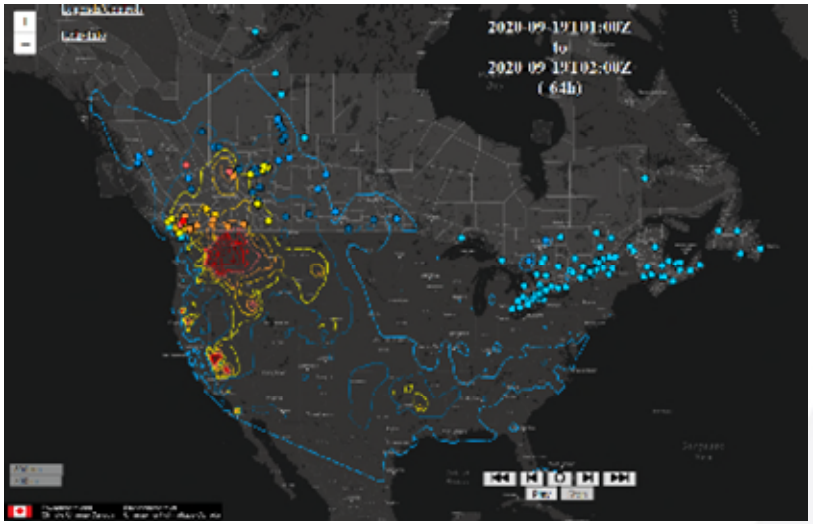
Bigger Data

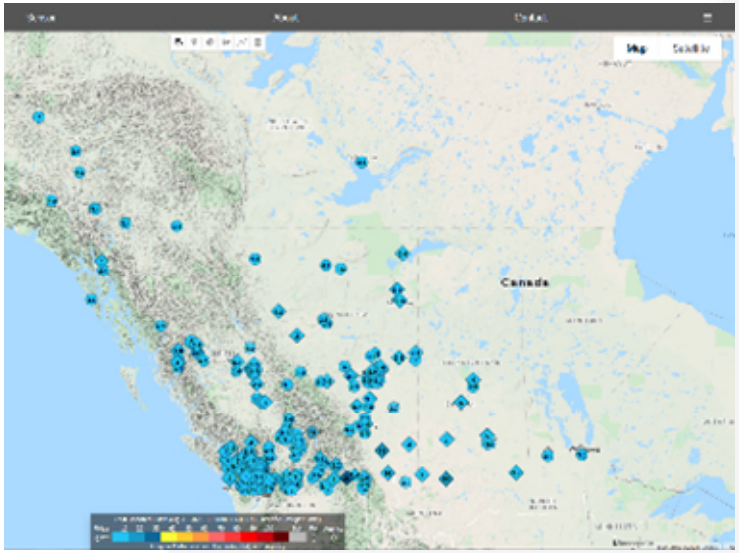


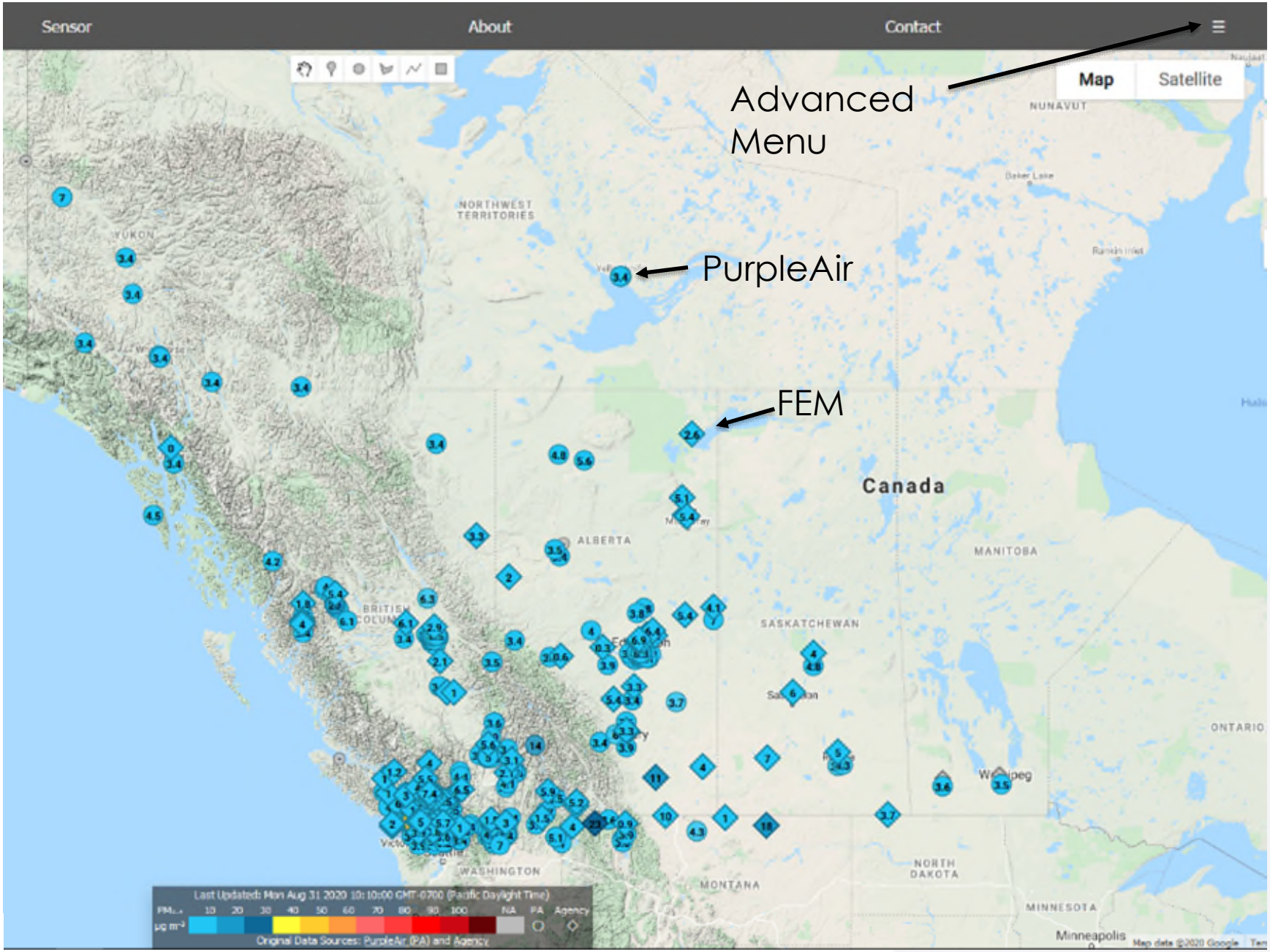
- Over 5000 PurpleAir sensors deployed across North America by many agencies **and citizen scientists**
- After data corrections and automated QC, a significant fraction (>90%) of data results in the same AQHI contribution as FEM equipment.

Dissemination of Data

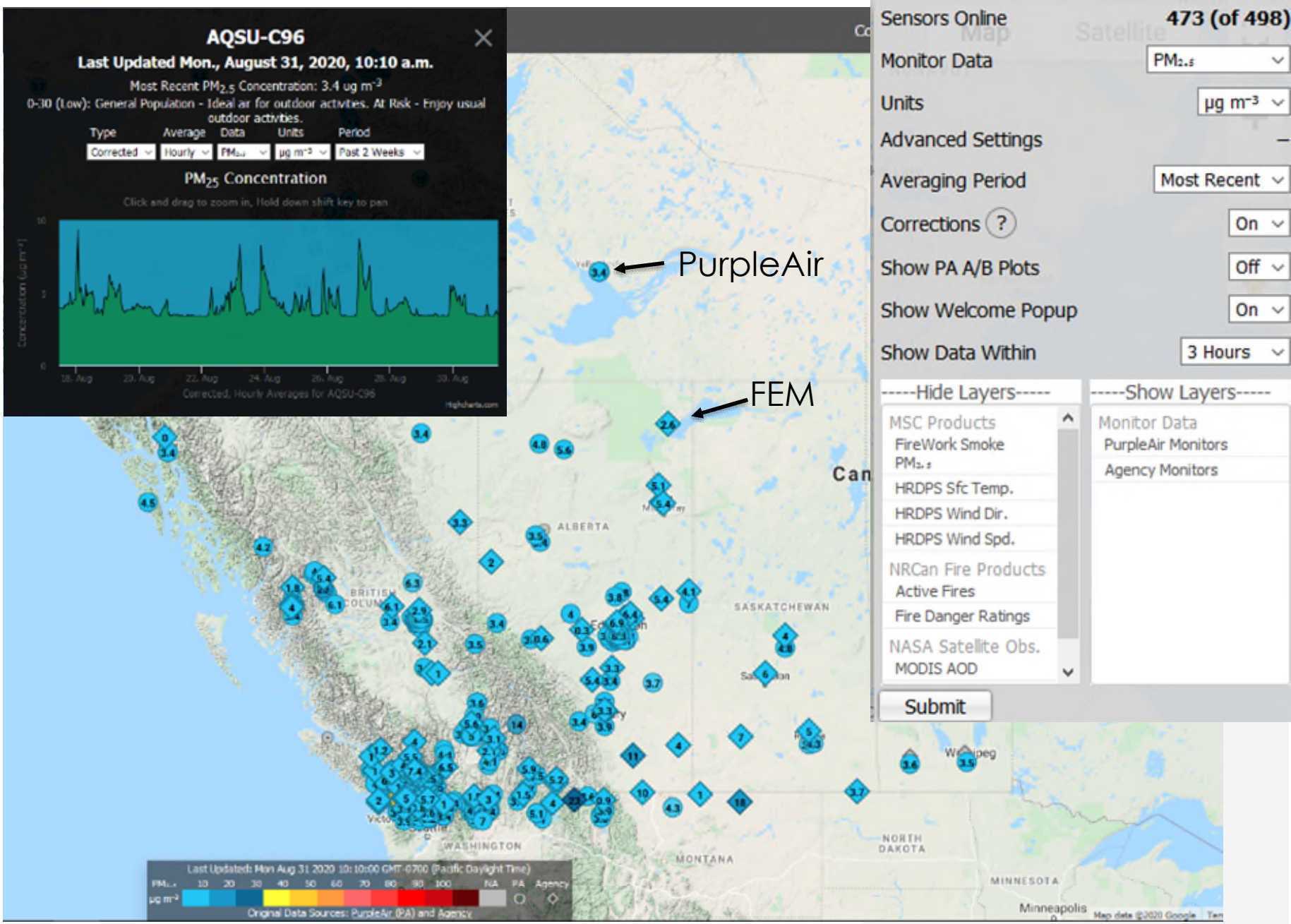
- Internal and external mapping tools have been developed
  - The external mapping product has been in collaboration with Dr. Peter Jackson at UNBC
  - Maps enable users to overlay a variety of layers to suit their needs







https://cyclone.unbc.ca/aqmap



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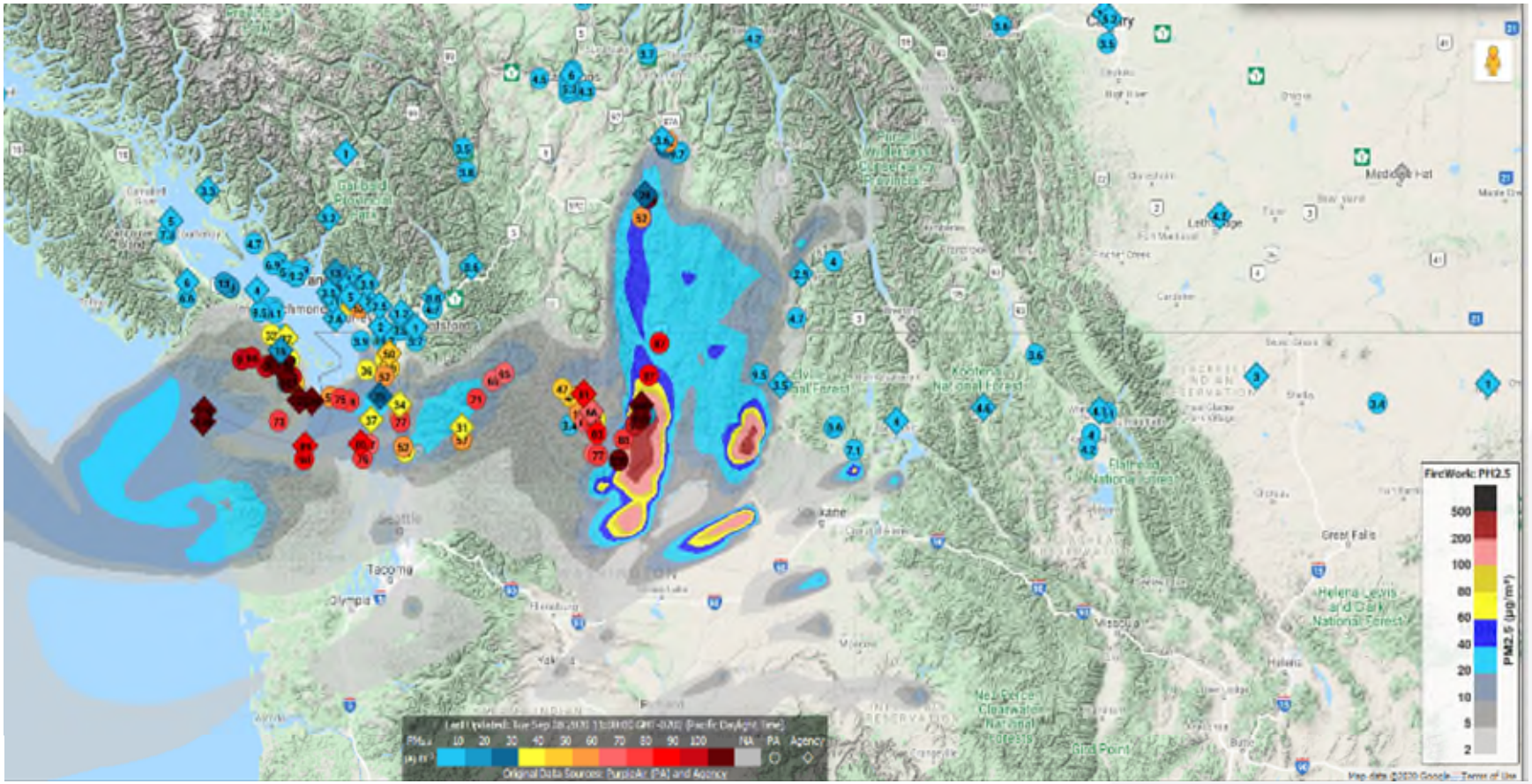
Model Validation – Firework & Low-cost PM sensors Sept 8, 2020



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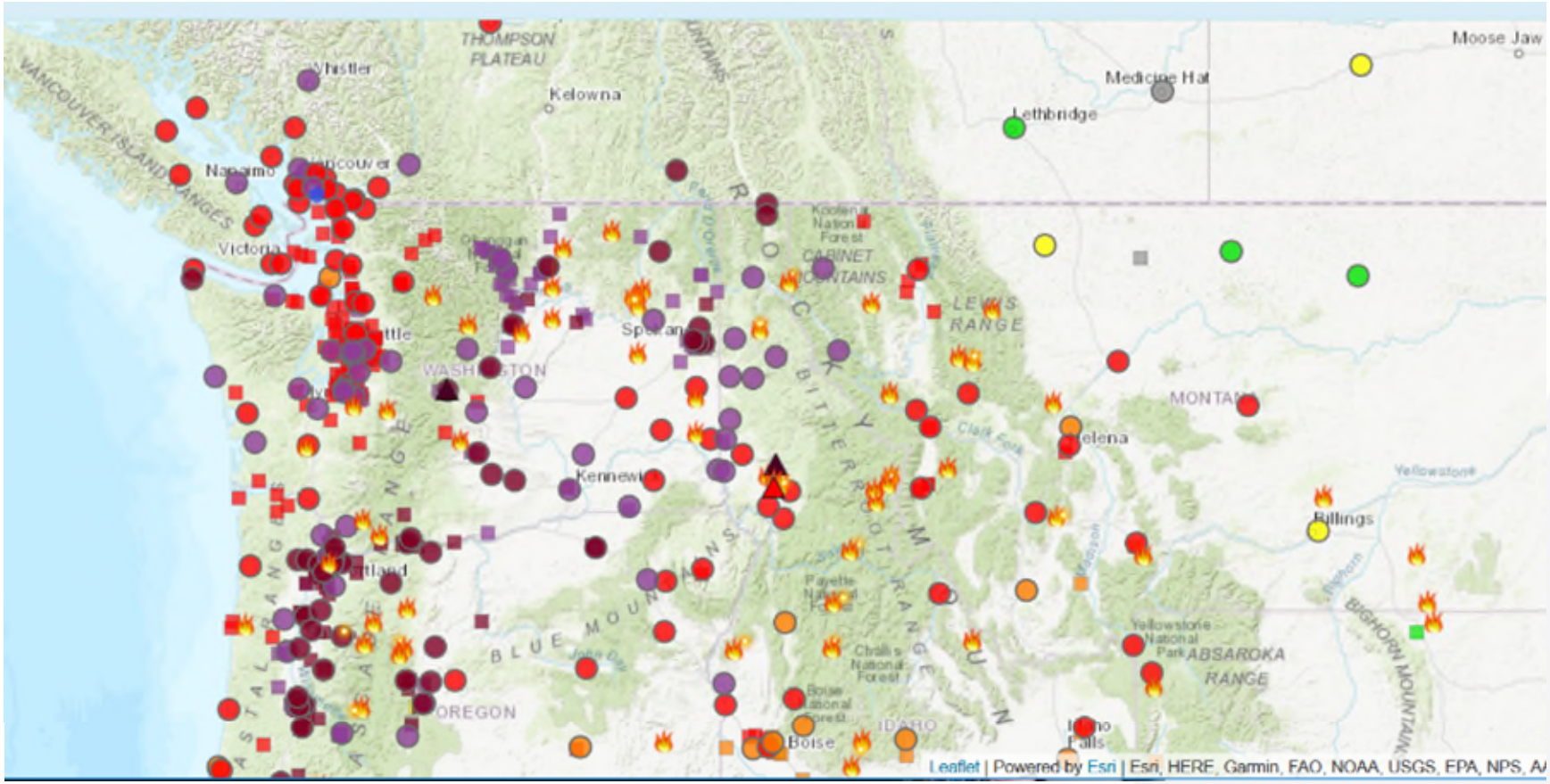
US EPA – Fire and Smoke Map



https://fire.airnow.gov

Increasing Spatial Coverage

- Include PurpleAir data from other organizations, citizens and agencies
- Collaborate with agencies, organizations and citizen groups who have a similar goal.
  - Develop a national working group
  - Examine areas that have limited measurements and look for partnerships in the region
  - Collaborate with First Nations
  - ECCC is sending sensors and developing the real-time mapping tool - collaborators install and provide power and WIFI

Current Collaborations

- UNBC – Prince George Intensive – citizens ~50 PA
- Wildfire Management Branch Saskatchewan Expansion - Northern Saskatchewan ~30 PA
- Health and Social Services Yukon ~15 PA
- Great Plains Air Zone (Southern Sask) ~ 12 PA
- Wildfire Management Branch Sask ~3 PA
- Lyton First Nations – 1 PA
- Saulteau First Nation (Northern BC) – 1 PA
- Steinbeck Manitoba – Citizen - 1 PA
- Northwest Territories – 5 PA

Future Collaborations

- Manitoba Heath Seniors and Active Living
- Port Alberni Air Quality Council
- Calgary Regional Airshed
- First Nations/First Nation Health Authorities
- **YOU?**

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