

# Minnesota's AQI forecasting program

From local to statewide in one year

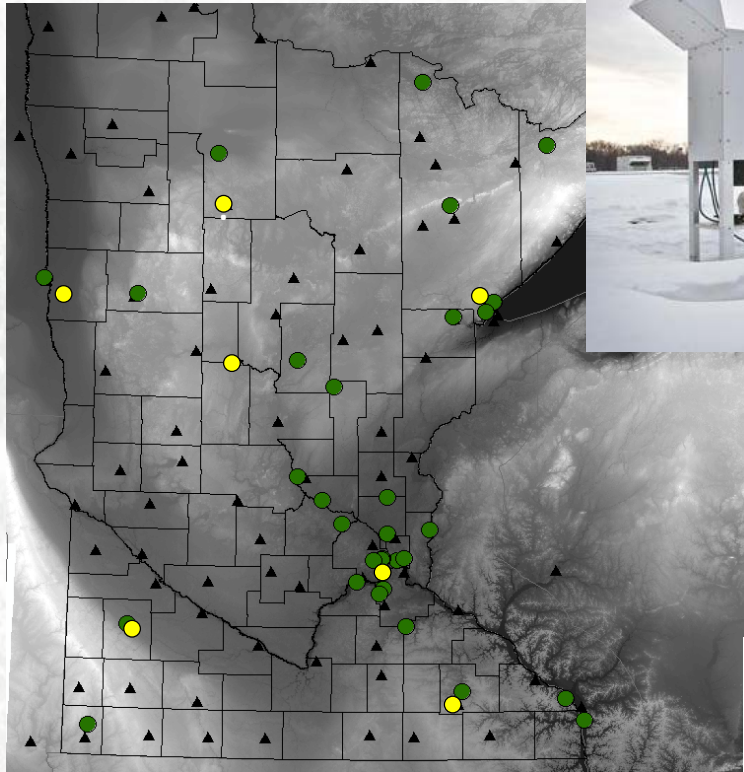
# Minnesota's AQI-WiFi

Air Quality Index

Weather innovation - Forecast intelligence system

- Increase signal strength (reach) of air quality forecasts.
  - Twin Cities and Rochester → Statewide
- Enhance alert issuance speed.
  - Hours → Minutes
- Minimize time spent forecasting.
  - MPCA meteorologists have other duties.
- Save money

# Connecting weather, geography and air quality

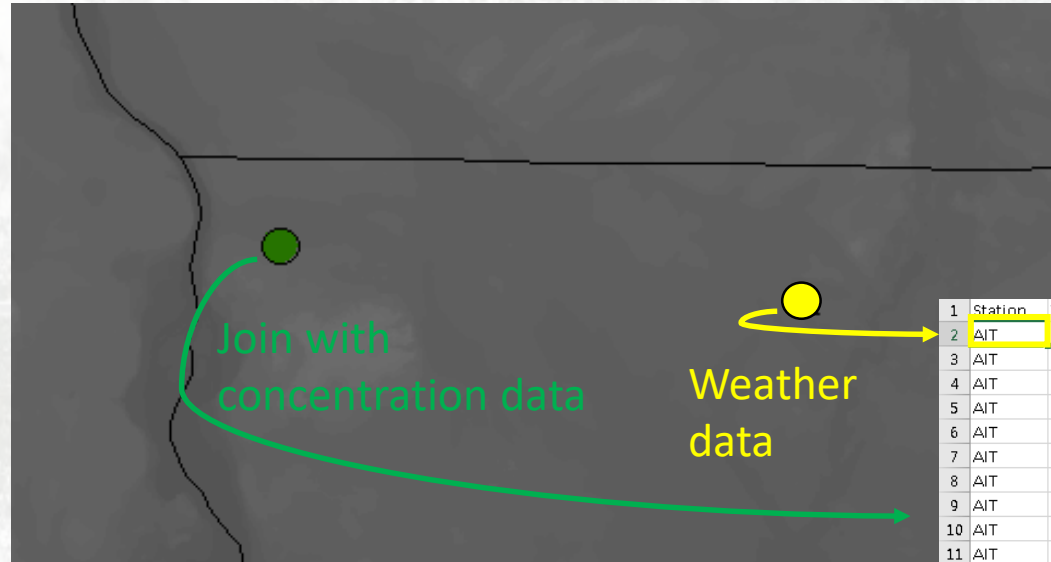


Factors considered:

- Proximity
- Hills and valleys
- Terrain variability
- Surface roughness
- Urban vs. rural
- Snow cover
- Proximity to Lake Superior

# Database of weather and concentrations

Meteorological/Air Quality database created for each air quality monitor.



1	Station	Year	Month	Day	Temp_F_5	Temp_F_N	Temp_F_S	Temp_F_W	Temp_F_E	Temp_F_S	Temp_F_W	Temp_F_N	Temp_F_E	Temp_F_S	Temp_F_W	Temp_F_N	Temp_F_E	Temp_F_S	Temp_F_W	WindDir_f	WindDir_s
2	AIT	2011	1	1	8.6	13.4	-0.4	-2.2	9	15.6	5	4.1375	2.4	7.4	W	W					
3	AIT	2011	1	2	8.6	8.6	-5.8	-10	14.4	18.6	2.84	-0.875	-1.3	7.16	Calm	Calm					
4	AIT	2011	1	3	6.8	6.8	-19	-19	25.8	25.8	-2.14	-6.125	-10.5	3.56	Calm	Calm					
5	AIT	2011	1	4	8.6	8.6	-6.4	-10	15	18.6	2.51	-0.8125	-2.45	7.04	Calm	Calm					
6	AIT	2011	1	5	17.6	17.6	10.4	1.4	7.2	16.2	15.02	10.15	13.3	17	Calm	Calm					
7	AIT	2011	1	6	12.2	12.2	-9.4	-9.4	21.6	21.6	5.3	4.25	-1.7	10.16	Calm	Calm					
8	AIT	2011	1	7	8.6	8.6	7.4	2	1.2	6.6	8.48	7.45	8.1	8.6	NW	NW					
9	AIT	2011	1	8	10.4	10.4	-8.2	-13	18.6	23.4	3.68	-0.35	-1.75	8.84	N	Calm					
10	AIT	2011	1	9	8.6	8.6	-16.6	-17.8	25.2	26.4	0.32	-6.55	-7.4	6.56	Calm	Calm					
11	AIT	2011	1	10	17.6	17.6	5	-4	12.6	21.6	12.86	8.7625	7.6	16.28	Calm	Calm					
12	AIT	2011	1	11	21.2	21.2	11	11	10.2	10.2	18.32	16.275	15.1	20.72	Calm	Calm					
13	AIT	2011	1	12	19.4	19.4	9.5	-3.4	9.9	22.8	16.07	10.8875	14.6	18.92	Calm	Calm					
14	AIT	2011	1	13	17	17	14	-2.2	3	19.2	15.32	11.7125	14.4	16.16	SE	SE					
15	AIT	2011	1	14	15.8	15.8	11.3	11.3	4.5	4.5	14.27	13.4875	13.35	15.08	Calm	Calm					
16	AIT	2011	1	15	8.6	10.4	0.8	-14.8	7.8	25.2	5.75	2.6375	5.15	7.76	NW	NW					
17	AIT	2011	1	16	8.6	10.4	-4	-5.8	12.6	16.2	3.92	1.8	-1	7.52	SE	SE					
18	AIT	2011	1	17	19.4	19.4	15.8	9.8	3.6	9.6	17.83333	15.21304	16.8	18.62	Calm	Calm					
19	AIT	2011	1	18	4.4	8.6	-0.4	-0.4	4.8	9	2.27	2.775	0.95	3.5	N	N					
20	AIT	2011	1	19	10.4	10.4	1.4	-2.2	9	12.6	7.01	3.9125	3.75	9.56	Calm	SW					
21	AIT	2011	1	20	1.4	2	-7	-18.4	8.4	20.4	-0.64	-3.875	1.1	-0.76	NW	NW					
22	AIT	2011	1	21	-4	-2.2	-25.6	-32.8	21.6	30.6	-9.94	-14.7	-17.6	-5.56	S	S					
23	AIT	2011	1	22	1.4	1.4	-15.4	-19.6	16.8	21	-4.06	-8.5625	-9.8	0.8	Calm	N					
24	AIT	2011	1	23	8.6	11	-11.2	-24.4	19.8	35.4	3.77	-3.1875	-4.55	8.06	S	S					
25	AIT	2011	1	24	19.4	19.4	12.2	12.2	7.2	7.2	17	15.7	14.3	18.92	Calm	Calm					
26	AIT	2011	1	25	17.6	19.4	12.2	12.2	5.4	7.2	16.22	16.2625	14.55	17.24	Calm	SW					

Initial data gathered from [Iowa State University's weather database](#).

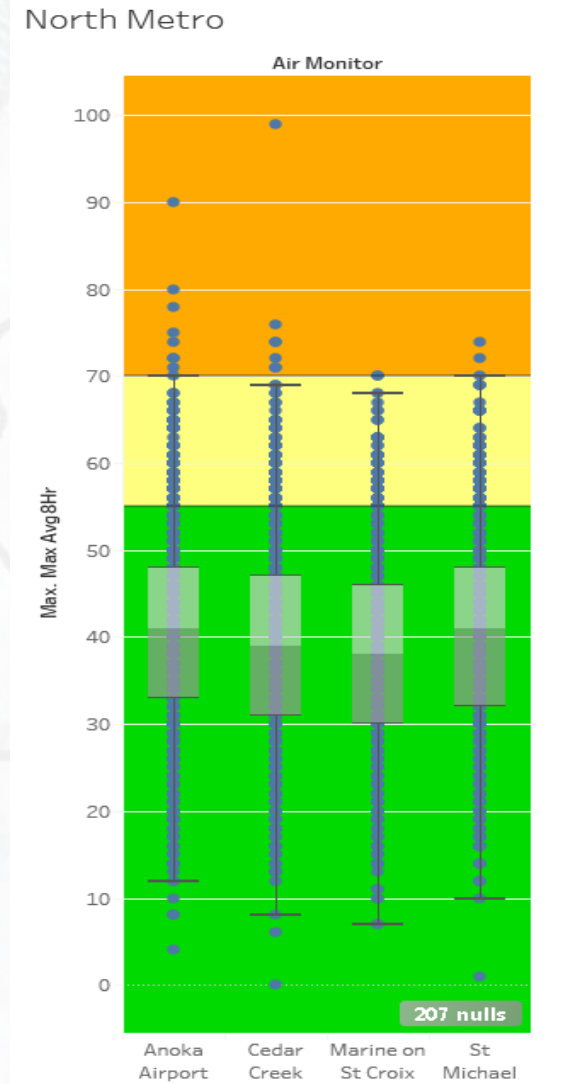
# Questions answered

Database can be queried by weather parameters:

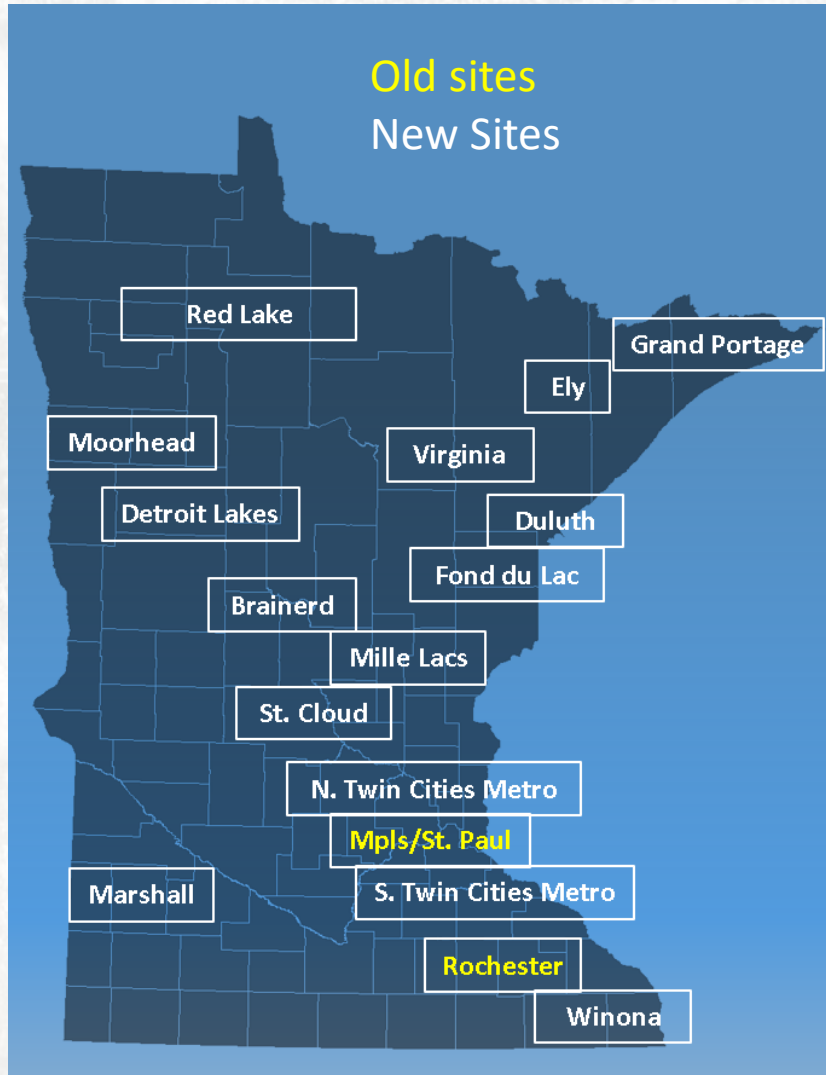
*“Given tomorrow’s forecast, what’s the range of possible AQI outcomes?”*

*“What is the most likely outcome?”*

*“Has a day like tomorrow ever produced alert conditions?”*



# Need for automation

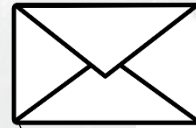


4 to 6 days  
2 pollutants  
\* 17 locations

= 136-204 forecasts each day

# Automating AQL prediction

How about artificial intelligence?



Kaggle Python Tutorial on Machine Learning

Start Free Course

16 Exercises 1 hour 21,034 Participants 1,450 XP



8.2k



21



35



235



DataCamp

*(Also available in R)*

If we can predict who survives the titanic, certainly we can predict air quality from our database parameters...

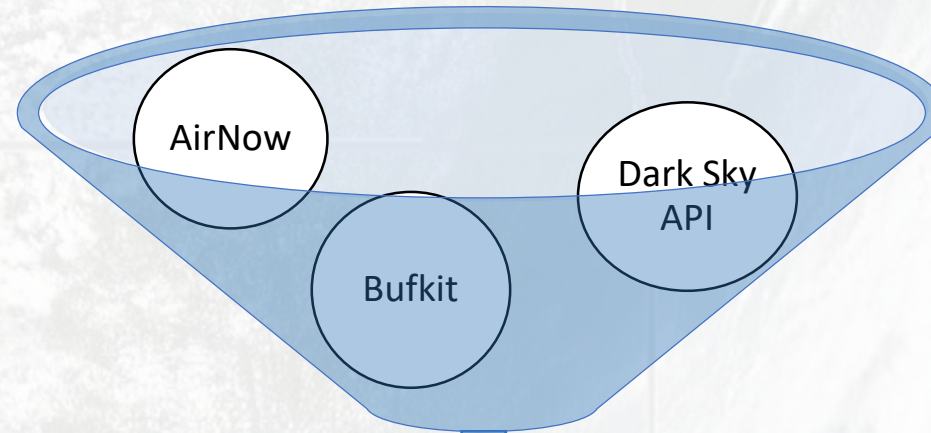
# Random forest regression



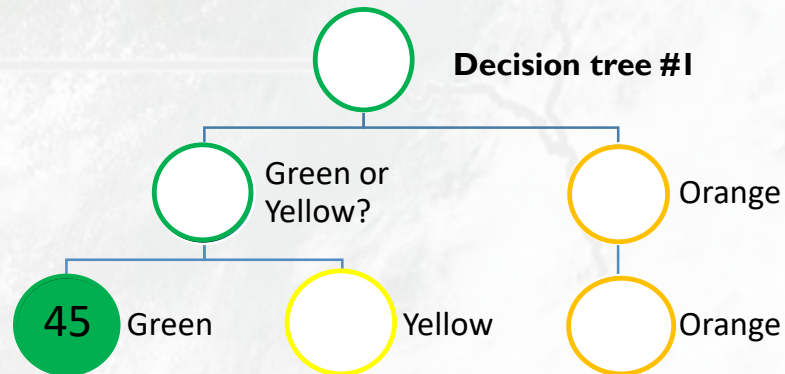
Testing revealed 17 weather parameters for optimum forecast accuracy.



# Automating base weather prediction



Base weather forecast  
(Forecasters may adjust)



X 1000 → **10 minutes**  
Average AQI



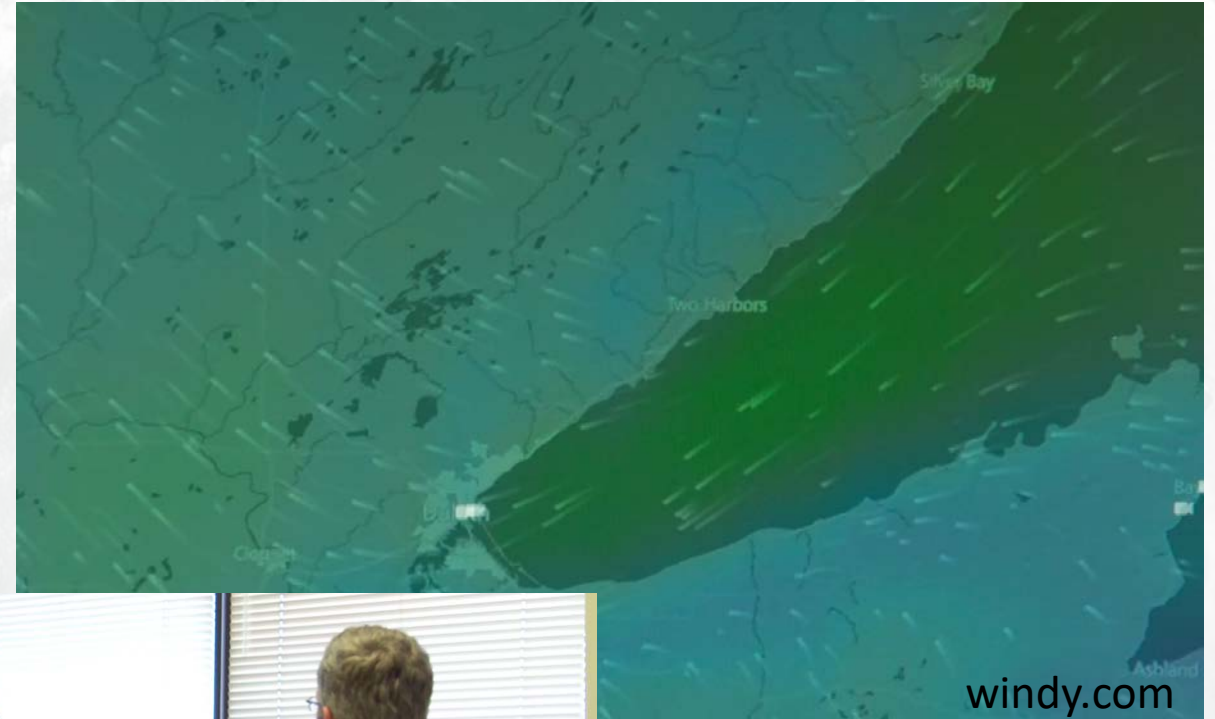
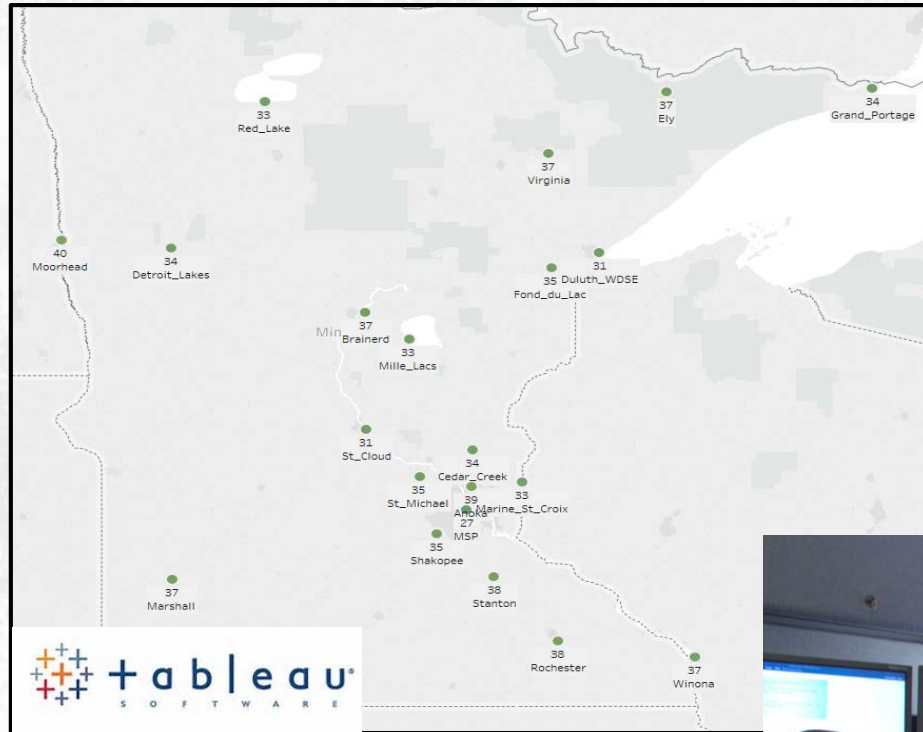
python™



Dark Sky API

**Bufkit Data Distribution System**

# Quality control tools



Forecast viewer  
helps meteorologists  
QC the forecast.

# Automating NWS alert creation

Air Quality Alert  
Relayed by the National Weather Service Fargo/Grand Forks ND  
1100 AM CDT Sat Apr 08 2017

MNZ001-002-003-004-005-006-007-008-009-013-014-015-016-022-023-027-028-029-030-031-040-090300-  
Clay-East Becker-East Marshall-East Otter Tail-East Polk-Grant-Kittson-Lake Of The Woods-Mahnomen-  
Norman-North Beltrami-North Clearwater-Pennington-Red Lake-Roseau-South Clearwater-West Becker-West  
Marshall-West Otter Tail-West Polk-Wilkin-

Including the cities of...Crookston...Detroit Lakes...East Grand Forks...Fergus  
Falls...Moorhead...Roseau...Thief River Falls

Including the tribal nations of...Red Lake

1100 AM CDT Sat Apr 08 2017

...Air Quality Alert issued for northwestern Minnesota...

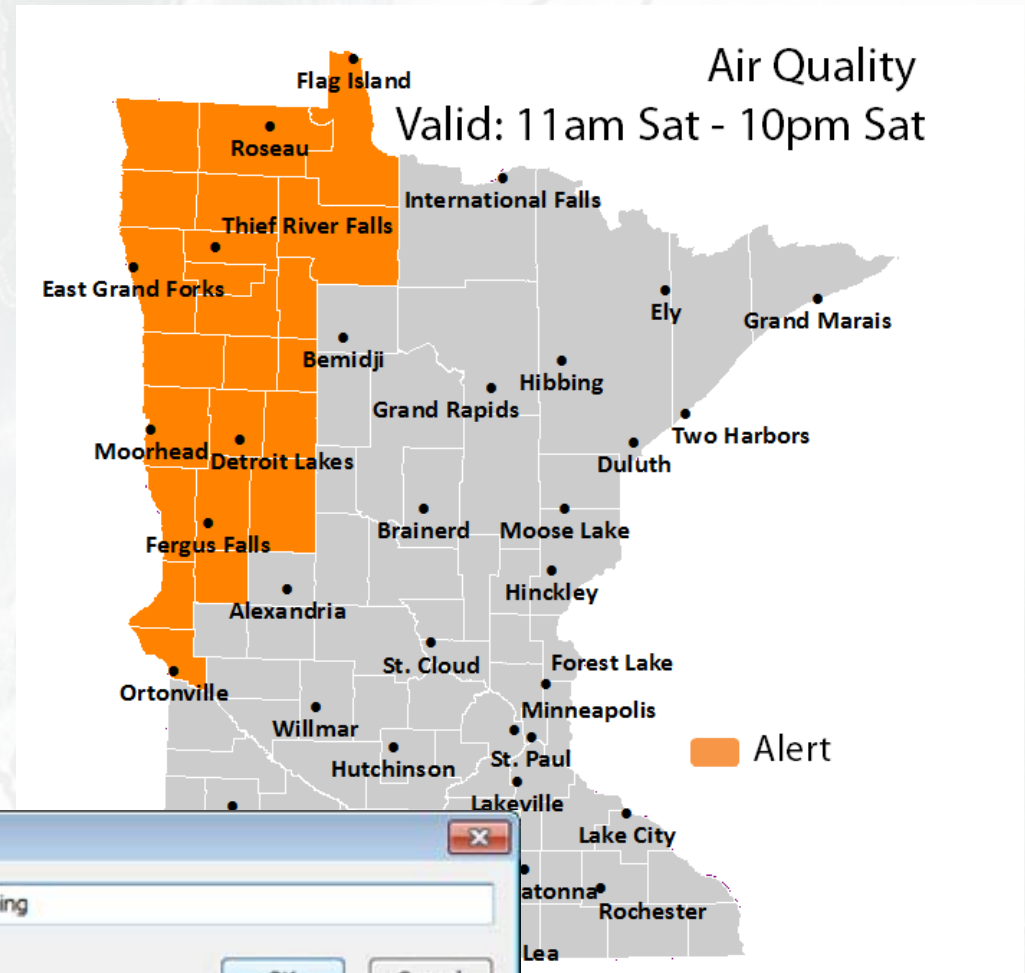
The Minnesota Pollution Control Agency has issued an Air Quality Alert for fine particle pollution  
effective 11 am today through 10 pm tonight.

A narrow plume of smoke originating from the fires across eastern Kansas is expected to affect west  
central and northwestern Minnesota through this evening. Fine particle pollution is expected to climb  
at or above a level that is considered unhealthy for sensitive groups. Conditions are expected to  
improve this evening as winds shift and carry the smoke out of the area.

An Air Quality Alert is issued when the AQI is expected to reach or exceed 101, a level considered  
unhealthy for sensitive groups. Sensitive groups, such as people with lung disease (including  
asthma), heart disease, children and older adults, and people who are active outdoors should limit  
prolonged exertion.

Visit <http://www.pca.state.mn.us> for information on current air quality conditions in your area, or  
call the MPCA Air Quality Forecasting and Air Quality Monitoring Division at 612-224-2600 for  
forecasts and air quality information. For more information on air quality, visit  
<http://mn.enviroflash.com>  
<http://beairawaremn.org>

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Python input

The Alert for Fargo/Grand Forks ND STARTS at what local time and day? (ex. 10 pm tonight)

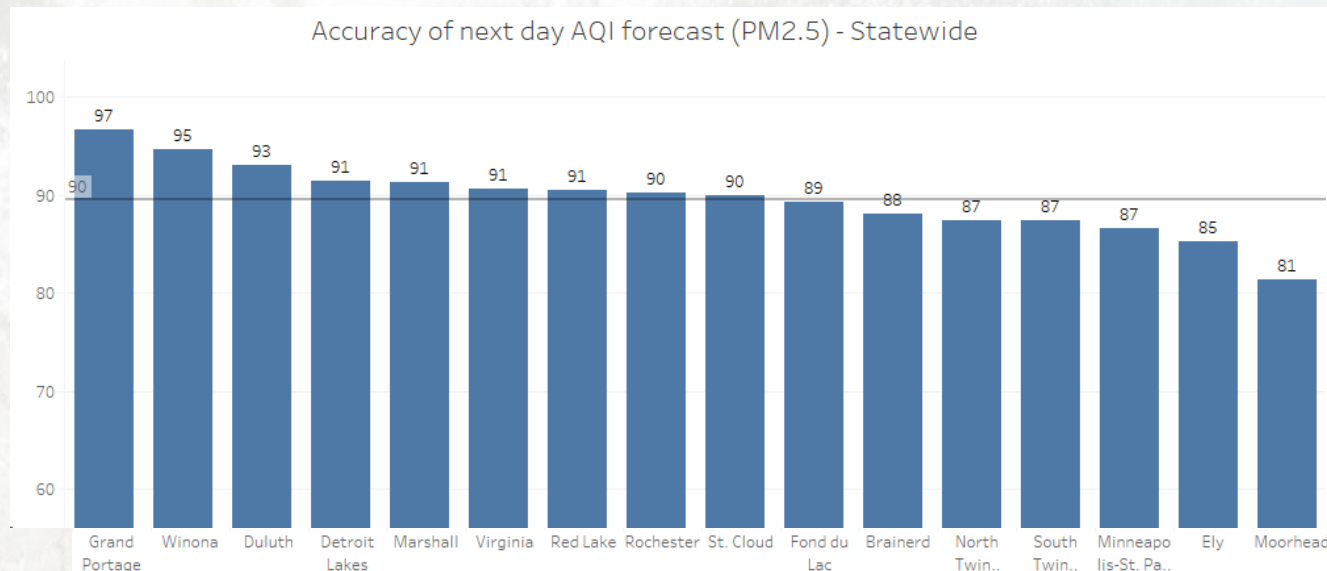
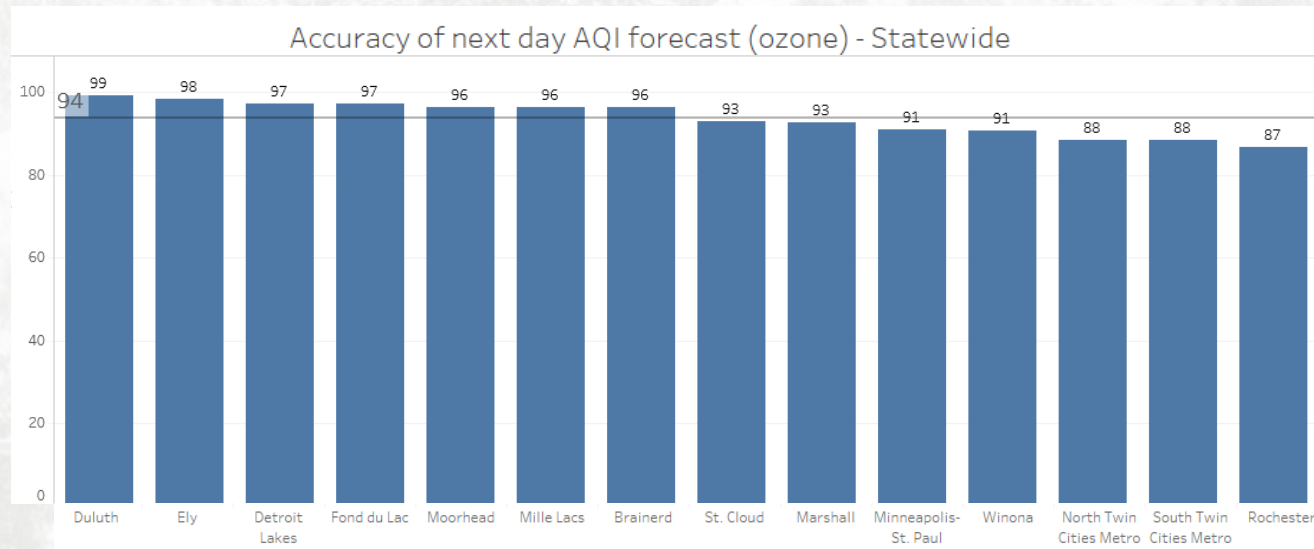
OK Cancel

# Minnesota's forecast accuracy

Ozone - Average 94% next day categorical accuracy for the state. 94% accuracy maintained through day 3.

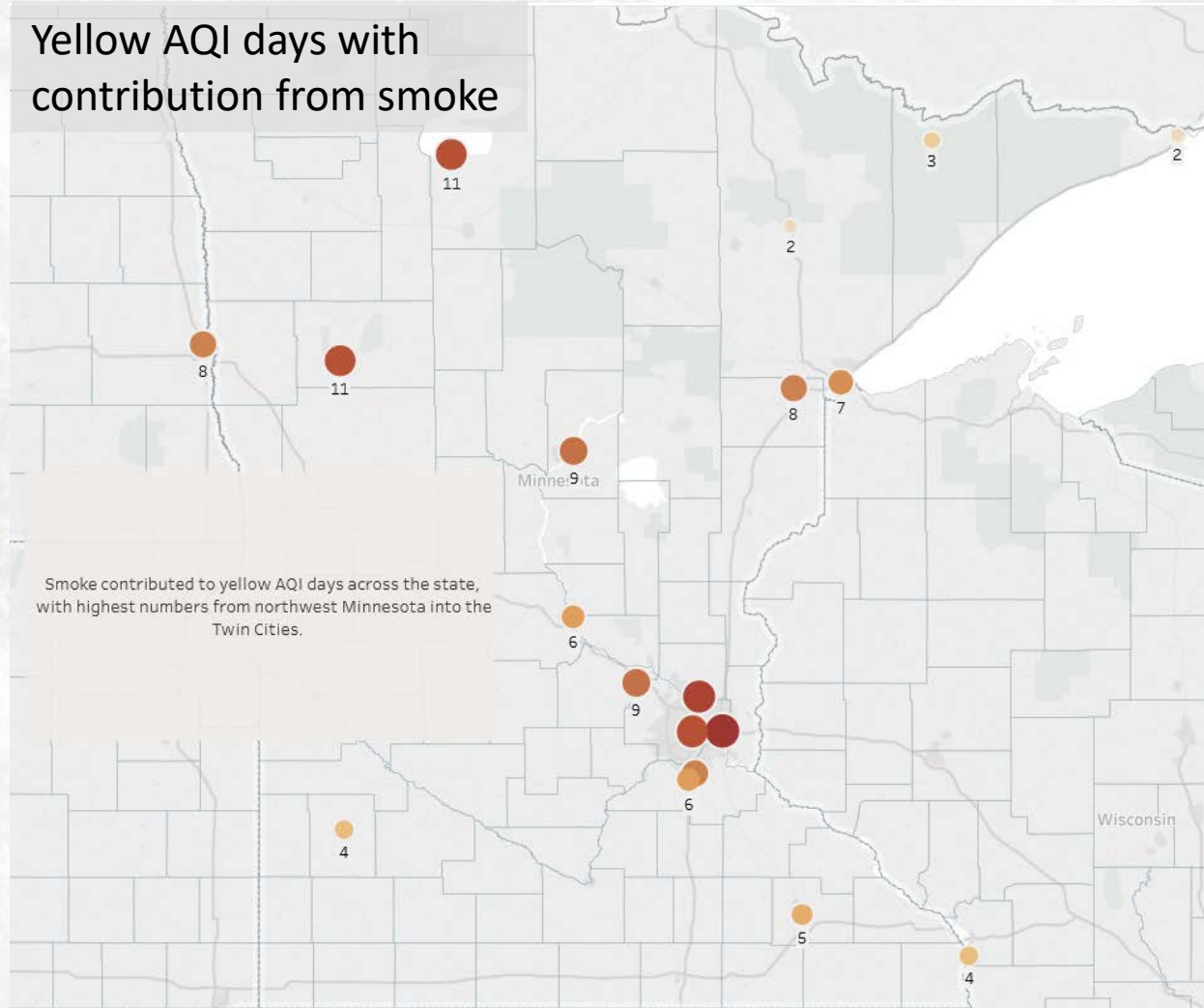
Same day and next day yellow forecast accuracy on average 36% greater than CMAQ. Up to 78% greater in some locations.

PM2.5 - Average 90% next day categorical accuracy for the state.



# Challenges remain

Yellow AQI days with contribution from smoke



Forecasting wildfire smoke remains our greatest challenge.

Little to no information on altitude of upstream smoke layers.

Smoke models provide some insight.

# What does it take?

## Resources

Development time (from scratch): 9 months

Daily tool operation: 10 minutes

Meteorologist's analysis & QC: 30-90 minutes

Forecast entry 15 minutes

Average time per meteorologist: 15%

### Free Tools/Data:

Python

Python tutorial on machine learning –kaagle and

DataCamp

Scikit Learn – python module

Darksky API for automated weather forecasts

Hourly weather

Land use land cover

Elevation

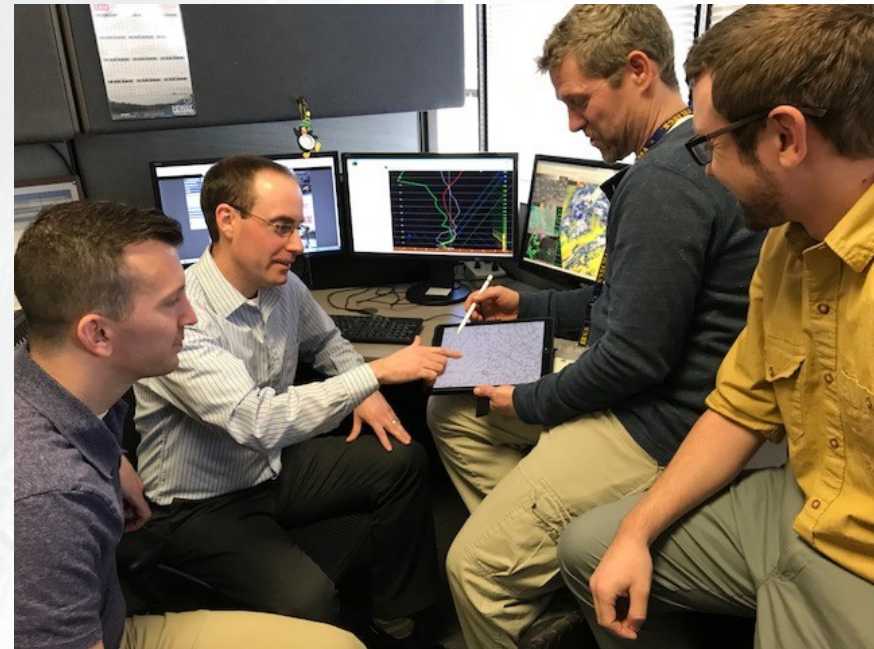
Hysplit output

### Other resources:

ArcGIS

Tableau

Operational meteorologists



(left to right) MPCA air quality meteorologists David Brown, Steve Irwin, Daniel Dix, and co-developer Dorian Kvale.

# View our forecasts

- Website

- <https://www.pca.state.mn.us/air/current-air-quality>

- Minnesota Air mobile app (Android, Apple, Windows)



- Twitter

- [@mpca\\_aqi](https://twitter.com/mpca_aqi)

# Questions

Questions about this presentation

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