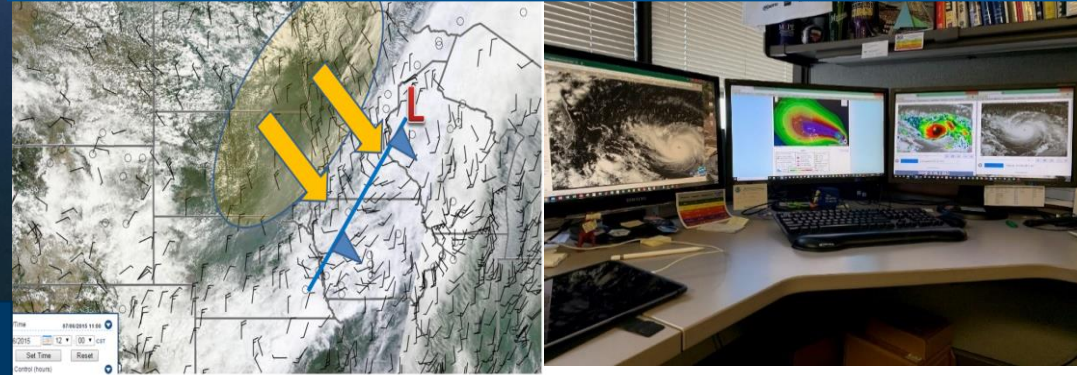




Intelligent and Interactive Air Quality Forecasting

*MPCA use of environmental data,
artificial intelligence, and
technology to predict air quality
and inform the public*



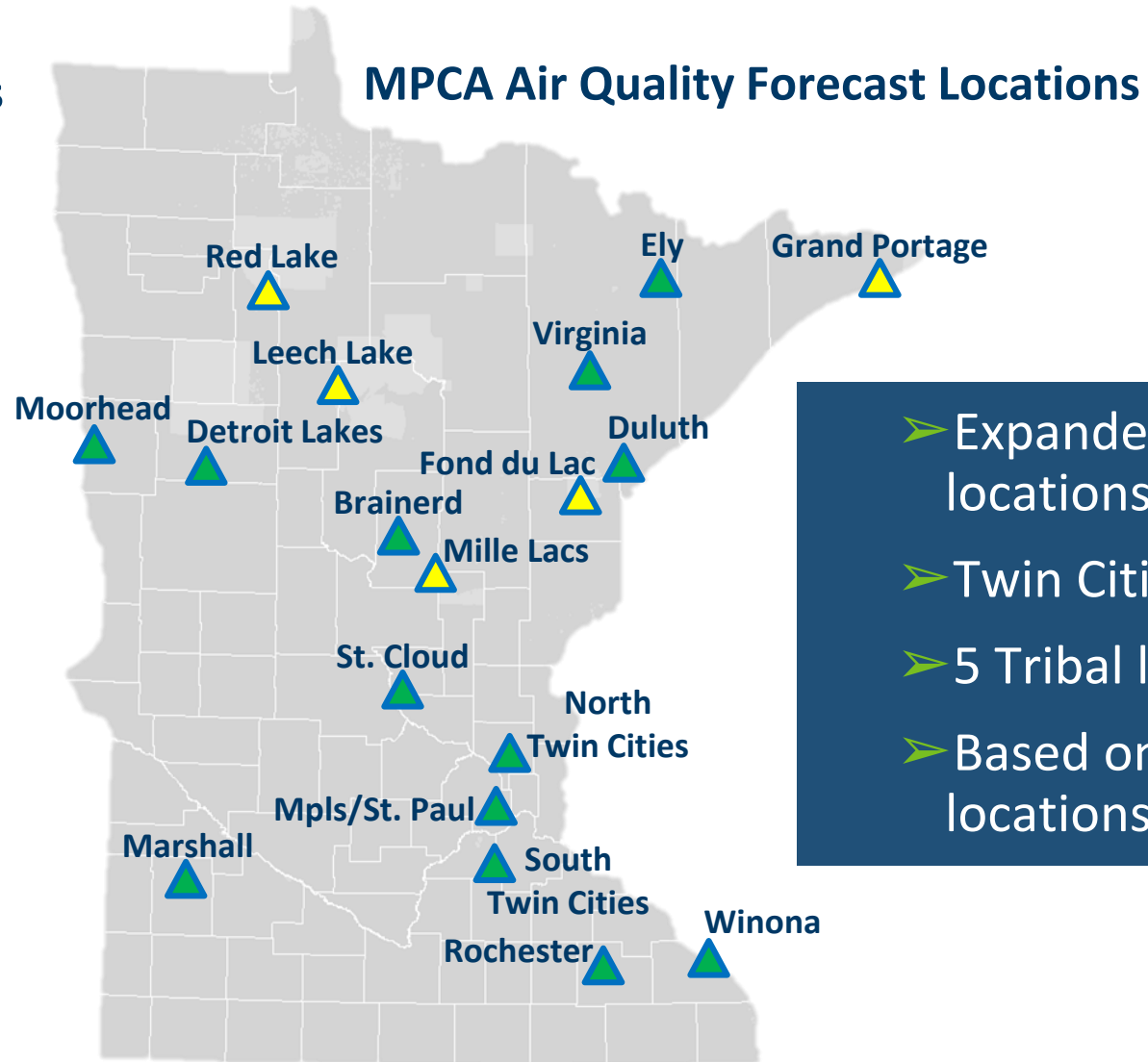
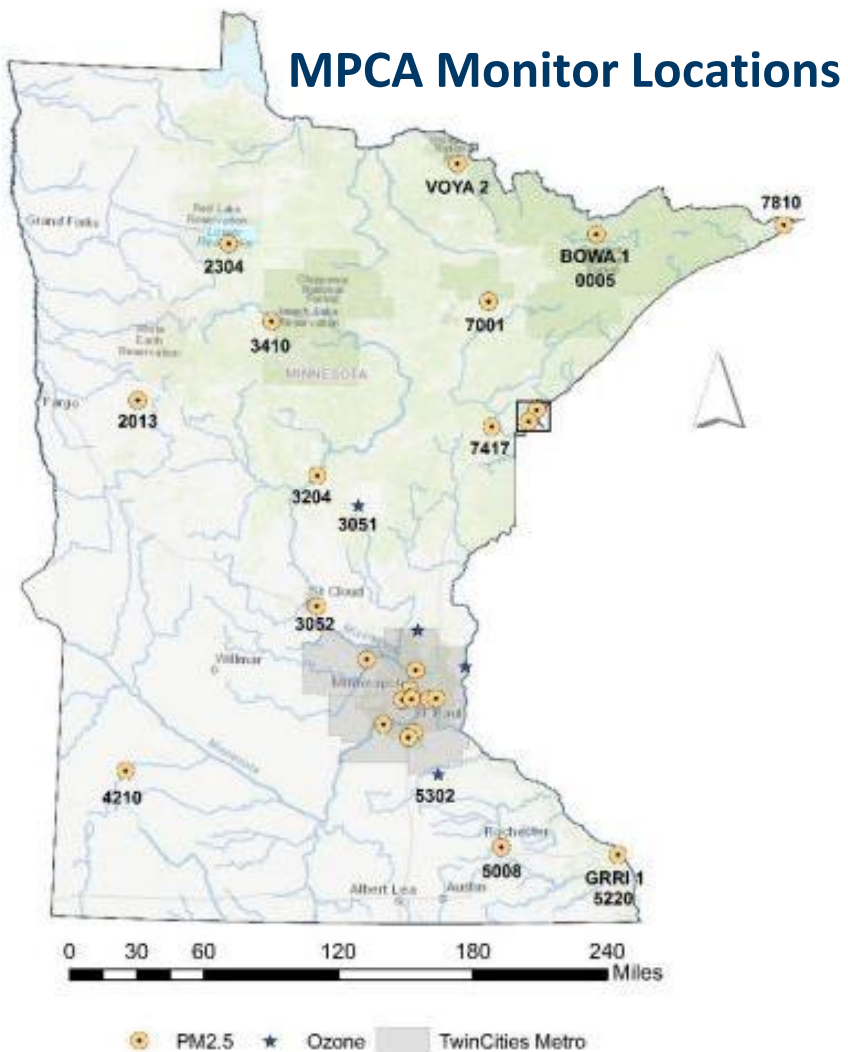
Air Quality Meteorologists
David Brown/Daniel Dix/Nick Witcraft



Our mission is to protect and improve the environment and enhance human health | <https://www.pca.state.mn.us>

NASA TEMPO EARLY ADAPTORS WORKSHOP - NOV, 2020

Air Quality Index (AQI) Forecast Locations



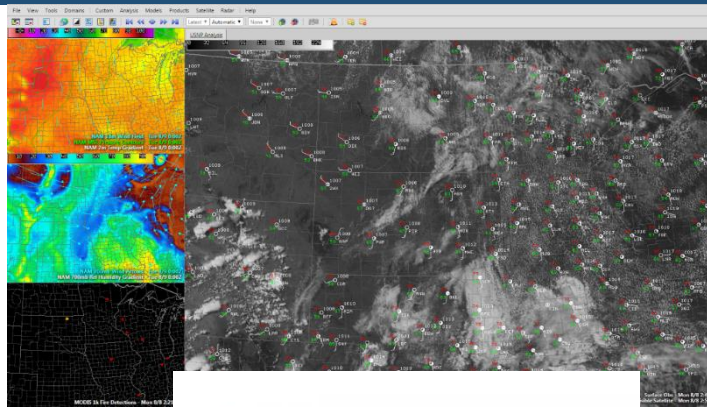
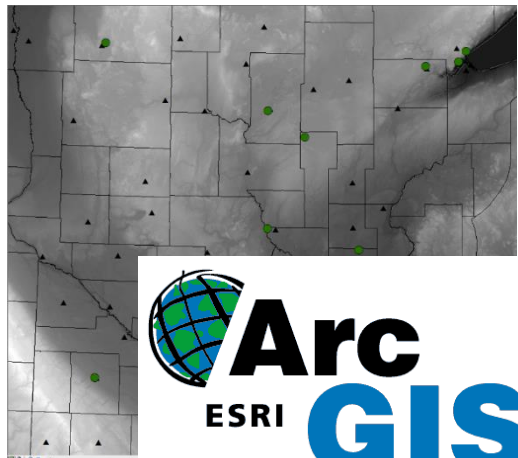
- Expanded from 2 to 18 locations (2017-2018)
- Twin Cities metro into 3
- 5 Tribal locations
- Based on monitor locations

Artificial Intelligence (AI) Model

- MPCA developed air quality prediction system utilizing machine learning, an artificial intelligence model
- Why machine learning?
 - Accessibility
 - Computational Requirements
 - Timing



The DataCamp Team



```
#####Regression Section

#The target is set to the column with the 8 hour average concentrations
#as that's the column the AI needs to learn from and it's what we're
#trying to predict.
target_reg = train["Max Avg8Hr"].values
#The feature forest is the set of parameters the AI should use to make
#its predictions.
features_forest_reg = train[["Month","Temp F Sunup Max","Rh Sunup Avg","Background 10M 500M Avg 24Hr Ozone Noon Ppb"],
Weight_val = np.array(train["Weight"].values)
#We then set up a random forest regressor controlling the depth, the
#minimum samples required to make a leaf in a decision tree, the
#number of decision trees, and the random state.
forest_reg = RandomForestRegressor(max_depth = 10, min_samples_leaf = 5, n_estimators = 1000, random_state = 1)
#The AI model is fit to the data using the parameters above.
my_forest_reg = forest_reg.fit(features_forest_reg,target_reg, sample_weight = Weight_val)

#print(my_forest_reg.feature_importances_)
#print(my_forest_reg.score(features_forest_reg,target_reg))

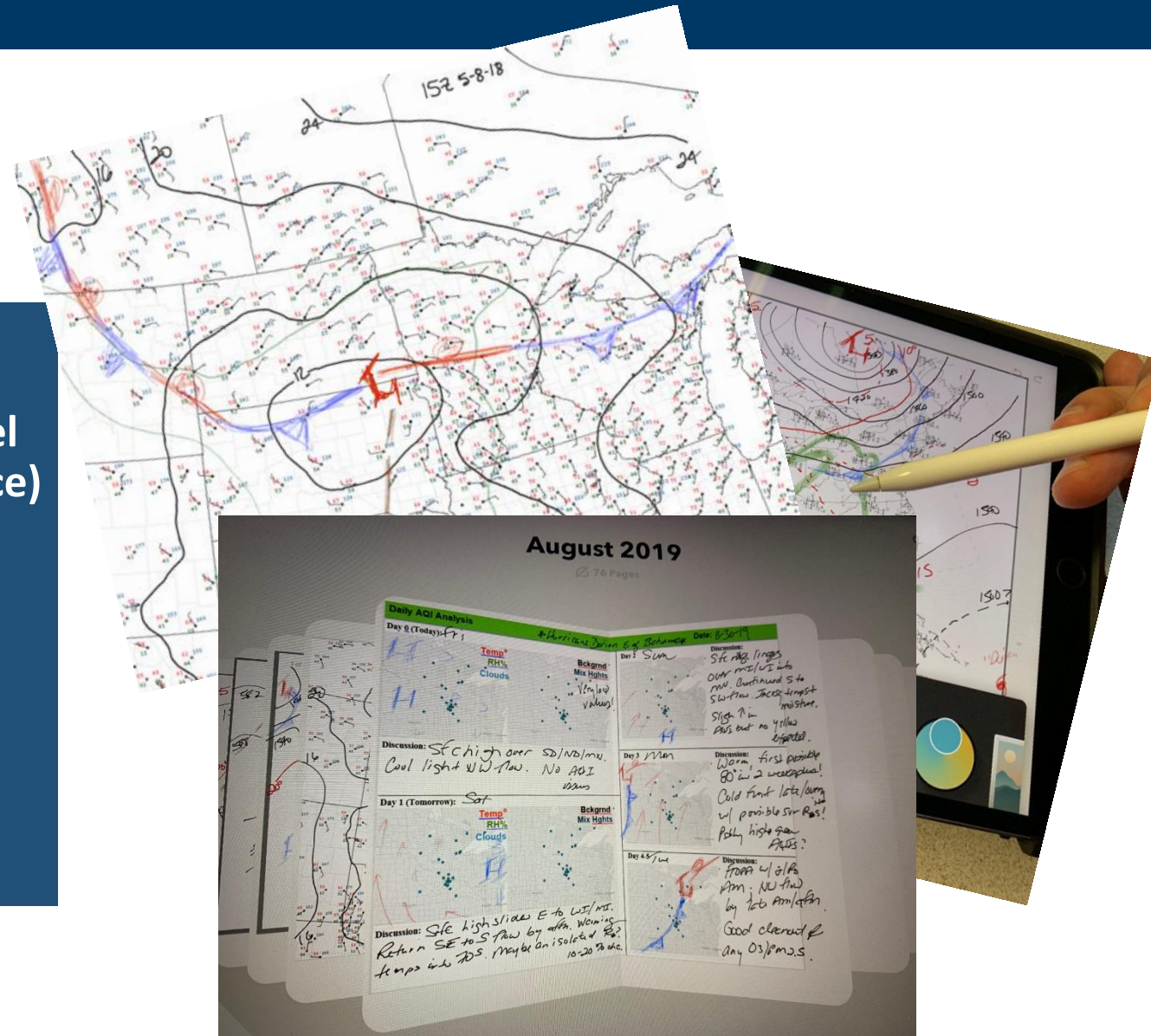
#The test features are the features in the met dataset that the AI should
#use to predict the target.
test_features_reg = test[["Month","Temp F Sunup Max","Rh Sunup Avg","Background 10M 500M Avg 24Hr Ozone Noon Ppb"],"Mi
#The model fit above is then used to make the predictions.
pred_forest_reg = my_forest_reg.predict(test_features_reg)

# Create a data frame with two columns
DayIndex = np.array(test["Index"]).astype(int)
my_solution_reg = pd.DataFrame(pred_forest_reg, DayIndex, columns = ["Max Avg8Hr"])

# Write your solution to a csv file with the name my_solution_reg.csv.
#Initially each forecast site gets an individual forecast file created.
my_solution_reg.to_csv("X:/Agency_files/Outcomes/Risk_Eval_Air_Mod/Air_Modeling/AQI_Forecasting/Tree_Data/Forecast/AQ
```

Air Quality Forecast Process

- Current weather conditions are analyzed
- Weather data are processed from forecast model output (variety of meteorological model guidance)
- Background (air quality monitor-derived) concentrations are estimated
- Weather inputs and background are refined if needed
- AI model is run and AQ initial forecast is created (meteorologists then adjust, if needed)



Air Quality Forecast Display Platforms

Forecasts

- Metro
- Northwest
- Northeast
- Central
- South

Central region

Brainerd

Today	Sat	Sun
101	Good	Moderate
Particles	Ozone	Particles

Mille Lacs

Today	Sat	Sun
101	Good	Moderate
Particles	Ozone	Particles

St. Cloud

Today	Sat	Sun
105	Moderate	Moderate
Particles	Particles	Particles

South Twin Cities Metro Air Quality Forecast

MPCA - EnviroFlash
to Me
August 14, 3:54 PM



Forecast for South Twin Cities Metro, MN Today and Tomorrow's Forecast			
Tuesday, Aug 14:	54 AQI	Moderate	Yellow
	51 AQI	Moderate	Yellow
	48 AQI	Good	Green
	44 AQI	Good	Green
			Ozone
Extended Forecast			
Thursday, Aug 16:		Good	Green
		Good	Green
Friday, Aug 17:		Good	Green
		Good	Green

A cold front has moved across most of Minnesota today with air quality improving to green (good) from north to south behind the front. Yellow (moderate) AQI conditions will continue across the southern 1/3 of the state ahead of the front due to lingering wildfire smoke. On Wednesday, light north-northeast winds will prevail over the state with green AQI levels expected over much of the state. The southeast corner of the state may see continued yellow AQI levels before smoke finally clears the state. Green AQIs on Thursday over much of the state under high pressure and temperatures in the upper 70s/low 80s. Friday and into the weekend, all eyes will be on northern Minnesota as there is a growing potential of Canadian wildfire smoke to return to the region.

Tweets

MN Air Quality Index @... · 6h ·
Statewide forecast: Aug 14 Yellow (moderate) south central and southern Minnesota including the Twin Cities, Marshall, Rochester, and Winona. Aug 15 Yellow for the southeast corner per lingering wildfire smoke; green (good) rest of the state.

MN Air Quality Index @... · 6h ·
Forecast for Rochester, MN Aug 14 Moderate (Yellow), Aug 15 Good (Green)

MN Air Quality Index @... · 6h ·
Forecast for Minneapolis-S

Local Air Quality Conditions
Zip Code: [] State: Minnesota Go My Current Location

Today's AQI Forecast
Thursday, September 12, 2019

City	FORECAST		CURRENT AQI
	Thu Sep 12	Fri Sep 13	
Brainerd	21	Good	14
Detroit Lakes	21	Good	14
Duluth	19	Good	18
Ely	19	Good	19
Fond Du Lac	19	Good	13
Grand Portage	19	Good	3
Leech Lake Nation-Cass Lake	21	Good	8
Marshall	20	Good	8
Mille Lacs	21	Good	13
Minneapolis-St. Paul	21	Good	4

Minnesota Air

Current Air Quality Map

Select Your Area

- Metro
- Northwest

Home About AQI Refresh

What Exactly is Being Forecasted?

- ✓ Wildfire smoke impacts
- ✓ Prescribed fire impacts – in state/regional
- ✓ Ground-level ozone
- ✓ Winter stagnation
- ✓ Recreational/winter time wood burning
- ✓ Agricultural activity impacts – dust during harvest, fall fertilizing
- ✓ Dust storm impacts
- ✓ *Special Events: Industrial accidents, etc.

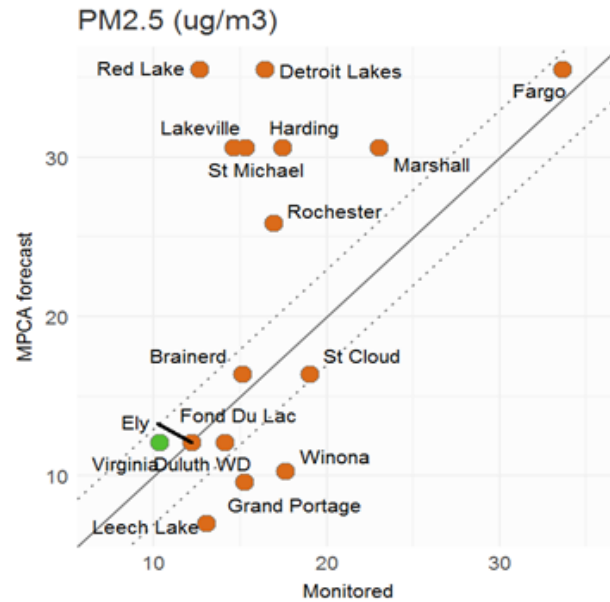
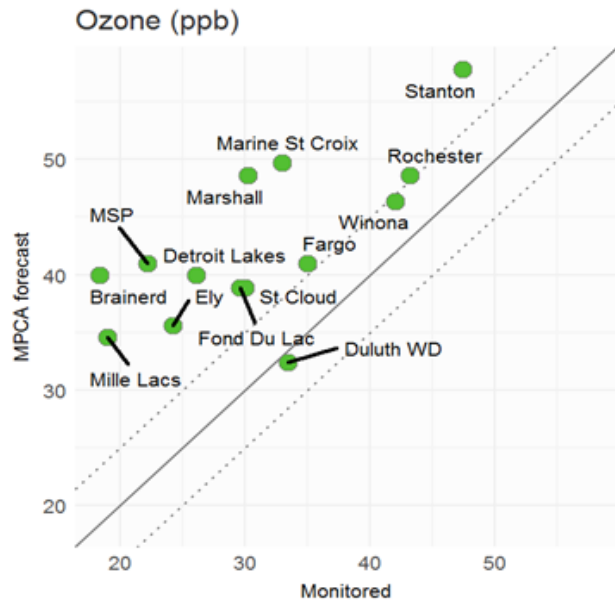
Wildfire Smoke Tested the Program in 2017, 2018, and 2019

Minnesota AQI report

Preliminary results for Thursday Aug 09, 2018

The category accuracy of the next-day forecast was **59%** (10/17) for PM2.5 and **93%** (13/14) for Ozone.

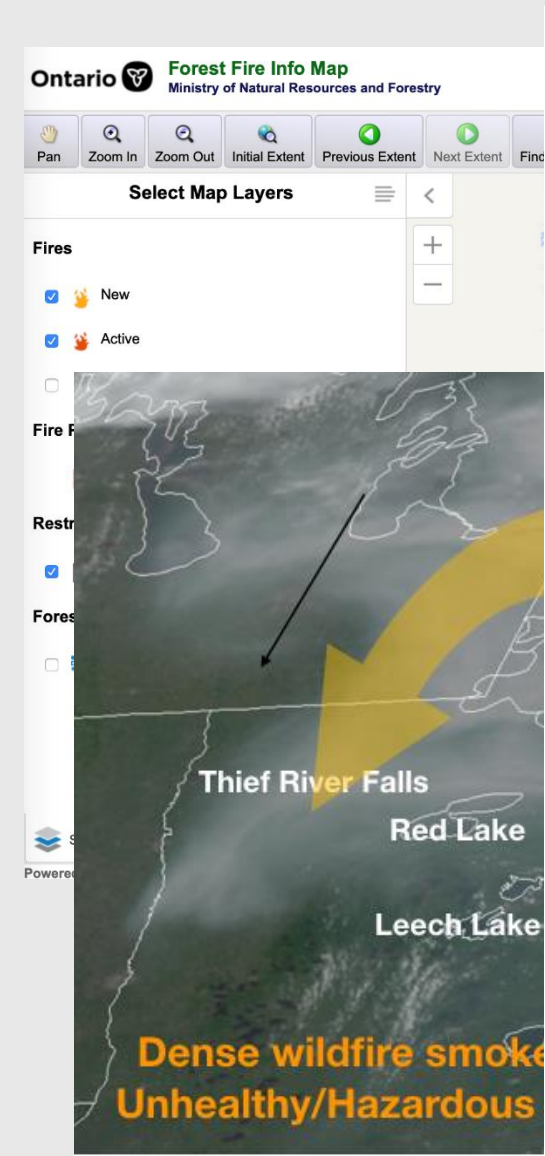
MPCA forecast vs Monitoring results



PM2.5 results in ug/m3

Site	Obs count	Monitored	MPCA	Ensemble	Big RF	GradBoost	Robot
Fargo	NA	34	35.5	16.5	13.1	16.1	17.5
Marshall	24	23	30.6	10.6	11.8	10.0	10.7
St Cloud	23	19	16.4	6.4	6.2	6.8	6.5
Winona	NA	18	10.3	8.2	9.1	6.8	8.7
Harding	24	17	30.6	11.2	11.9	12.5	11.8
Rochester	24	17	25.9	10.8	9.4	10.4	10.2
Detroit Lakes	23	16	35.5	6.9	7.3	6.2	7.0
St Michael	24	15	30.6	8.9	10.7	10.3	9.6
Grand Portage	23	15	9.6	7.7	8.5	7.7	8.7
Brainerd	24	15	16.4	6.0	5.5	4.5	5.4
Lakeville	24	15	30.6	11.9	11.4	12.2	10.8
Fond Du Lac	24	14	12.1	11.4	11.7	10.6	11.7
Duluth WD	24	14	12.1	10.1	10.8	11.6	7.5
Leech Lake	24	13	7.0	7.1	8.0	7.1	6.4
Red Lake	24	13	35.5	10.1	10.2	9.0	9.1
Ely	24	12	12.1	12.9	13.1	10.3	12.1
Virginia	24	10	12.1	9.7	8.1	7.5	9.5

Heavy Smoke Transports South into Minnesota

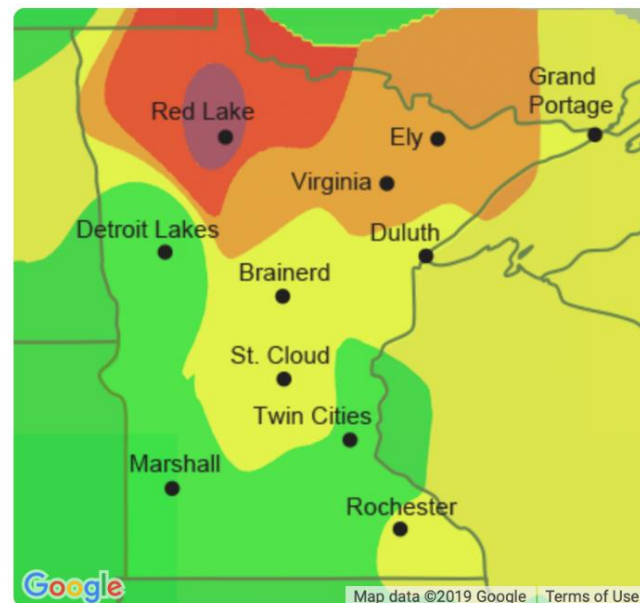


Search...

- Air
- Water
- Waste
- Regulations
- Living Green
- Data
- About the MPCA

Air

Current air quality

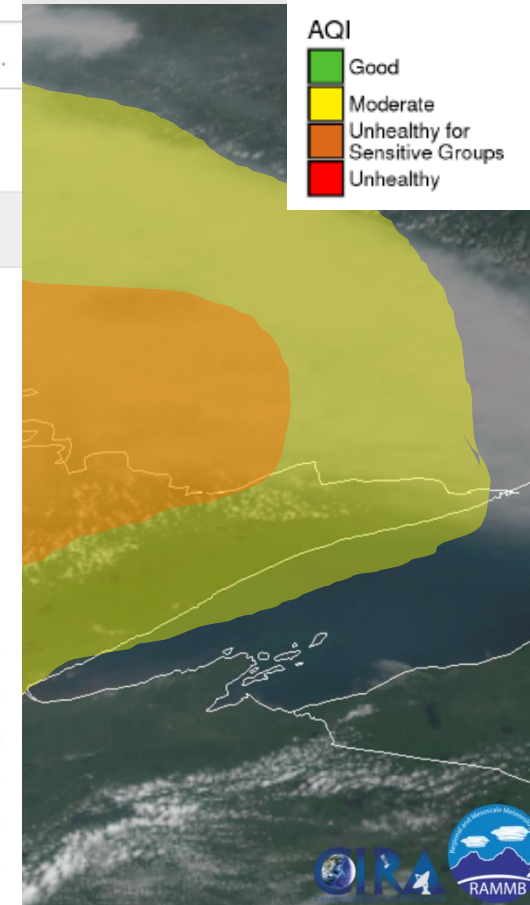


Current conditions

Last Updated: 07/06/2019 9AM CDT

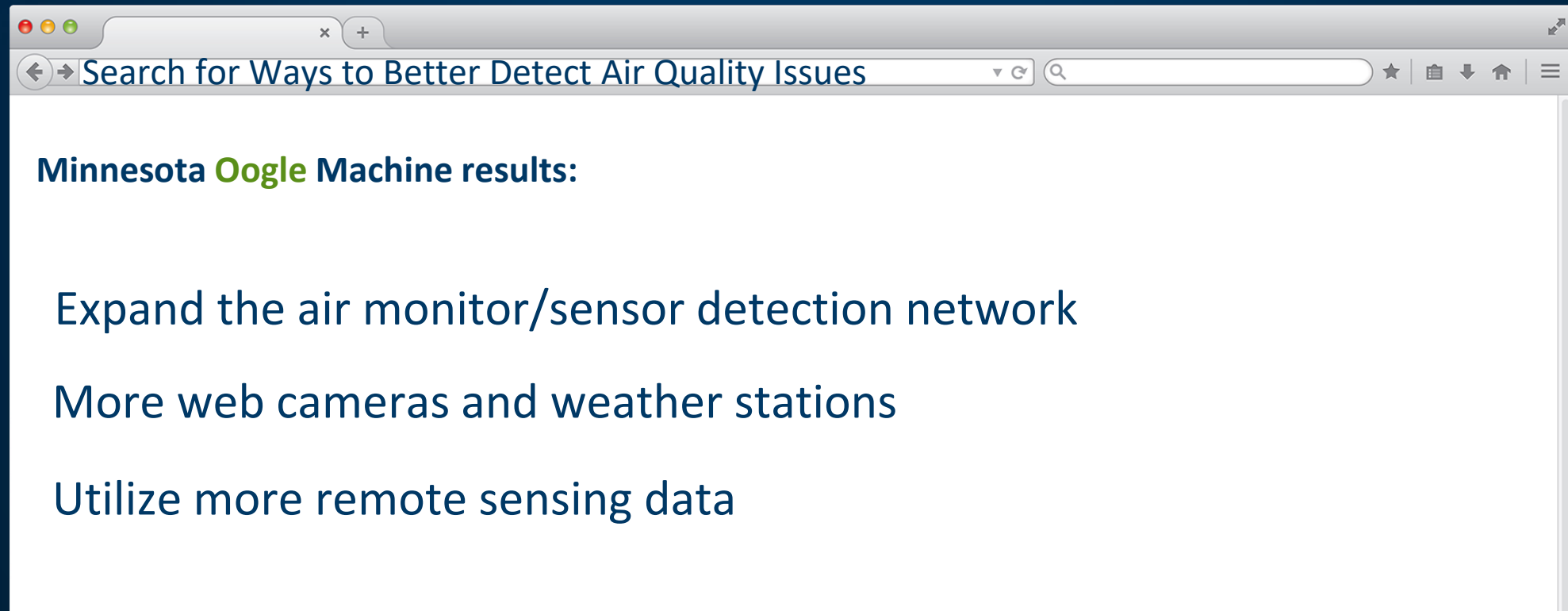
	Ozone	Particles
Brainerd	N/A	N/A
Detroit Lakes	16	13
Duluth	N/A	N/A
Ely	23	136
Marshall	20	41
Rochester	22	52
St. Cloud	19	68
Twin Cities	N/A	N/A

(NowCast AQI)

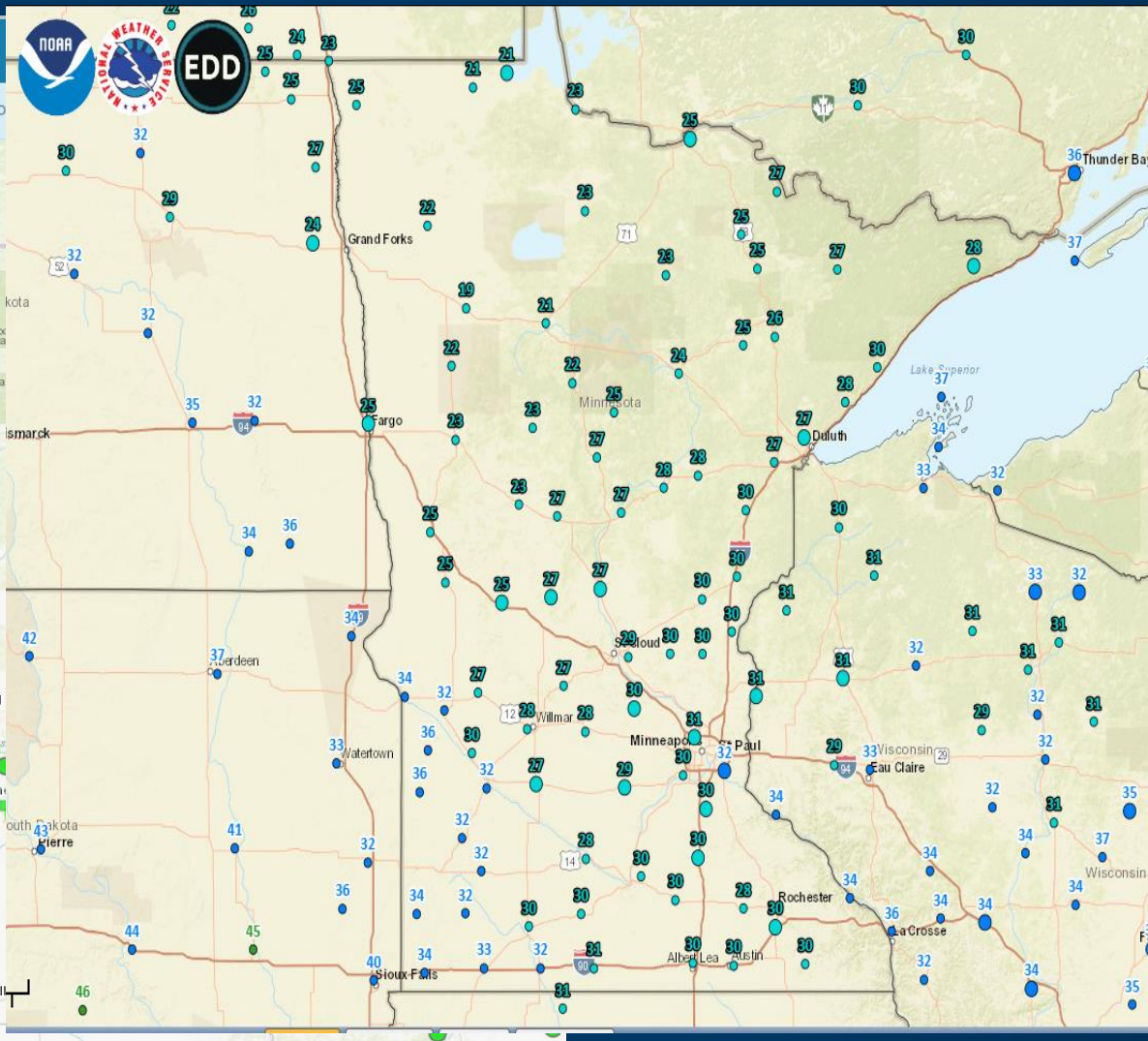
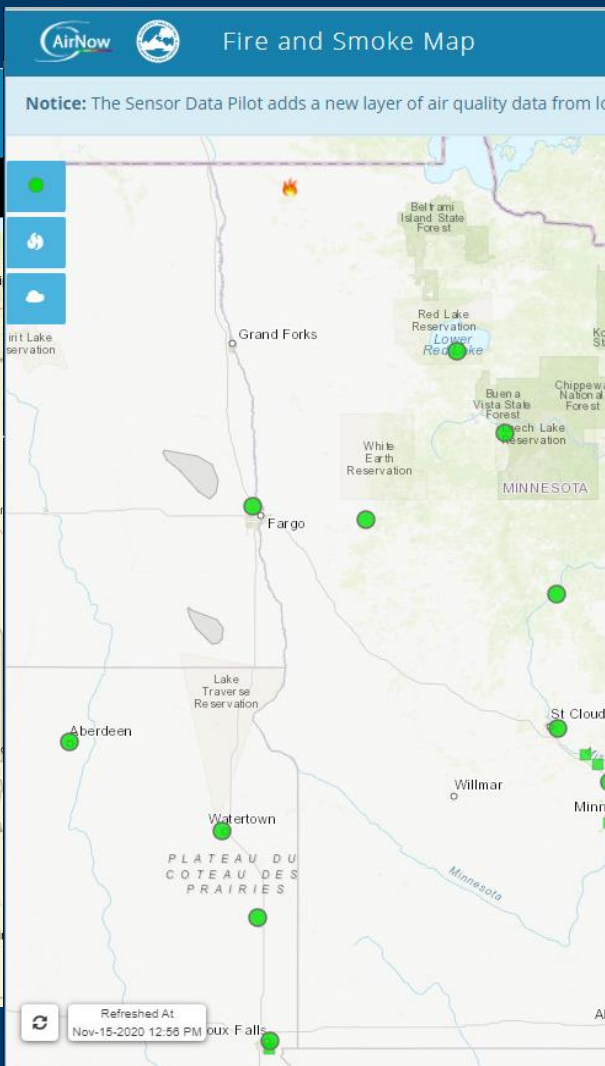
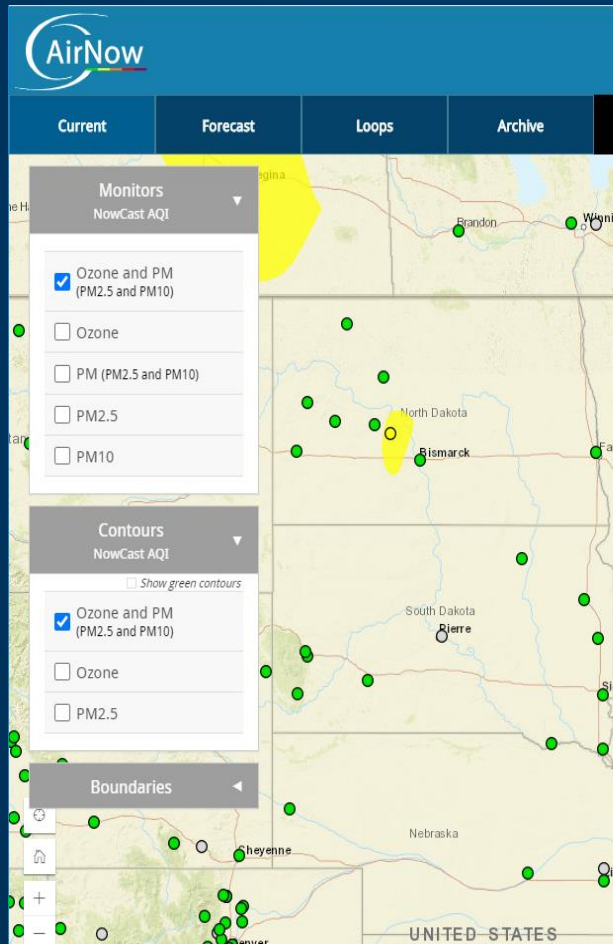


ly formed and N winds
Minnesota overnight

Things Learned and Future Items to be included as Additional Tools and Techniques to Improve Analysis and Forecasting



Air Quality Monitoring/Sensor Network



Remote Sensing: Satellite Data

GOES-East

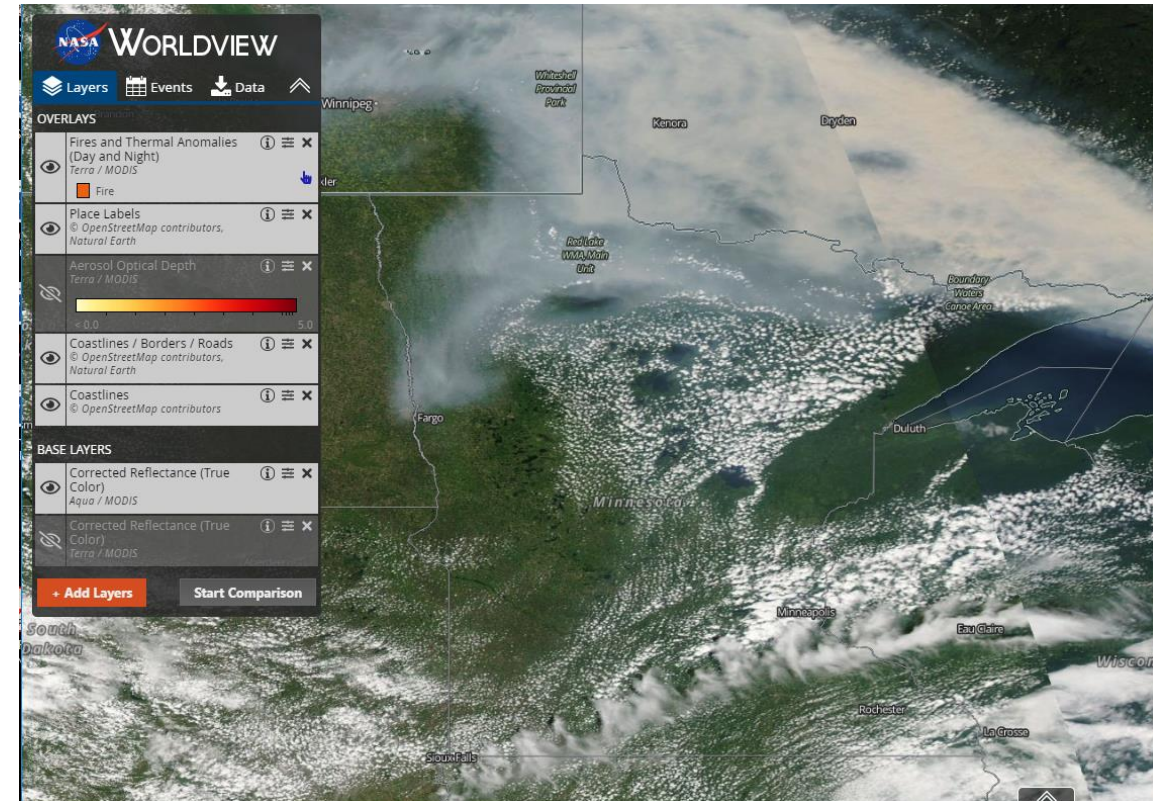
Various Bands Utilized

- GeoColor/True-Color
- Band 1: Visible (blue)
- Band 2: Visible (red)
- Band 7: Shortwave IR
- Band 10: Low WV
- Band 12: Ozone

NASA MODIS

GOES-East - Latest CONUS Images
Images updated every 3 minutes. GLM images updated every minute.

GeoColor True Color day/night Multispectral IR at night 15 Nov 2020 - 20:01 UTC	GLM FED-GeoColor Geostationary Lightning Monitor 15 Nov 2020 - 20:01 UTC	AirMass RGB HCI composite based on one data from IR and WV bands 15 Nov 2020 - 20:01 UTC	Sandwich RGB Multi-spectral blend combines IR band 15 with visible band 2 15 Nov 2020 - 20:01 UTC	Derived Motion Winds Derived Motion Winds 15 Nov 2020 - 19:46 UTC
Day Cloud Phase RGB HCI used to evaluate the phase of cooling cloud base 15 Nov 2020 - 20:01 UTC	Nighttime Microphysics HCI used to distinguish clouds from fog 15 Nov 2020 - 20:01 UTC	Band 1 0.47 μm Blue - Visible 15 Nov 2020 - 20:01 UTC	Band 2 0.64 μm Red - Visible 15 Nov 2020 - 20:01 UTC	Band 3 0.87 μm Water - Near IR 15 Nov 2020 - 20:01 UTC
Band 4 1.37 μm Cirrus - Near IR 15 Nov 2020 - 20:01 UTC	Band 5 1.6 μm Stratosphere - Near IR 15 Nov 2020 - 20:01 UTC	Band 6 2.2 μm Cloud Particle - Near IR 15 Nov 2020 - 20:01 UTC	Band 7 2.13 μm Shortwave Window - IR 15 Nov 2020 - 20:01 UTC	Band 8 6.2 μm Upper-Level Water Vapor - IR 15 Nov 2020 - 20:01 UTC
Band 9 6.5 μm Mid-Level Water Vapor - IR 15 Nov 2020 - 20:01 UTC	Band 10 7.3 μm Lower-Level Water Vapor - IR 15 Nov 2020 - 20:01 UTC	Band 11 8.4 μm Cloud Top - IR 15 Nov 2020 - 20:01 UTC	Band 12 9.6 μm Ozone - IR 15 Nov 2020 - 20:01 UTC	Band 13 10.3 μm Clear Longwave Window - IR 15 Nov 2020 - 20:01 UTC
Band 14 11.2 μm Longwave Window - IR 15 Nov 2020 - 20:01 UTC	Band 15 12.3 μm Dirty Longwave Window - IR 15 Nov 2020 - 20:01 UTC	Band 16 13.3 μm CO ₂ Longwave - IR 15 Nov 2020 - 20:01 UTC		



Future – What does it hold for AQ Forecasting and Alerting

MPCA Actions

- ✓ Continued research on air quality forecasting
- ✓ Improving AI modeling
- ✓ Adding more data/obs
- ✓ Increased meteorologist experience
- ✓ Outreach/Education

Increased Frequency?

- *Wildfire smoke pollutants*
- *Warm season ozone*
- *Wintertime stagnation*
- *Agric/Industrial Effects*

Evolving Climate in Minnesota

- *Warming Temperatures (Winter & Summer)*
- *Increasing Moisture*
- *Droughts?*
- *Wildfires in North Woods*

Beyond Minnesota

- *Wildfire threats*
- *Regional transport of ozone pollutants*
- *Dramatic storm events*

Thank You!

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