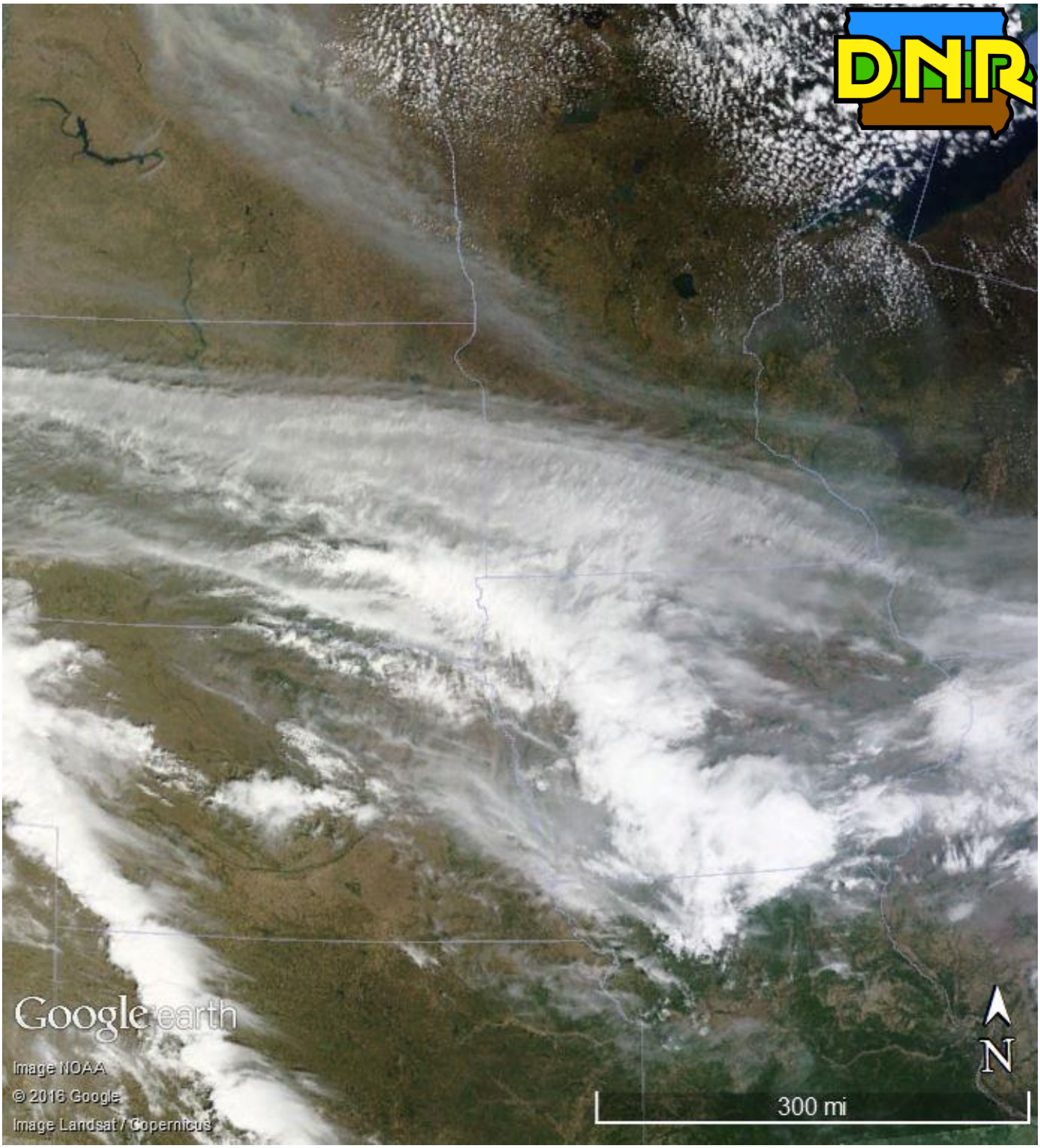
The May 2016 Smoke Event in Iowa

Iowa Department of Natural Resources – Air Quality Bureau



MODIS imagery courtesy of NASA's Earth Observatory from May 7, 2016.

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I. Introduction

On May 7, 2016 smoke from a Canadian wildfire was transported into Iowa. This smoke at the surface dramatically increased $PM_{2.5}$ concentrations for a series of hours across Iowa. Smoke can cause an assortment of health conditions depending on the amount and duration of exposure.

EPA has established health standards to limit ambient levels of seven common air pollutants—carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), airborne lead, pariculate matter with an aerodynamic diameter of 10 microns or less (PM_{10}) and fine pariculate with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$). EPA regularly reviews these National Ambient Air Quality Standards (NAAQS) to incorporate the latest information from public health studies. Monitors that are accurate enough to implement the standards are designated as federal reference method (FRM) or federal equivalent method (FEM) monitors by EPA. Adverse health effects will be experienced by the public whenever pollutant levels exceed the thresholds established in the NAAQS.

Iowa operates a network of FRM $PM_{2.5}$ samplers that is complimented by a network of continuous beta-attenuation monitors (BAMs). Iowa's BAMs were not configured to exact FEM specifications in 2016, but they are accurate enough for hourly reporting of the Air Quality Index (AQI). While 24-hour average concentrations on the BAMs that are greater than or equal to 35.5 $\mu g/m^3$ signfiy that the AQI has degraded to the point where sensitive groups can be negatively affected, it does not necessarily directly correlate to an exceedance on the FRM samplers[1]. Iowa also operates three CO monitors in the cities of Cedar Rapids, Des Moines and Davenport (Figure 1a-c). These monitors sampled a prolonged wildfire smoke episode over Iowa in late-June and early July.

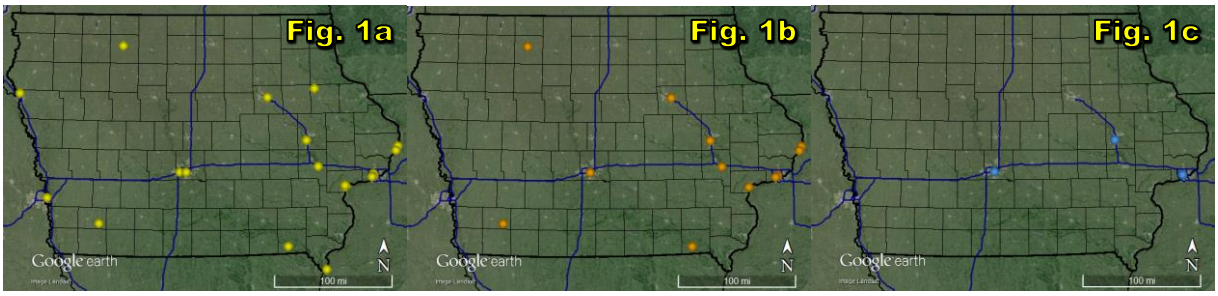

Figure 1a-c. Maps depicting the location of FRM samplers (1a), BAMs (1b) and CO (1c) monitoring sites.

II. Wildfire Smoke and Health Effects

Smoke generated from wildfires is comprised of a complex assortment of carbon dioxide, water vapor, carbon monoxide, particulates, hydrocarbons, nitrogen oxides, trace minerals and other organic compounds. The exact composition of the smoke depends on the type of material being burned and local meteorogical conditions.

Smoke is lofted high into the air by the heat produced. It can then be transported by winds to different locations. Depending on the current weather conditions, the smoke will cool and may rapidly descend or remain aloft. If it descends and reaches the surface, air quality will be negatively impacted even though it has dispersed as it traveled from its source.

[1] A comparison of various BAMs and their collocated FRM samplers can be found at http://www.shl.uiowa.edu/env/ambient/bamfrm.xml

Transported smoke particles are typically very small and reside completely within the categorization of $PM_{2.5}$ and comprise much of the health concerns. Gaseous pollutants like CO tend to only pose concerns for those close to the fires. However, some elevated levels of CO may be observed at long distances from the fire. People can inhale these particles deeply into their respiratory systems. Effects of inhaling the smoke include respiratory tract irritation, reduced lung function, bronchitis, asthma attacks, persistent coughing, wheezing, dificulty breathing and premature death.

While the negative effects of the smoke is of greatest concern to small children, the elderly and those with pre-existing respiratory conditions, $PM_{2.5}$ in smoke can affect healthy people as well. Effects from the $PM_{2.5}$ in smoke can cause transient reductions in lung function, pulmonary inflammation, negative effects on the body's immune system and negatively affect the body's physiological processes to remove foreign material from the lungs such as pollen and bacteria. In addition to respiratory problems, smoke can also cause eye irritation.

The effects of wildfire smoke tend to fall within short-term exposure conditions and are unlikely to greatly increase the risk to chronic health conditions or cancer. Most healthy adults and children will recover quickly, but sensitive populations may see effects from wildfire smoke exposure that include more severe symptoms that persist longer. [2,3,4]

III. Meteorological Synopsis and Background

A strong El Niño was developing in 2015[5] and persisted through the winter of 2015-2016. This lead to relatively dry conditions and much warmer temperatures for Alberta and Saskatchewan. The warmer temperatures and lack of precipitation created an environment prone to fire development.[6, 7]

In early May, warm temperatures were experienced concurrent with the start of a fire near Fort McMurray in Alberta, Canada on May 1, 2016. Strong winds and dry weather allowed the fire to grow rapidly. It consumed 98.4 – 131.2 feet of forest per minute at its peak.

The Fort McMurray wildfire burned out of control (Figure 2) until roughly July 5, 2016 and charred nearly 590,000 hectares of forest lands, more than 2,400 structures and forced a mass evacuation of the 80,000 residents in Fort McMurray on May 3, 2016.[8]

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[2] How Smoke from Fires Can Affect Your Health. http://www.airnow.gov/index.cfm?action=smoke.index

[3] Wildfire Smoke; A Guide for Public Health Officials. http://www.arb.ca.gov/carpa/toolkit/data-to-mes/wildfire-smoke-guide.pdf

[4] Fires and Your Health. http://airnow.gov/index.cfm?action=topics.smoke_events

[5] NOAA - Strong El Niño sets the stage for 2015-2016 winter weather. http://www.noaanews.noaa.gov/stories2015/101515-noaa-strong-el-nino-sets-the-stage-for-2015-2016-winter-weather.html

[6] 'Perfect storm' of El Niño and warming boosted Alberta fires. http://www.bbc.com/news/science-environment-36212145

[7] El Nino Added to Alberta's Fire Woes Before Fort McMurray Burned. https://www.bloomberg.com/news/articles/2016-05-05/el-nino-added-to-alberta-s-fire-woes-before-fort-mcmurray-burned

[8] Fort McMurray wildfire now considered under control. http://www.cbc.ca/news/canada/edmonton/fort-mcmurray-wildfire-now-considered-under-control-1.3664947

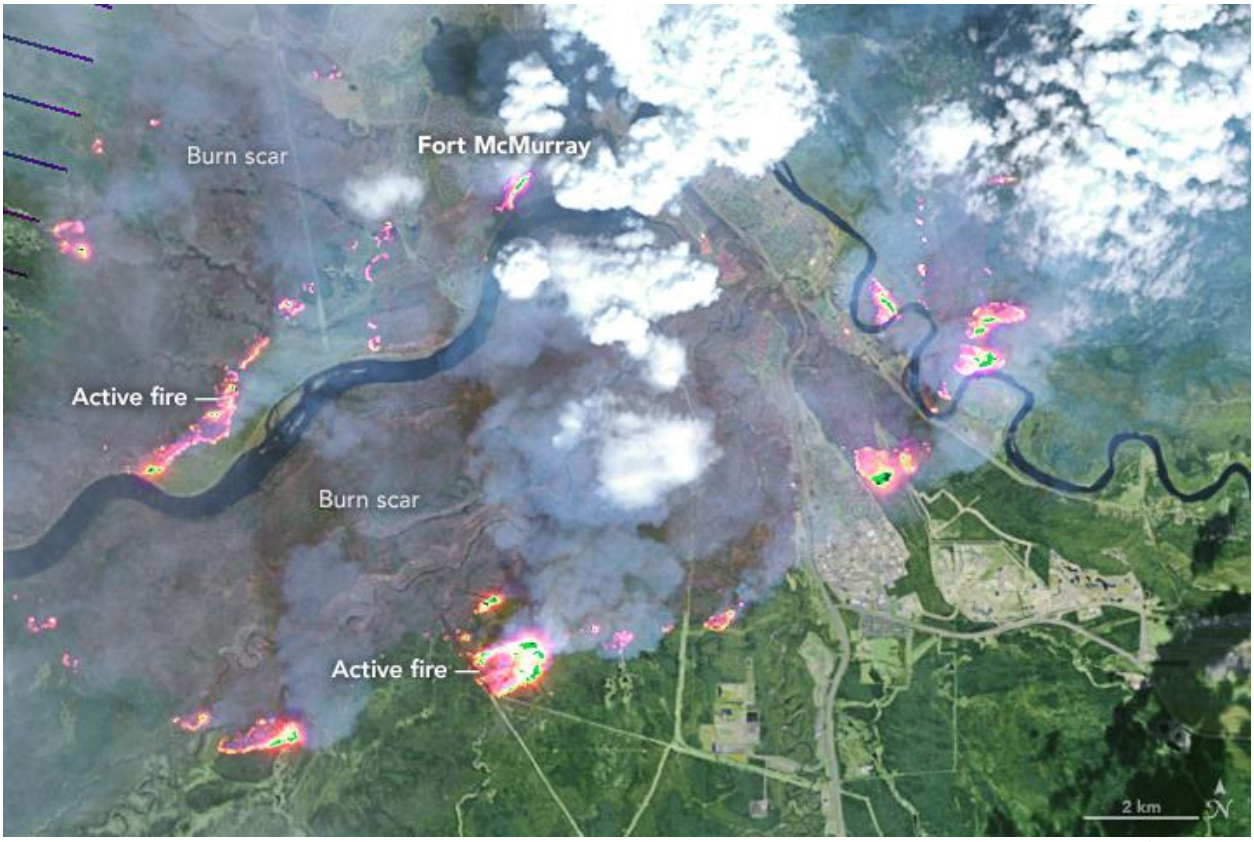


Figure 2. Satellite image of the Fort McMurray fire taken on May 4, 2016 from the Landsat 7 satellite.[9]

Smoke from the Fort McMurray fire and other fires in southeastern Saskatchewan and southwestern Manitoba first appeared over the upper Midwest on May 3, 2016 and persisted mainly higher in the atmosphere. As a cold front approached and traversed Iowa on May 7, 2016[10] (Figure 3), the trailing northwesterly winds at the surface and aloft pushed the higher surface smoke concentrations into Iowa. This caused $PM_{2.5}$ concentrations to rise to nearly three to six times the current 24-hour NAAQS for $PM_{2.5}$ (35 µg/m^3) for several hours.

IV. Typical Iowa $PM_{2.5}$ and CO Values for June-July

$PM_{2.5}$ concentrations in Iowa have typically been lower in the summer months with no monitored exceedances of the 24-Hour NAAQS with the exception of smoke plumes from fireworks displays.

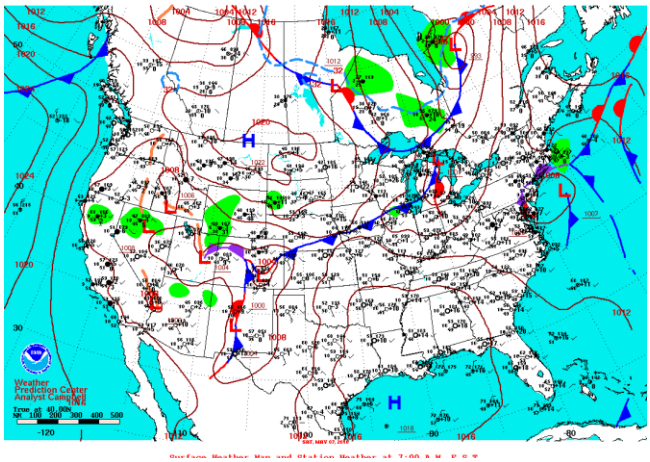


Figure 3. Daily Weather Map plot for the US on May 7, 2016 at 7 am EST.

[9] Wildfire Spreads in Fort McMurray. https://earthobservatory.nasa.gov/NaturalHazards/view.php?id=87988
[10] Daily Weather Maps: http://www.wpc.ncep.noaa.gov/dailywxmap/index_20160507.html

Typical CO concentrations in Iowa also tend to be very low. CO has two NAAQS. The one-hour limit is 35,000 ppb, and the eight hour average limit is 9,000 ppb, and the maximum one-hour concentration for monitoring sites in Cedar Rapids, Des Moines and Davenport was 970 ppb with an overall average concentration for each site ranging from 200-235 ppb (Table 1).

Site Name	Maximum 1-Hour Concentration (ppb)	Average Concentration (ppb)
Cedar Rapids, Public Health	970.0	235.0
Des Moines, Health Dept.	820.0	211.4
Davenport, Jefferson School.	683.4	200.7

Table 1. CO concentrations for various Iowa sites for the time period of May 2016 (omitting the window between May 7-8).

V. Elevated $PM_{2.5}$ and CO Levels From Canadian Wildfire Smoke

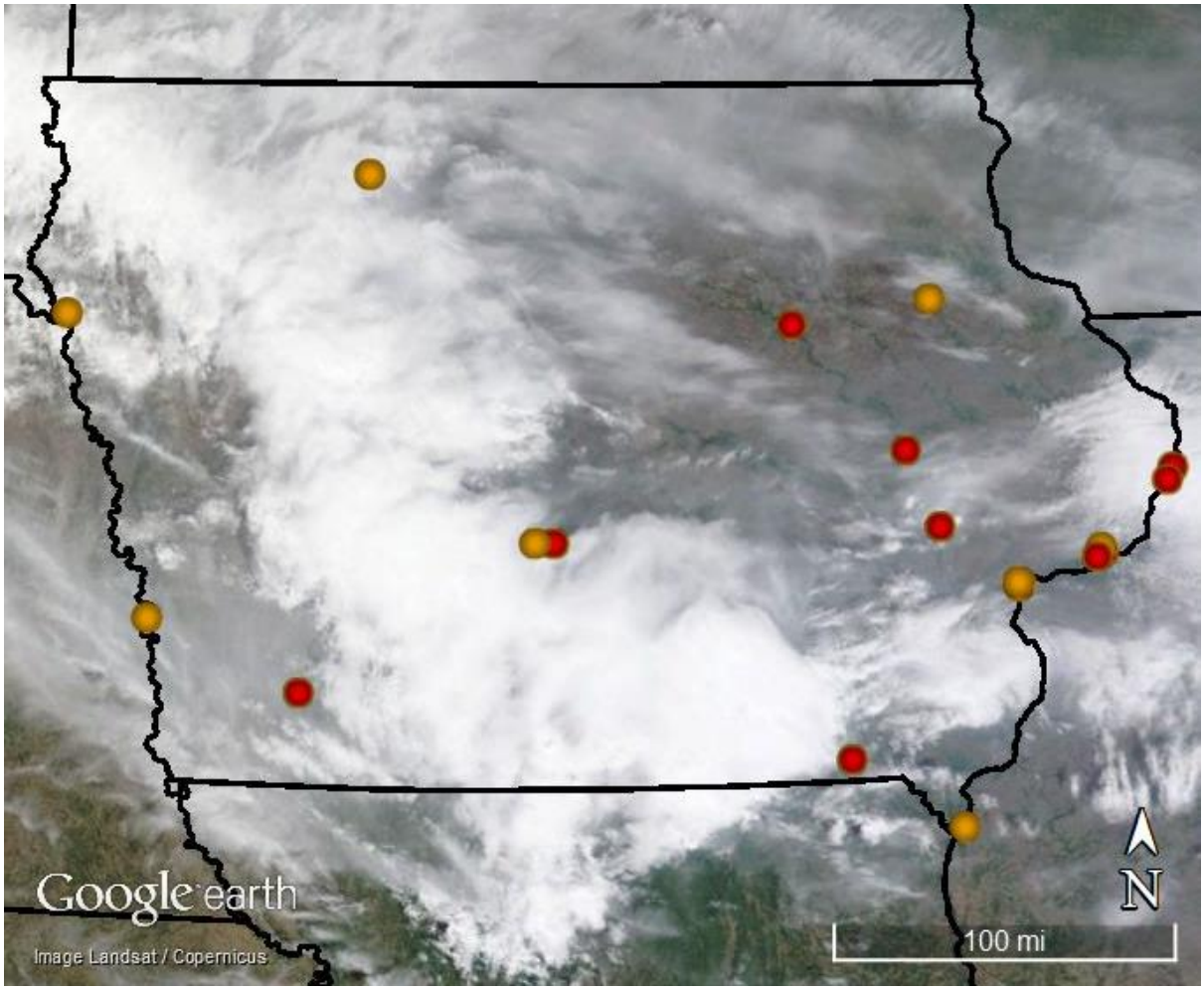
The dense smoke plume arrived in Iowa on May 7, 2016 from the northwest. It then spread across the state affecting monitors in northwestern Iowa first. Both BAMs and FRM samplers recorded exceedances of the 24-hour $PM_{2.5}$ NAAQS on May 7, 2016 (Table 2). No exceedances of the one-hour or eight hour CO NAAQS were recorded on any day during the smoke's intrusion into Iowa. However, elevated levels of CO were observed that coincided with the rise in $PM_{2.5}$ concentrations.

Site Name	May 7, 2016	
	FRM ($\mu g/m^3$)	BAM ($\mu g/m^3$)
Waterloo, Water Tower	-	38.3
Clinton, Chancy Park	15.5	17.8
Clinton, Rainbow Park	14.1	16.2
Iowa City, Hoover School	32	31.1
Cedar Rapids, Public Health	35.6	37.6
Viking Lake State Park	-	40
Muscatine, High School E. Campus	30.6	30
Emmetsburg, Iowa Lakes CC	-	60.8
Des Moines, Heath Dept.	43	47.2
Davenport, Jefferson School	18.5	16.6
Davenport, Hayes School	17.5	17.7
Lake Sugema	-	47.1

Table 2. Daily concentrations for $PM_{2.5}$ monitors in Iowa on May 7, 2016.

Figure 4 shows the progression of the smoke through Iowa along with relative locations of FRM (orange dots) and BAM (red dots) $PM_{2.5}$ monitoring sites on May 7, 2016 via a MODIS image that is overlayed in Google Earth. Many of these sites have collocated FRM and BAMs.

Generally the dense smoke appears as a gray color over the green surface. It is important to remember that even though the smoke may appear dense on the satellite image, the surface $PM_{2.5}$ readings may not be elevated due to the smoke being trapped at an elevated altitude over a monitoring site. The satellite images convey how much smoke is present in a column of air over a point on the surface. Meteorological conditions also affect the ability to depict smoke from satellite images. Much of the smoke is obscured by clouds. Figure 5 shows the network average hourly concentration from BAM sites on May 7, 2016.



Figures 4. Daily MODIS smoke imagerly displayed in Google Earth with $PM_{2.5}$ monitoring locations. Orange dots correspond to FRM sites. Red dots correspond to BAM sites. Some smoke is obscured by clouds.

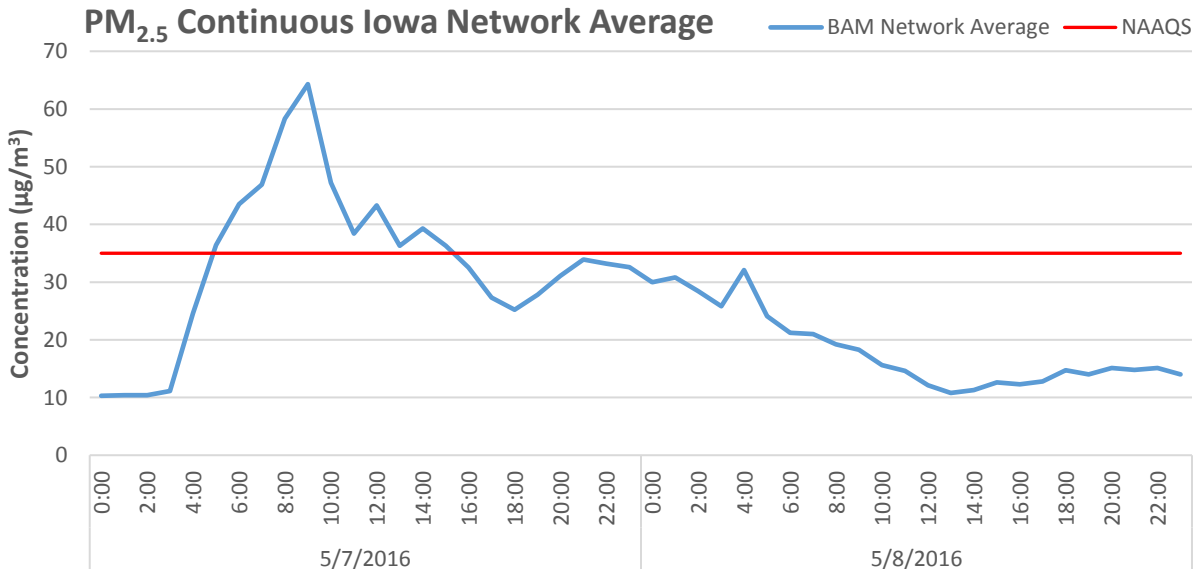


Figure 5. Hourly network average $PM_{2.5}$ concentrations recorded by BAM sites in Iowa.

Maps of the exceedances recorded by the $PM_{2.5}$ monitoring networks in Iowa are show in Figures 6 and Figure 7. The maps with BAM concentration (Figures 10) show the thick surface smoke's southeasterly progression through Iowa with exceedances recorded in the northwestern and southwestern portions of the state. The FRM map (Figure 11) has does not have concentrations for all locations. This is a result of the sampling schedules (one sample every three days) associated with each site.

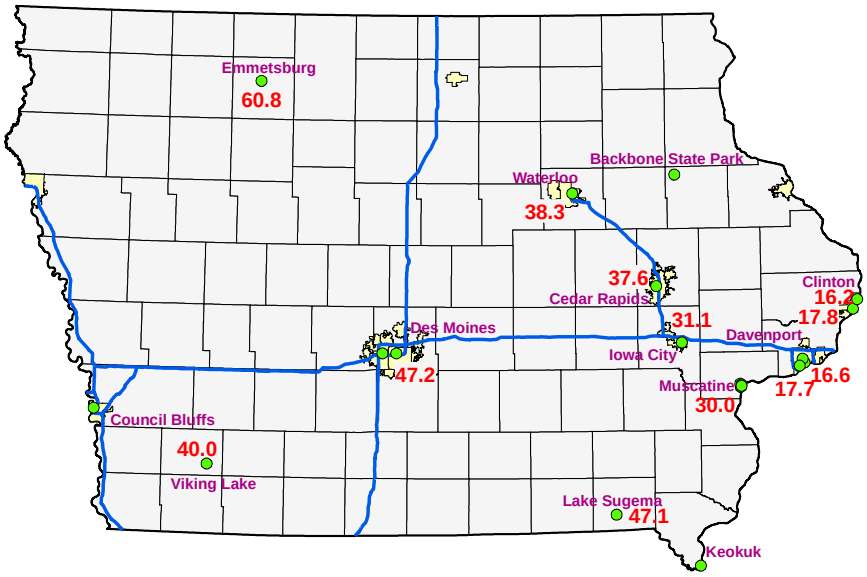


Figure 6. BAM 24-hour average $PM_{2.5}$ concentrations on May 7, 2016.

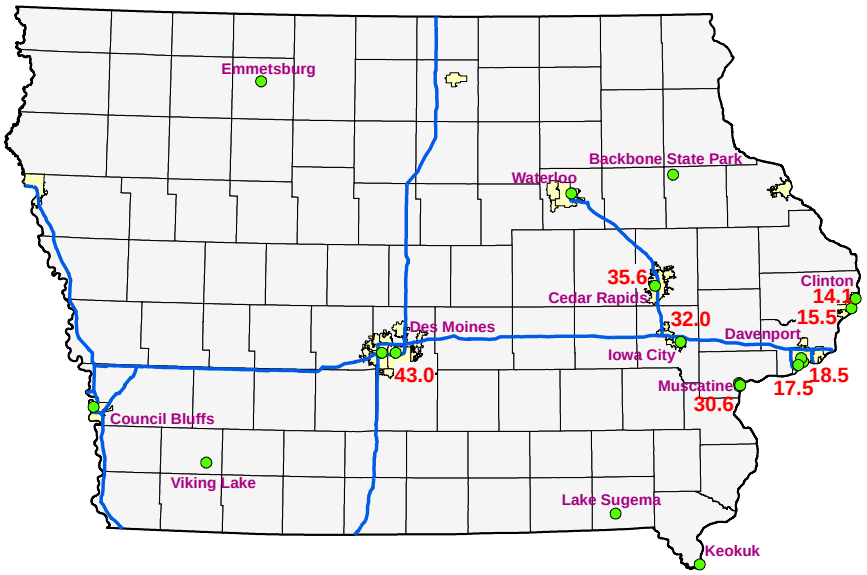


Figure 7. $PM_{2.5}$ concentrations measured by the FRM samplers on May 7, 2016. Not all sites have concentrations. This is typically due to the sampling schedule (e.g. blank sites take a sample once every three days).

While no exceedances of any of the CO NAAQS were observed during the smoke's presence in Iowa, elevated levels of CO were detected by the analyzers in Cedar Rapids, Davenport and Des Moines. Maximum one-hour concentrations while the wildfire smoke was in Iowa were 970 ppb, 683 ppb and 820 ppb respectively. The elevated CO concentrations (one-hour network average) also tracked with

the hourly $PM_{2.5}$ concentrations reported by BAMs (Figure 8a-8c). In the figure spikes are noted in both $PM_{2.5}$ and CO that coincide with the arrival of the smoke.

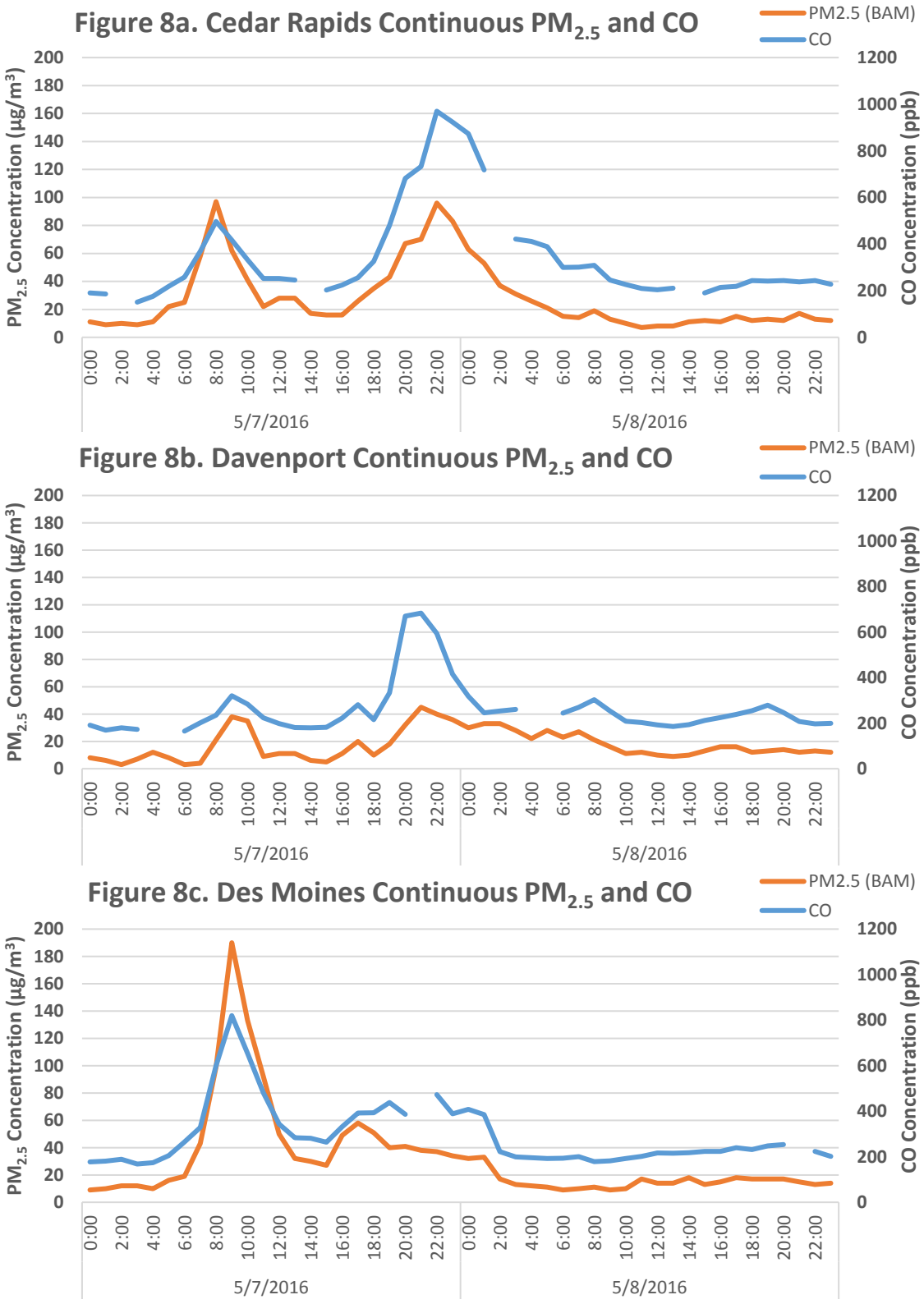


Figure 8a-8c. Hourly network average of continuous $PM_{2.5}$ and CO. Spikes in both data are noted with the arrival of the wildfire smoke (May 7th).

VI. Conclusions

Thick smoke from wildfires in Fort McMurray and other areas of Canadian provinces and territories was carried south into Iowa on May 7, 2016. This negatively affected the air quality in Iowa as the smoke passed. Exceedances of the 24-Hour $PM_{2.5}$ NAAQS were noted at several sites across Iowa during this period. It is important to note that a daily exceedance does not constitute a violation of the 24-Hour $PM_{2.5}$ NAAQS.

VII. References

Fires and Your Health. *http://airnow.gov/index.cfm?action=topics.smoke_events*

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