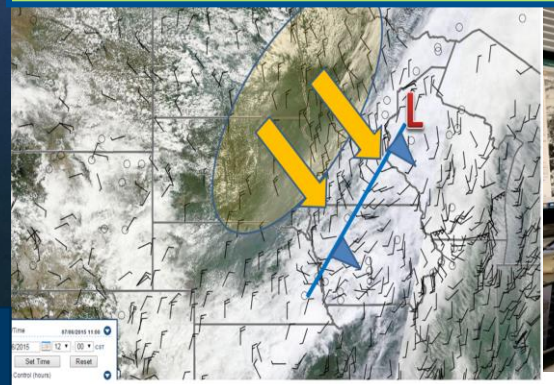
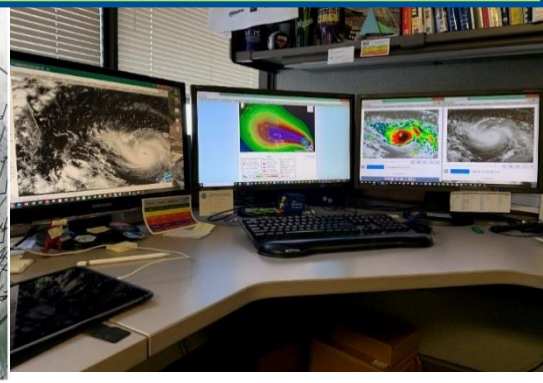
Intelligent and Interactive Air Quality Forecasting

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

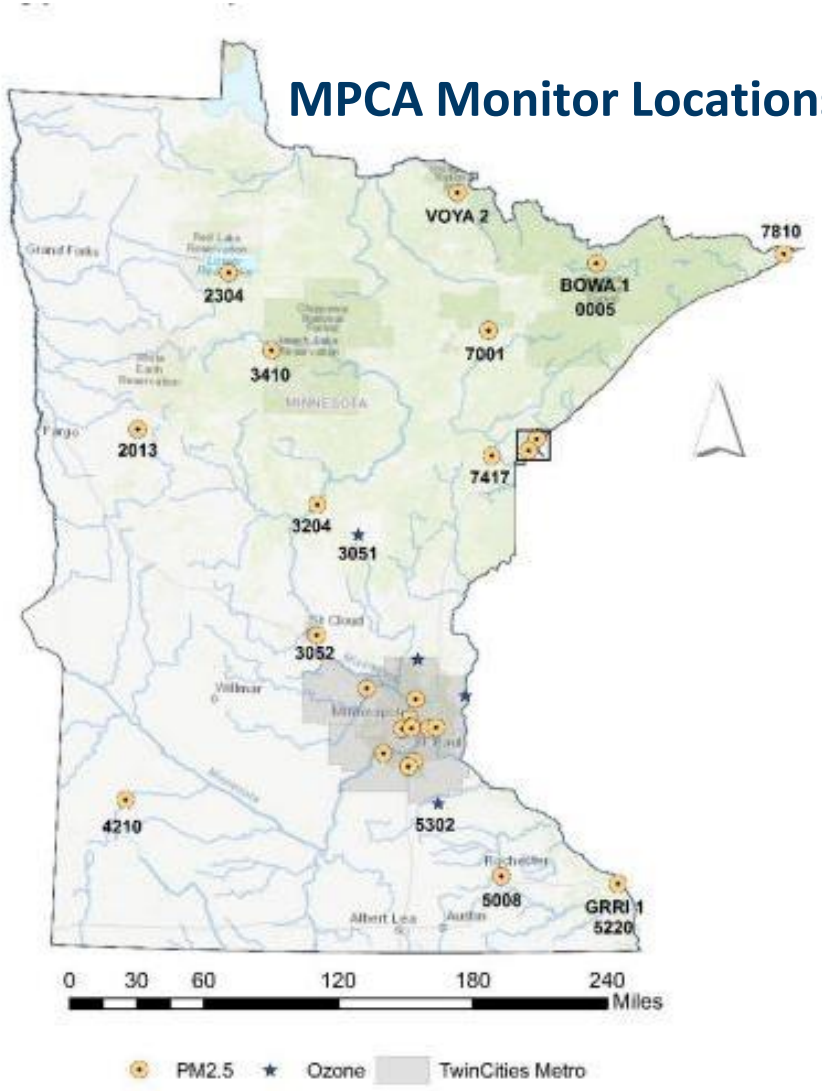
NASA TEMPO EARLY ADAPTORS WORKSHOP - NOV, 2020

MINNESOTA POLLUTION CONTROL AGENCY

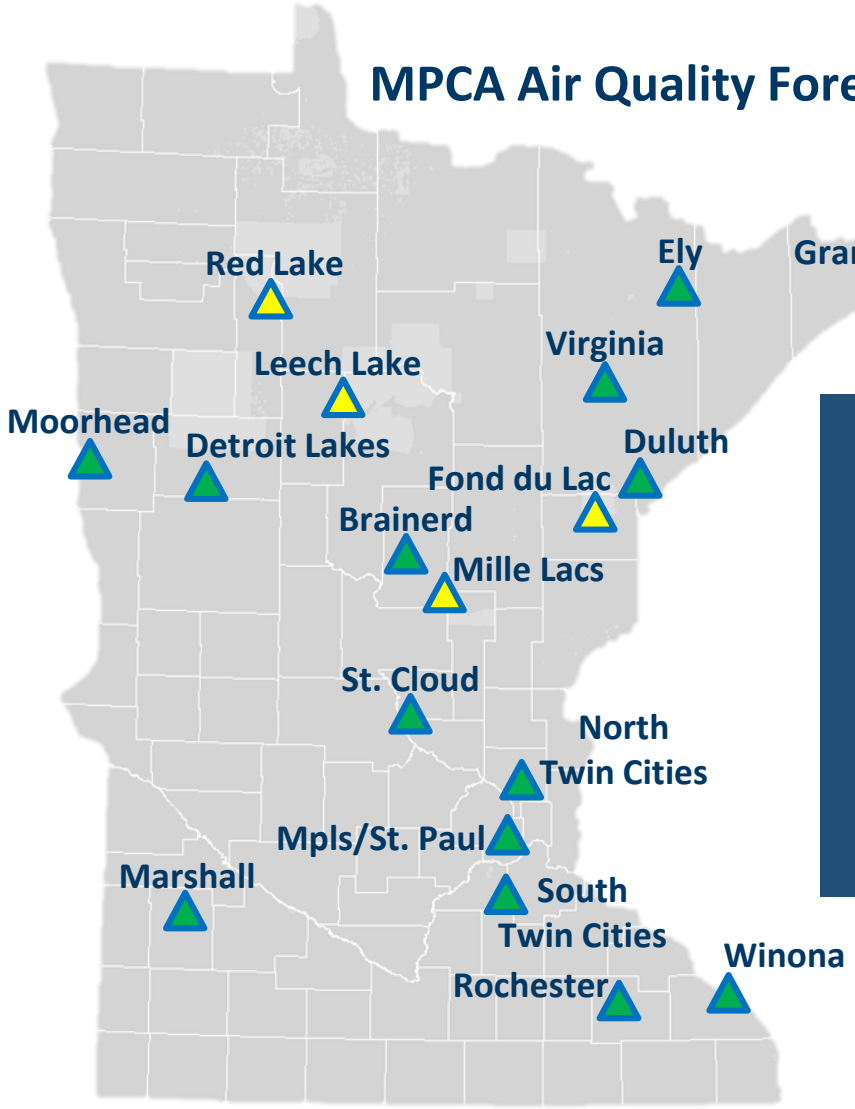
Our mission is to protect and improve the environment and enhance human health | https://www.pca.state.mn.us

Air Quality Index (AQI) Forecast Locations

MPCA Monitor Locations



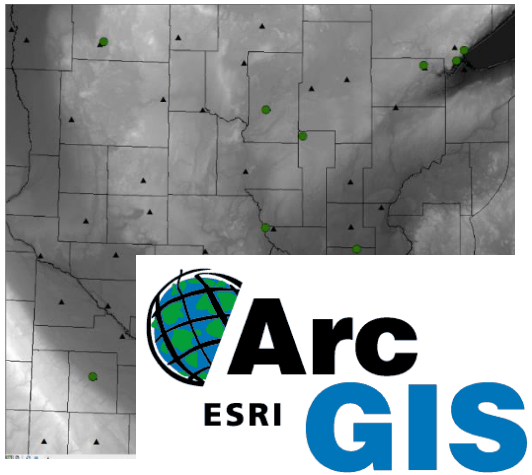
MPCA Air Quality Forecast Locations

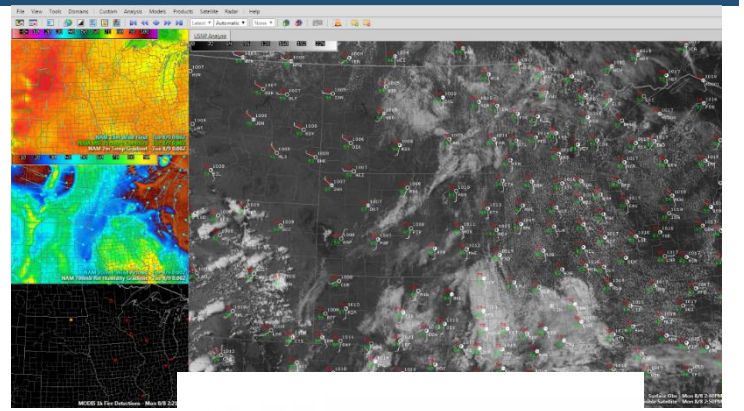


- Expanded from 2 to 18 locations (2017-2018)
- Twin Cities metro into 3
- 5 Tribal locations
- Based on monitor locations

Artificial Intelligence (AI) Model

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





ESRI ArcGIS

tableau SOFTWARE

scikits learn

R

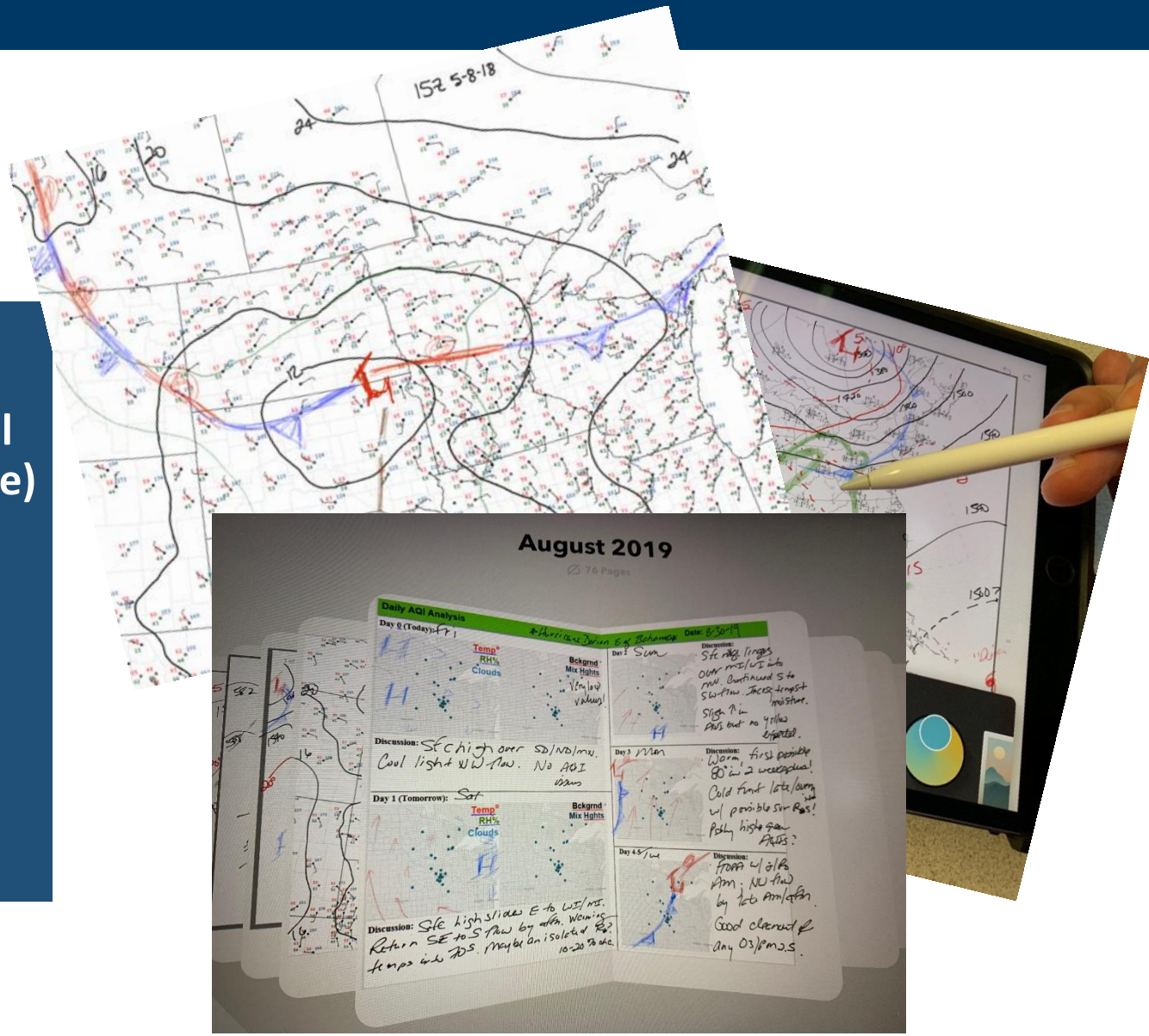
python

The DataCamp Team

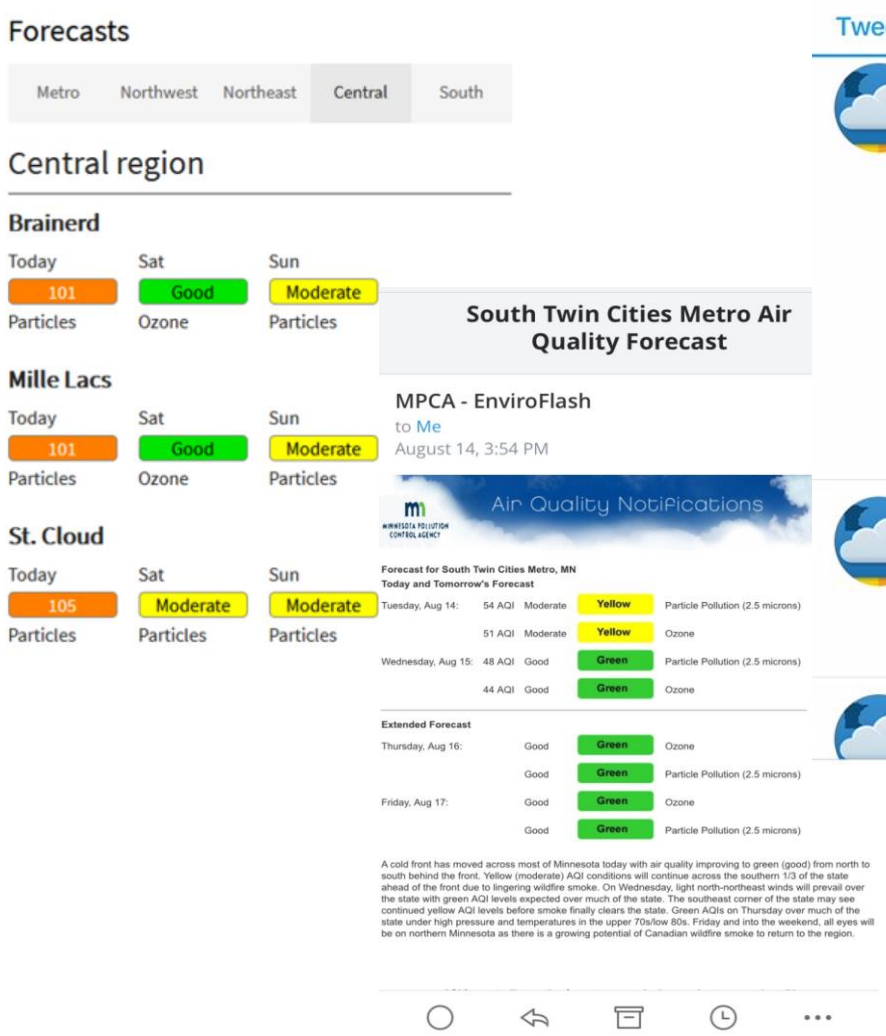
```
######Regression Section

#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
```

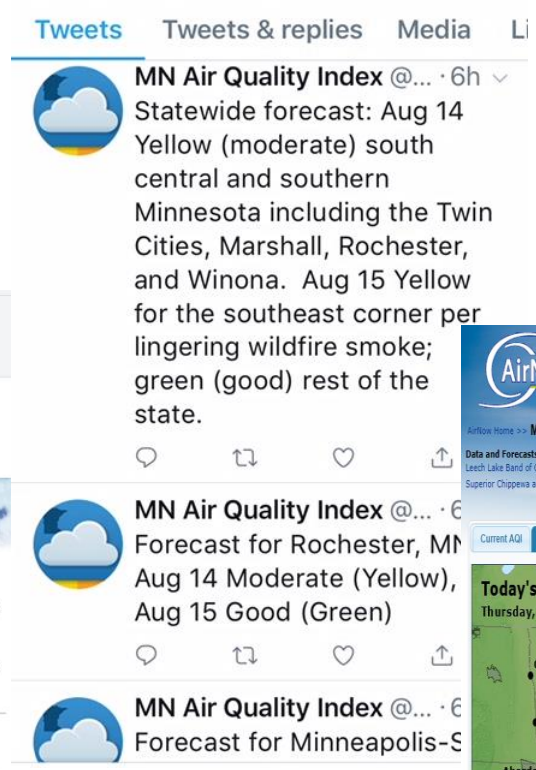
Air Quality Forecast Process

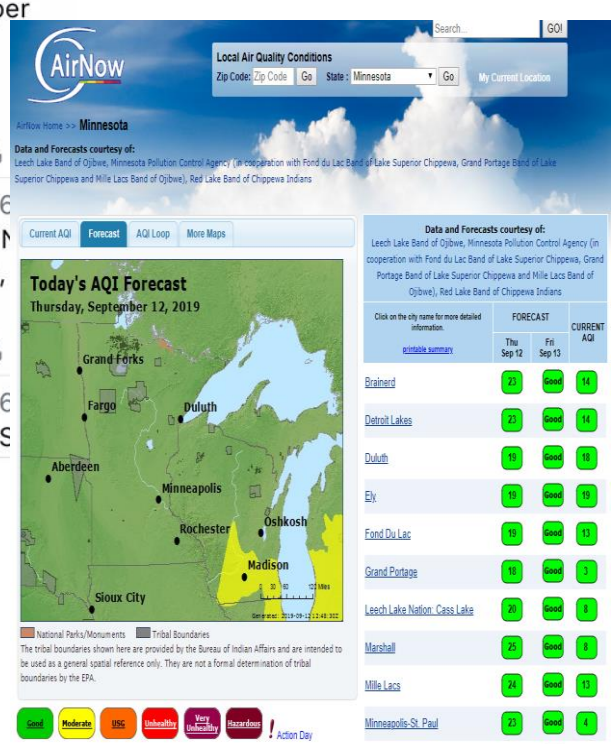
- Current weather conditions are analyzed
- Weather data are processed from forecast model output (variety of meteorological model guidance)
- Background (air quality monitor-derived) concentrations are estimated
- Weather inputs and background are refined if needed
- AI model is run and AQ initial forecast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

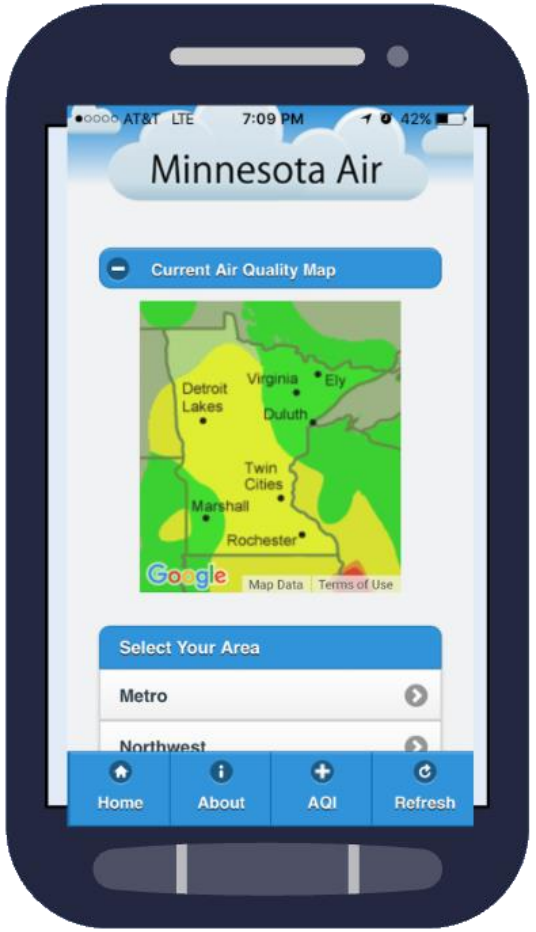


Air Quality Forecast Display Platforms









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.

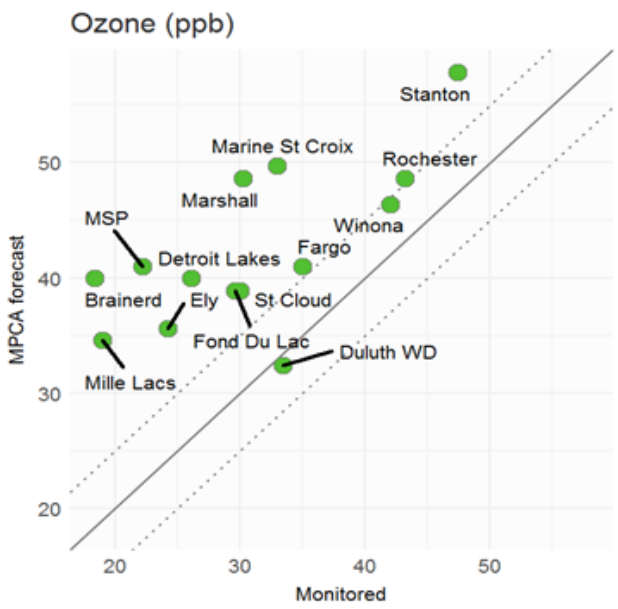
Wildfire Smoke Tested the Program in 2017, 2018, and 2019

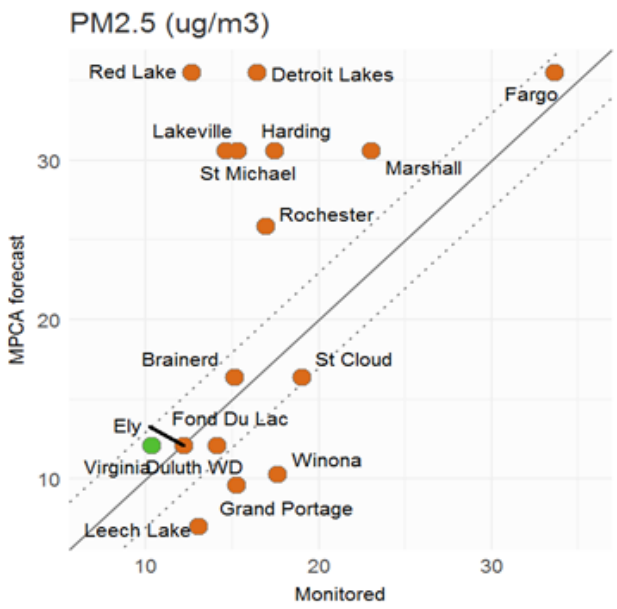
Minnesota AQI report

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

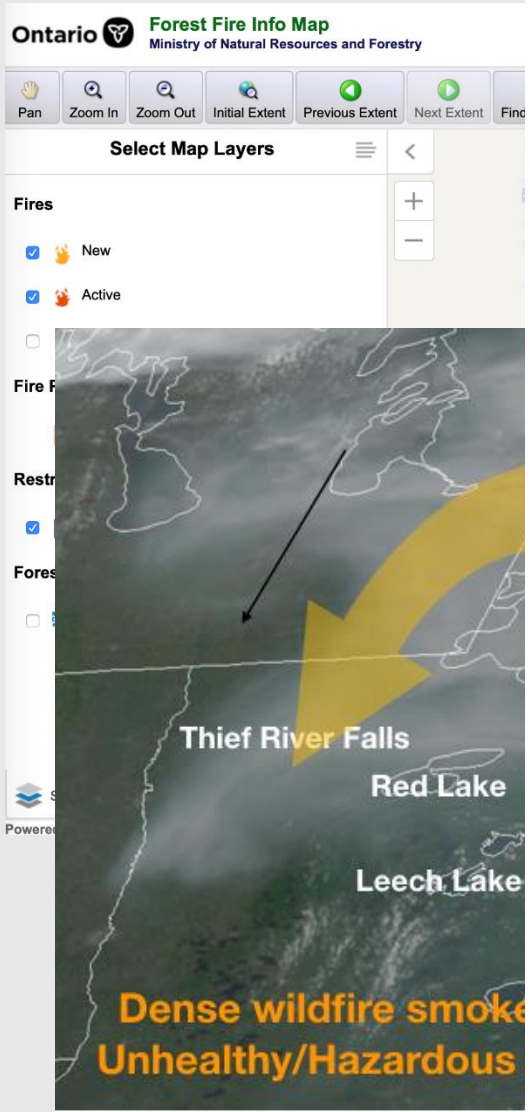




PM2.5 results in *ug/m3*

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



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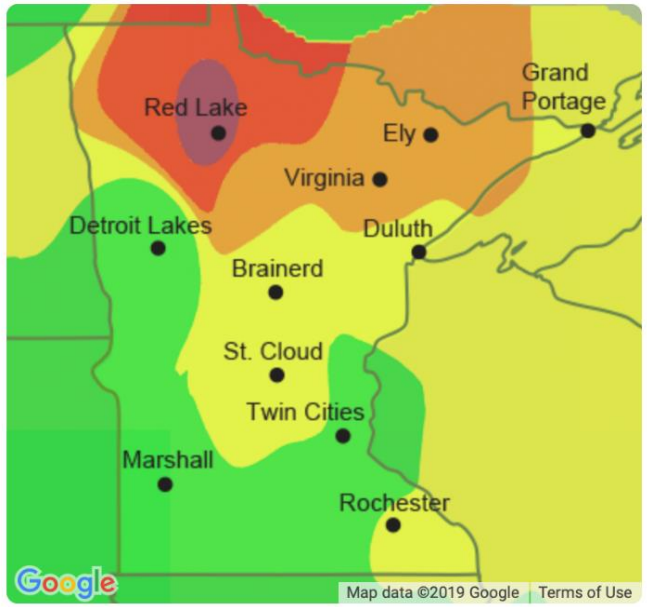
Air

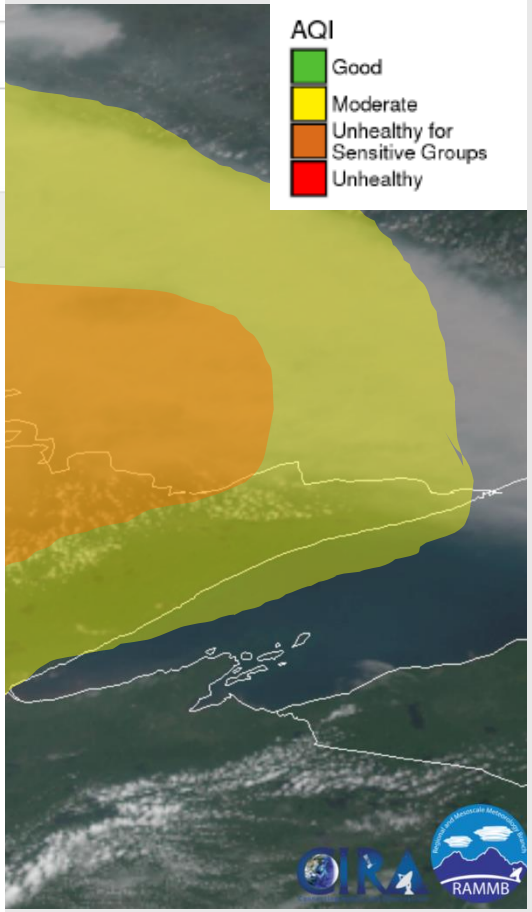
Current air quality



Current conditions

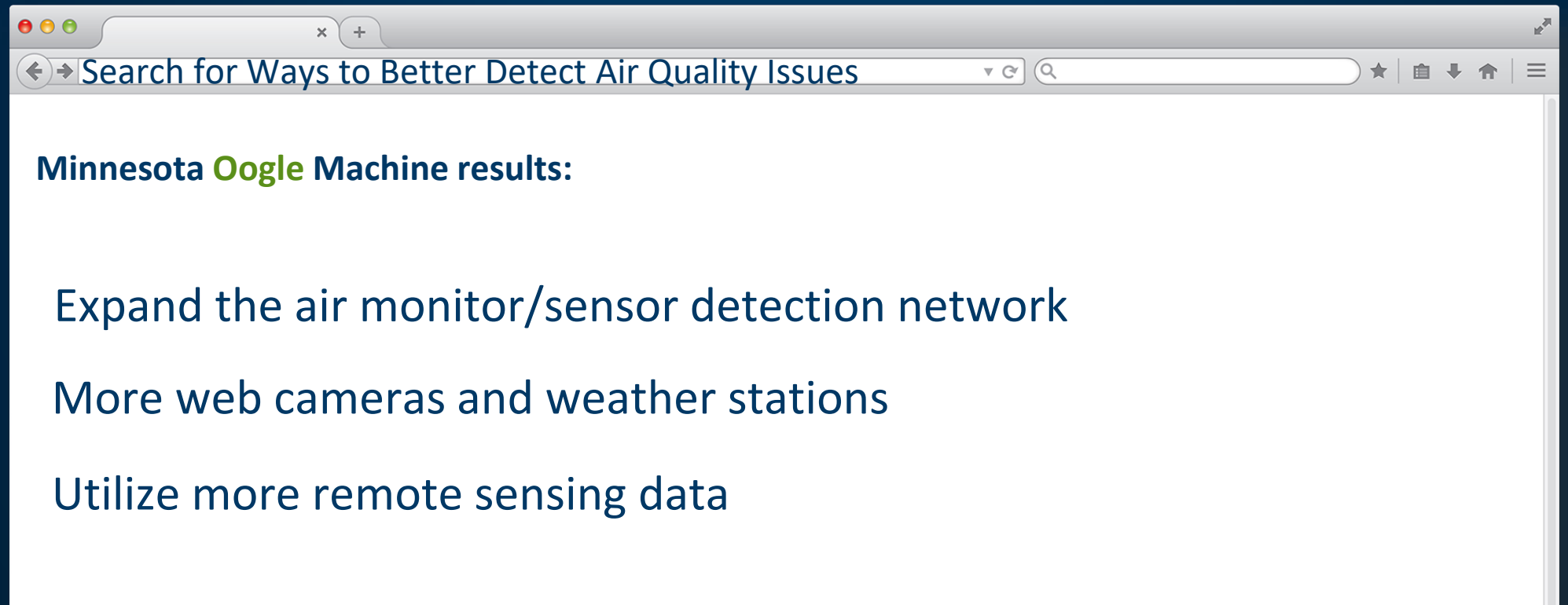
Last Updated: 07/06/2019 9AM CDT

	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 (NowCast AQI)	N/A	N/A

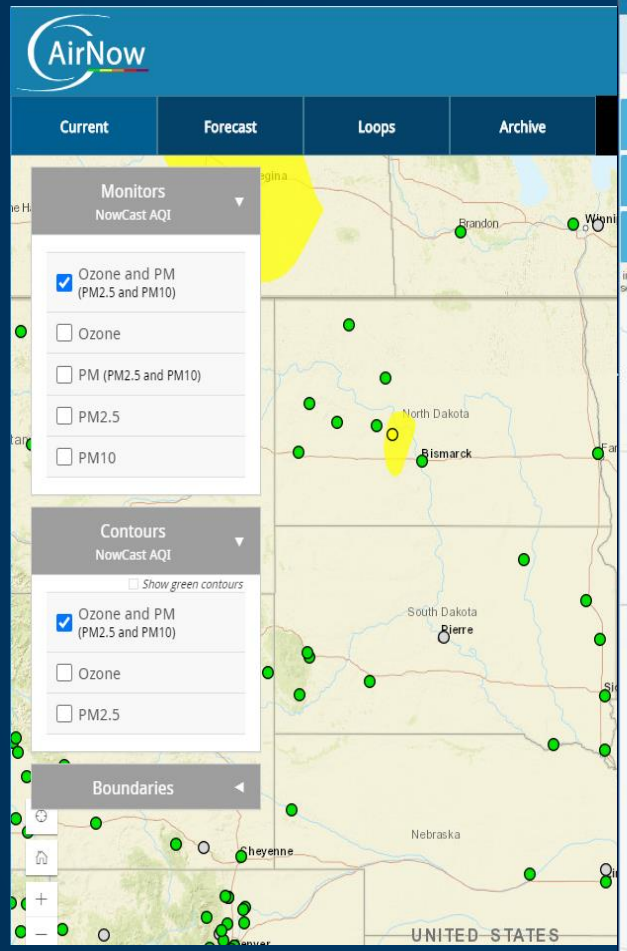


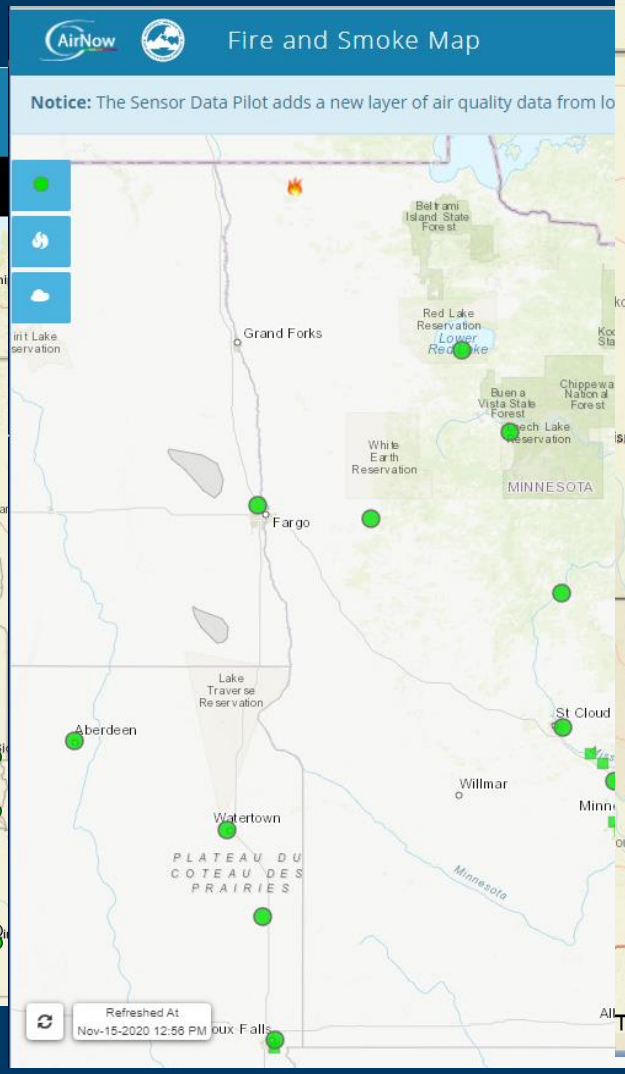
lly formed and N winds
nnesota overnight

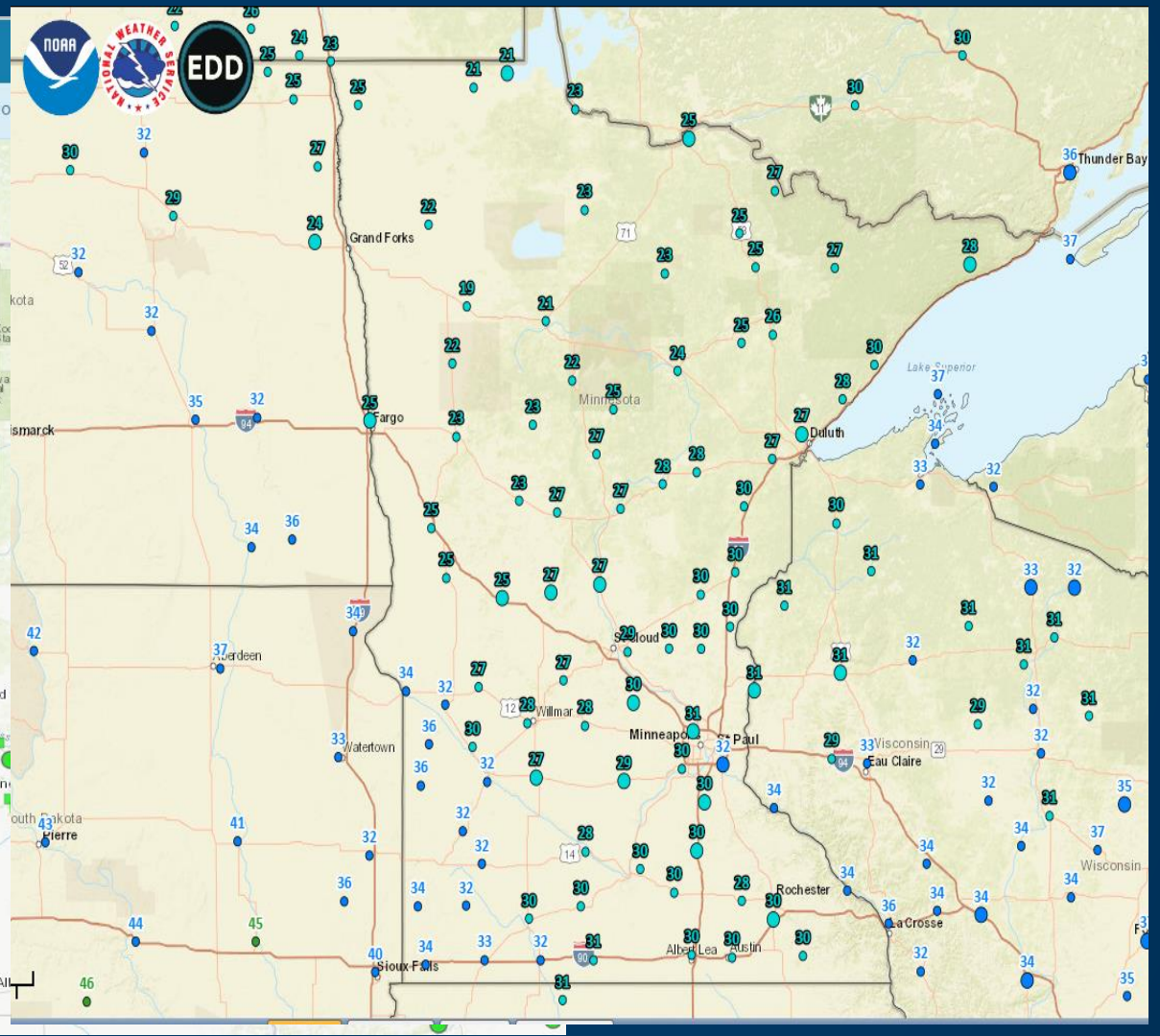
Things Learned and Future Items to be included as Additional Tools and Techniques to Improve Analysis and Forecasting



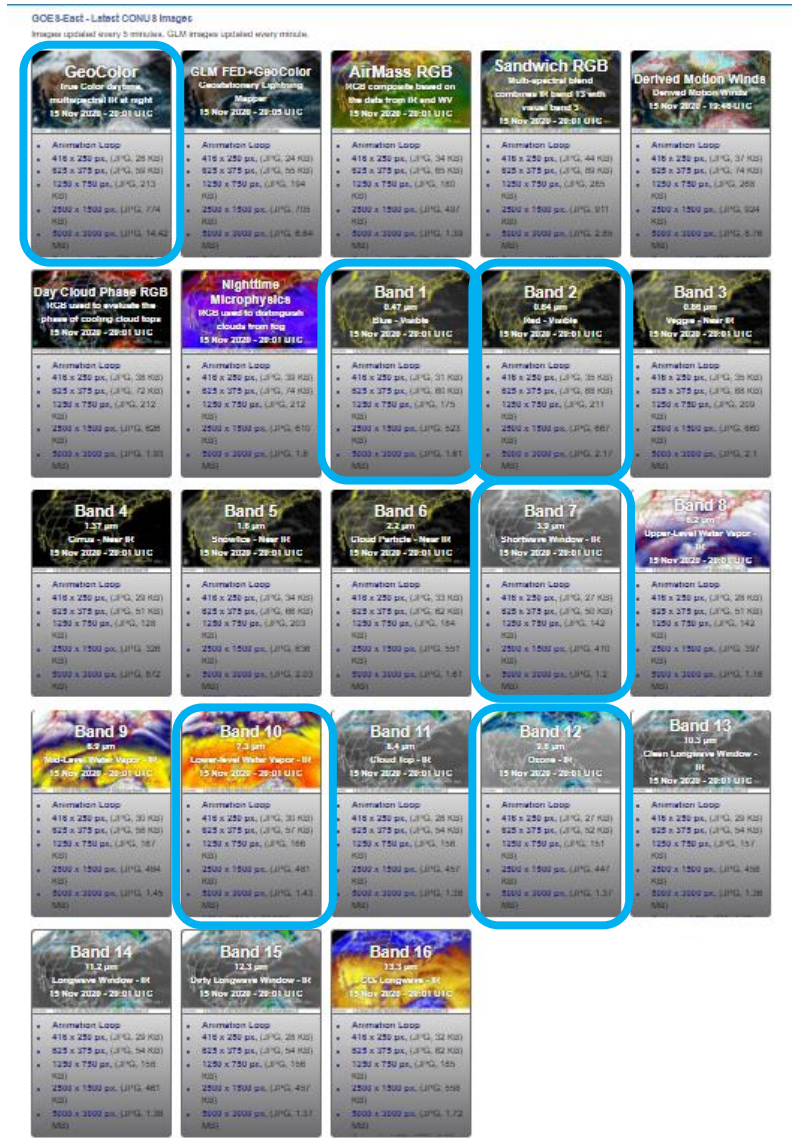
Air Quality Monitoring/Sensor Network







Remote Sensing: Satellite Data



GOES-East

Various Bands Utilized

GeoColor/True-Color

Band 1: Visible (blue)

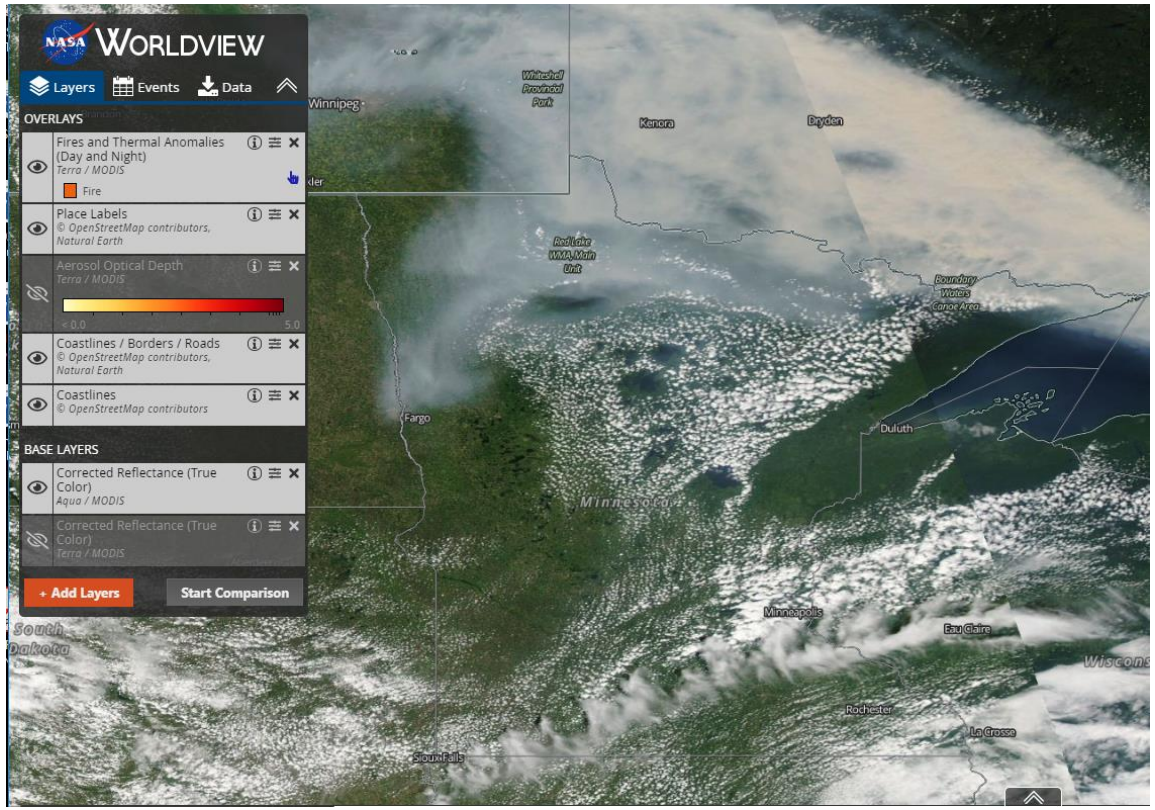
Band 2: Visible (red)

Band 7: Shortwave IR

Band 10: Low WV

Band 12: Ozone

NASA MODIS



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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