Wildfires in Manitoba and Ontario (CANADA) Cause Smoky Skies and Low Visibility in Grand Forks

The massive wildfires in Manitoba and Ontario (Canada), which have burned hundreds of thousands of acres and raged for weeks (video: https://www.youtube.com/watch?v=4YEhym16mS4). The smoke from massive Canadian wildfires located north of the Canadian border in Ontario and Manitoba (from May 2021 to July 2021) has led to high concentrations of fine Particulate Matter (PM) in the air which deteriorate the air quality leading to increase health issues for everyone, but mainly for sensitive groups like people with asthma and other respiratory problems. Moreover, due to the fact that smoke particles are small and light, they can be transported hundreds (if not a few thousand) miles away from their source. Heavy smoke from the Canadian wildfires was transported to Grand Forks by northerly winds. We present here two events.

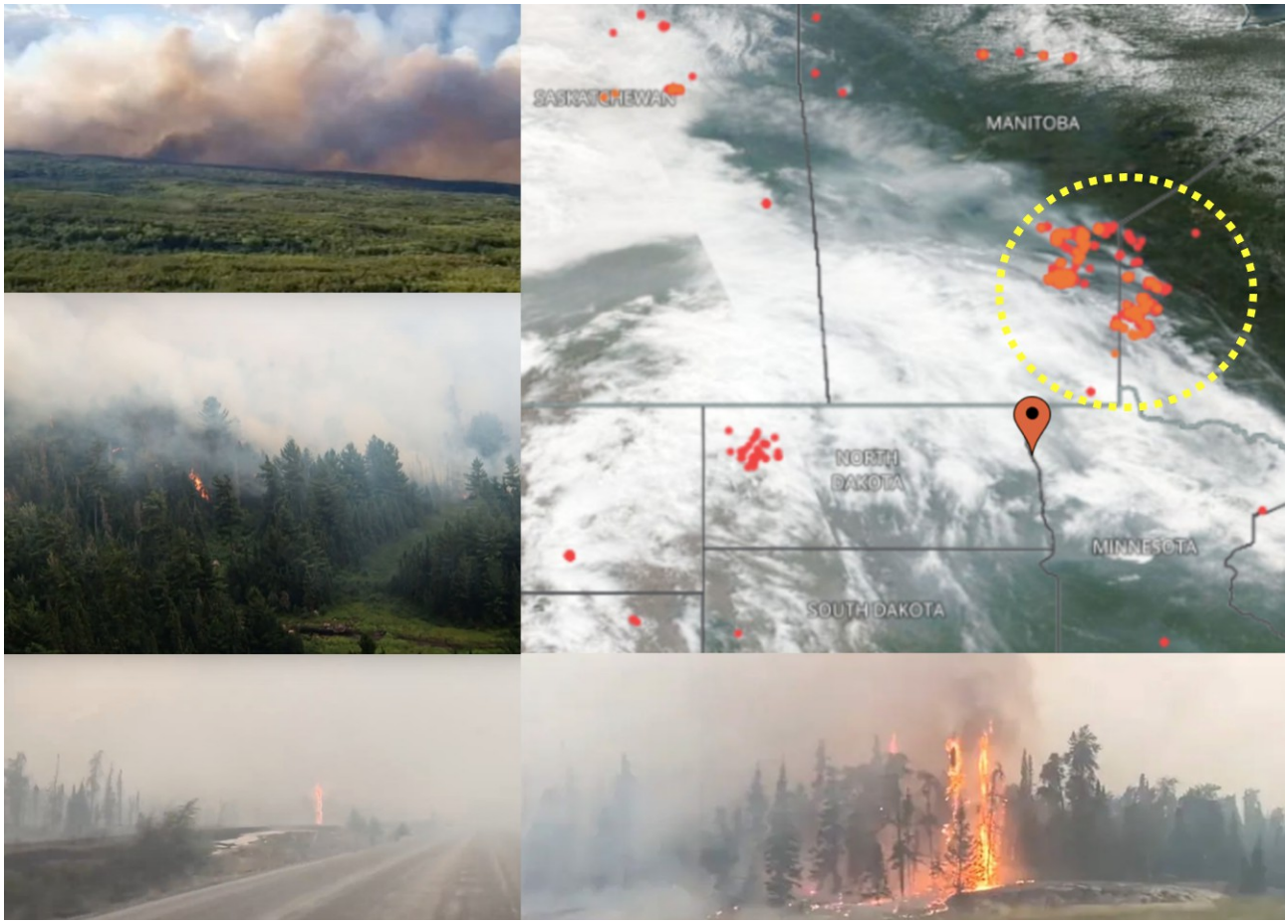

Figure 1: Photos of the Wildfires in Manitoba and Ontario (Canada) during the summer 20211 and a satellite image capturing the locations of wildfires in Southern Manitoba and Ontario on July 20st , 2021 based on heat detected by satellites.

Event 1: Smoke from Canadian wildfires is creating haze in Grand Forks on July 6th 2021

Observations from instruments on the MetTrailer showed a low visibility event on the morning of July 6th , 2021. Between 12:00 and 23:15 UTC , the visibility is reduced to between 2-15 km (Figure 2). During the low visibility event, the temperature fell from approximately 15.0˚C to 13.5˚C before returning to above 15.0˚C (Figure 3). The temperature change had a corresponding change in relative humidity to 93 % (Figure 4).

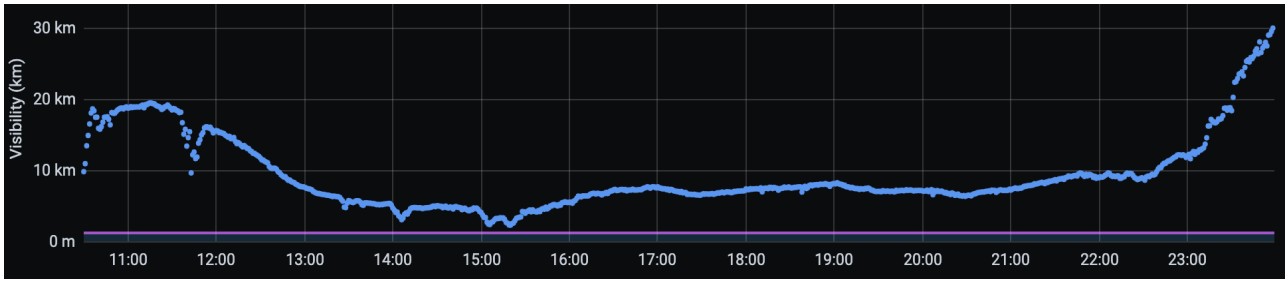

Figure 2: Image showing one day measurements of visibility from the CS125 Present Weather and Visibility Sensor on the MetTrailer located at the Delene's residents. Measurements are provided from 10:30 to 23:59 UTC, on 06 July 2021.

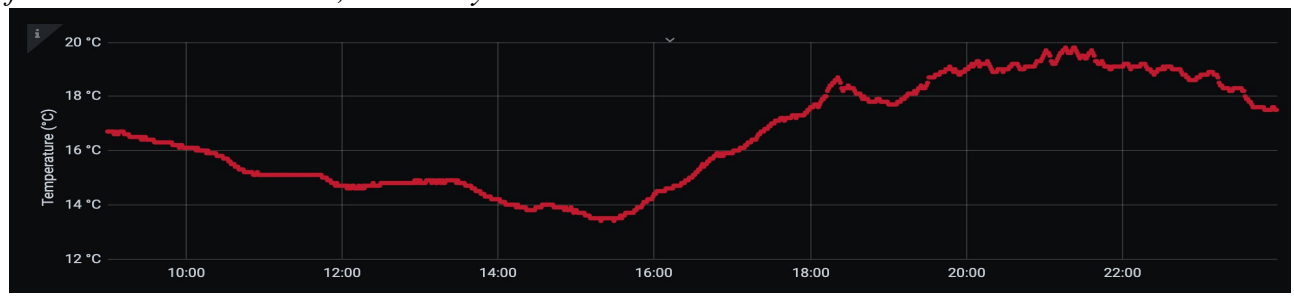

Figure 3: Image showing one day measurements of temperature from the CS125 Present Weather and Visibility Sensor on the MetTrailer located at the Delene's residents. Measurements are provided from 09:30 to 23:59 UTC, on 06 July 2021.

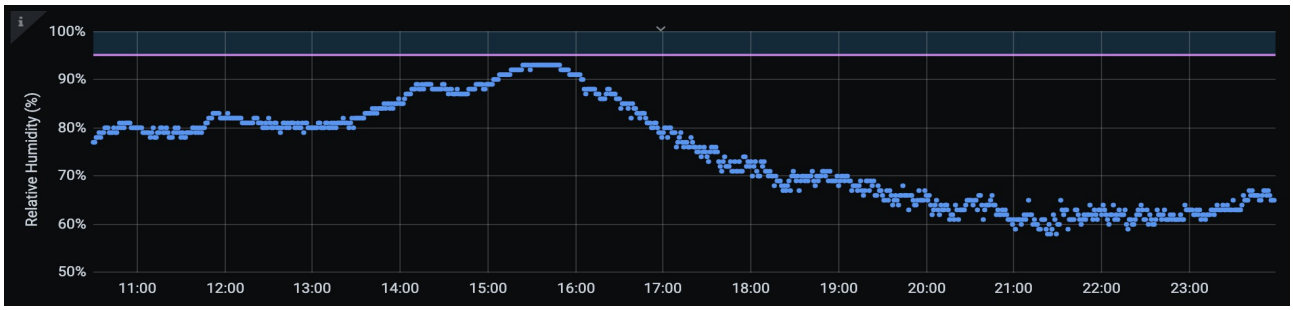

Figure 4: Image showing one day measurements of relative humidity from the CS125 Present Weather and Visibility Sensor on the MetTrailer located at the Delene's residents. Measurements are provided from 10:30 to 23:59 UTC, on 06 July 2021.

The images obtained from Deeplens camera from 12:03 UTC to 16:13 UTC showing a haze layer above the field (Figure 5). This haze layer is what the CS125 Present Weather and Visibility Sensor detected with the reduced visibility of 2-4 km.

Figure5: Set of four images from the Deeplens camera on the MetTrailer located at the Delene's residents. Images are at 12:03, 14:03, 15:03, and 16:13 UTC.

Figure 6: Image captured from the UND Department of Atmospheric science sky camera on July 6th 2021 at 12:35.

The haze covering Grand Forks area on July 6th, 2021, as seen in Figures 5 and 6, is caused by smoke transported from devastating fires in Canada. This event was well captured by satellite sensors as the resulting smoke plumes, fanned by northerly winds, were transported over Grand forks area (see Figure 7).

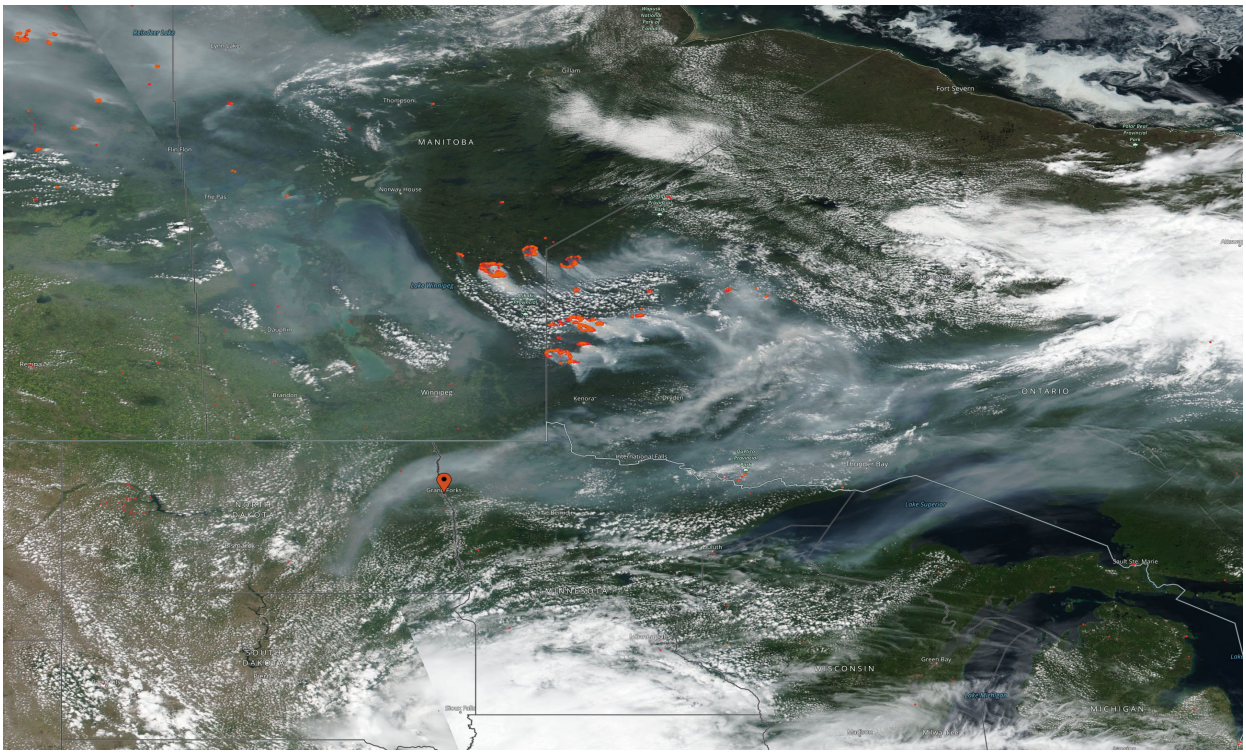

Figure 7: Image from Satellite sensors capturing the transported smoke plume on July 6th 2021 (source: [NASA Worldview https://worldview.earthdata.nasa.gov](https://worldview.earthdata.nasa.gov))

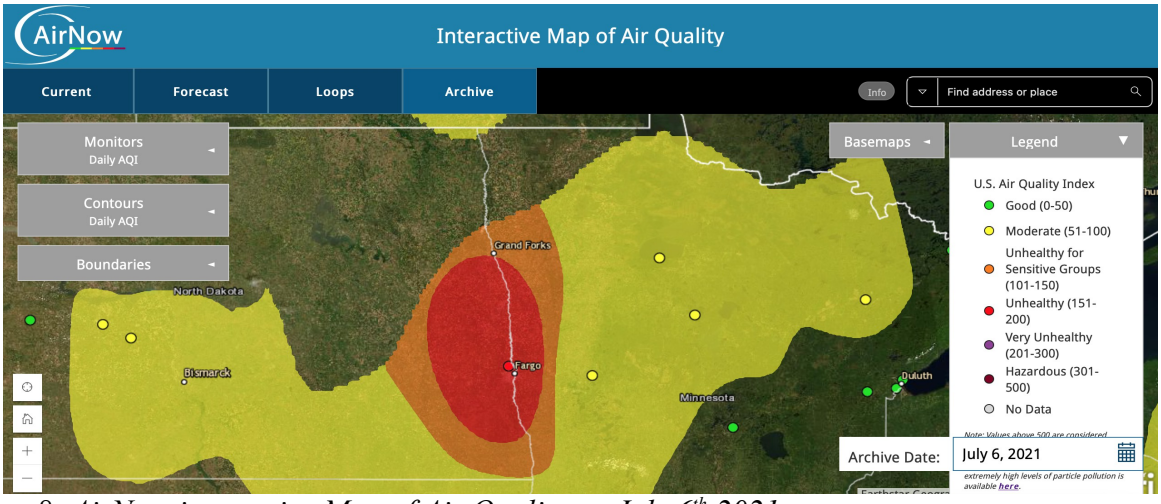

Figure 8: AirNow interactive Map of Air Quality on July 6th 2021 (source:https://gispub.epa.gov/airnow)

According to the AirNow Interactive map of air quality, July 6th, 2021 had a rating of "Unhealthy for sensitive Groups" (air quality index reaches between 101-150) over Grand Forks area which was caused due to elevated PM concentrations. Forecasts from the numerical model show high concentrations of the surface wildfire smoke emissions (estimated based on vegetation cover) over Grand forks area (See Figure 9).

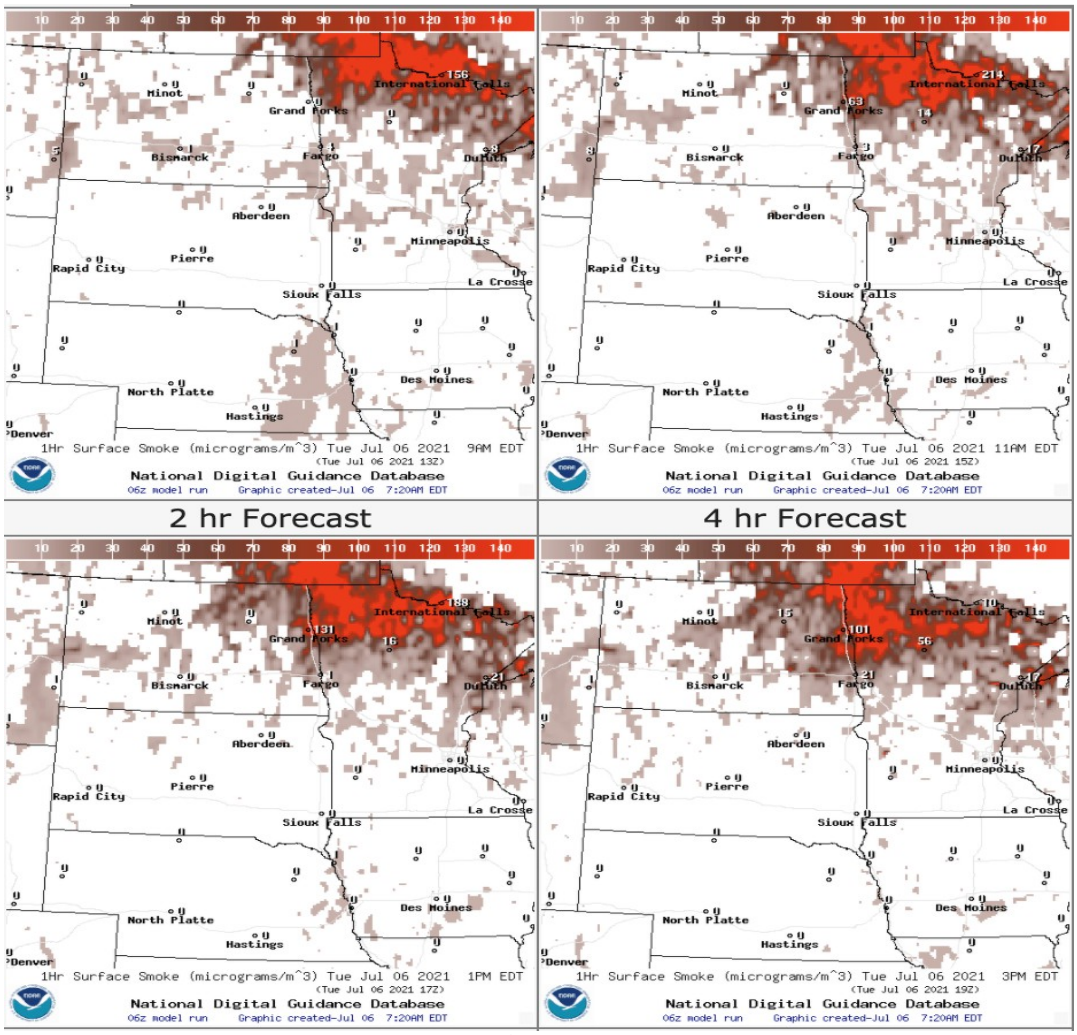

Figure 9: Surface smoke forecasts on July 6th 2021 (source:Air Quality Smoke Forecast, https://www.weather.gov/fgf/AirQualitySmokeForecast)

Event 2: Smoke From Canadian Wildfires is Creating Smoky Fog in Grand Forks on July 20th 2021

Figure 10: Image captured from the UND Department of Atmospheric science sky camera on July 20th 2021 at 12:45.

The smoky fog that formed over Grand Forks area on Tuesday July 20th was the result of a particular set of circumstances. First of all, the raging forest fires in Manitoba and Ontario have been producing heavy smoke for weeks. Surface winds out of the north blew that smoke southward. Light rain showers generated downward-moving air and also cooled the air in the lower atmosphere, creating a temperature inversion that trapped much of the smoky air close to the ground. These same conditions tend to produce fog, and the tiny smoke fine particles became condensation nuclei for humidity in the air to cling to. The end result was a dense, dirty, sooty fog with a very poor air quality and low visibility.

Observations from instruments on the MetTrailer showed a low visibility event on the morning of July 20th, 2021. Between 06:00 and 13:30 UTC , the visibility is reduced to between 1-5 km (Figure 10). During the low visibility event, the temperature fell from approximately 21˚C to 18˚C before returning to above 21.0˚C (Figure 11). The temperature change had a corresponding change in relative humidity to 99 % (Figure 12).

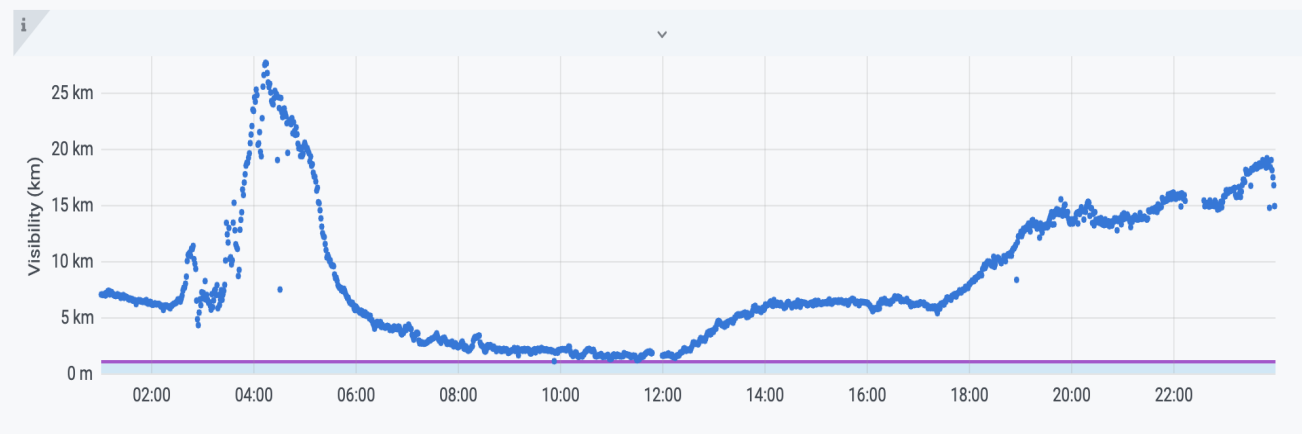

Figure 10: Image showing one day measurements of visibility from the CS125 Present Weather and Visibility Sensor on the MetTrailer located at the Delene's residents. Measurements are provided

from 1:00 to 23:59 UTC, on 20 July 2021.

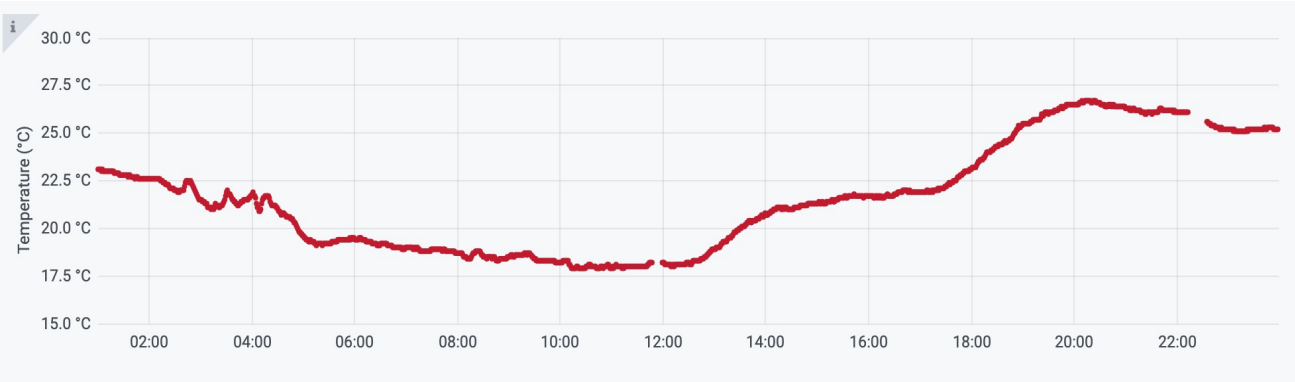

Figure 11: Image showing one day measurements of temperature from the CS125 Present Weather and Visibility Sensor on the MetTrailer located at the Delene's residents. Measurements are provided from 01:00 to 23:59 UTC, on 20 July 2021.

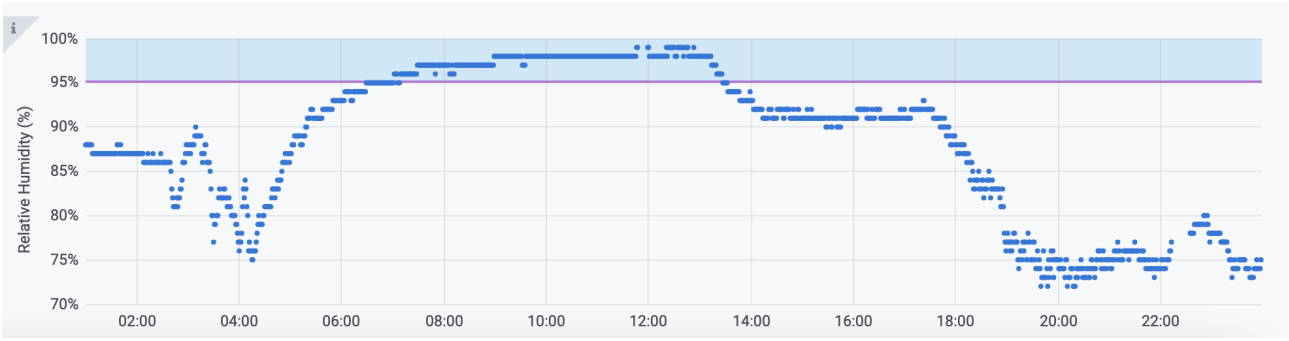

Figure 12: Image showing one day measurements of relative humidity from the CS125 Present Weather and Visibility Sensor on the MetTrailer located at the Delene's residents. Measurements are provided from 01:00 to 23:59 UTC, on 20 July 2021.

The images obtained from Deeplens camera from 10:34 UTC to 13:04 UTC showing a fog layer above the field (Figure 13). This fog layer is what the CS125 Present Weather and Visibility Sensor detected with the low visibility of 1-5km.

Figure13: Set of three images from the Deeplens camera on the MetTrailer located at the Delene's residents. Images are at 10:34, 12:04 and 13:04 UTC.

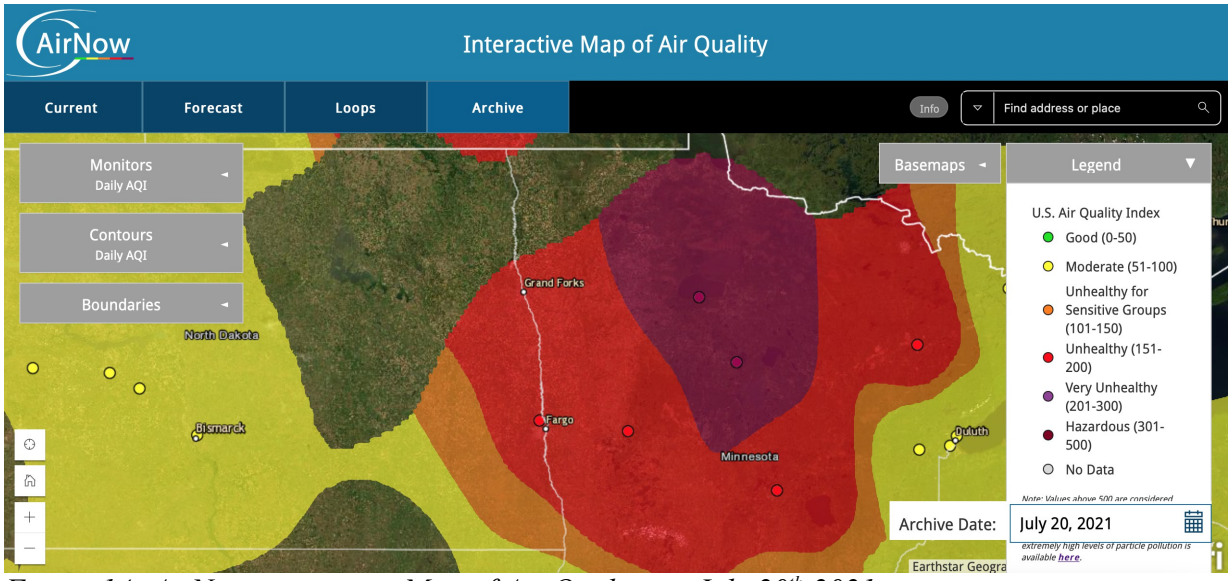

Figure 14 :AirNow interactive Map of Air Quality on July 20th 2021 (source:https://gispub.epa.gov/airnow)

According to the AirNow Interactive map of air quality, July 20th, 2021 had a rating of "Unhealthy" (air quality index reaches between 151-200) over Grand Forks area which was caused due to elevated PM concentrations.

Conclusion:

The relationship between $PM_{2.5}$ concentration and visibility is not always linear but depends on the relative humidity (RH) which is associated with particle hygroscopic growth. For example, by taking in moisture under high RH conditions, the particle size of water-soluble $PM_{2.5}$ can increase, leading to an increased extinction coefficient and reduced visibility. However, the quantitative relationship between $PM_{2.5}$ concentration and visibility under various meteorological conditions has not been extensively studied.

These two events present the evidence of the PM role and its interaction with meteorological factors in impairing visibility, which must be considered when diagnosing and forecasting the latter.

Visibility forecast is quite challenging for numerical models due to its complexity of the process involving radiation, turbulence, droplet microphysics, dynamics, aerosol chemistry, and surface conditions. Numerical Weather prediction models consider fog as the most adverse meteorological condition for visibility. However, the prediction of fog itself is still difficult due to its complicated formation and maintenance processes of small spatial and short time scales. The visibility forecast becomes even more difficult if PM concentrations are taken into account. At the moment, most numerical weather prediction models neglect aerosol loading when predicting visibility. Future studies should focus on implementing visibility-aerosol interactions in numerical weather predictions models to enhance the accuracy of visibility forecasting.