Exceptional Events Waiver Request

For Exceptional $PM_{2.5}$ Events between July 6 and August 8, 2009 at the State Office Building in Fairbanks, Alaska

Air Quality Division

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Introduction

Fairbanks is the second largest city in Alaska. It lies in the Fairbank North Star Borough, which covers an area of 7,361 square miles and has a population of 99,200[1]. Fairbanks is situated on the banks of the Chena River in the upper Tanana Valley in the interior region of the state. North of the city are low hills that border the Tanana Valley (Figure 1). Interior Alaska experiences average winter temperatures ranging between -2°F and -19°F and average summer temperatures between 53°F and 72°F. Temperatures have been recorded as low as -78°F in mid-winter, and as high as 93°F in summer. Average annual precipitation is 11.3 inches and ice fog is common during the winter. Fairbanks experiences 21 hours of direct sunlight between May 10 and August 2 each summer, and less than four hours of direct sunlight between November 18 and January 24 each winter.

In December of 2009, the Environmental Protection Agency (EPA) designated 244 square miles (3.3%) and with an estimated population of over 85,000 (Figure 2) residents (88%) of the FNSB as a $PM_{2.5}$ non-attainment area. The non-attainment area encompasses the cities of Fairbanks and North Pole. During the summer months (May through September), the main source of elevated $PM_{2.5}$ concentrations is smoke from wildland fires. During the winter months (October through March), local home heating emissions are the dominant $PM_{2.5}$ source[2], to a much greater extent than industrial or mobile source emissions.

During the summer of 2009, specifically on nine days in July and August 2009, the fine particulate monitor located in downtown Fairbanks recorded elevated concentrations impacted by wildland fire smoke in the interior of Alaska. ADEC has prepared this document as part of its Exceptional Events Waiver Request (EEWR) to exclude these nine days of air quality data in July and August of 2009 from regulatory decisions pursuant to section 319(b)(3)(B) of the Clean Air Act.

The air quality sampler located at the State Office Building (SOB) site, AQS ID 02-090-0010-88101, in downtown Fairbanks recorded elevated $PM_{2.5}$ concentrations that were caused by smoke originating from wildland fires in Interior Alaska. Because there were multiple fires and because it is not possible to separate the impacts from individual fire events, ADEC combined the documentation for all nine days into one EEWR.

[1] http://www.co.fairbanks.ak.us/
[2] http://dec.alaska.gov/air/anpms/comm/fbks1_pm.htm

Figure 1: Map of Alaska and inset showing Tanana Valley, Fairbanks and North Pole

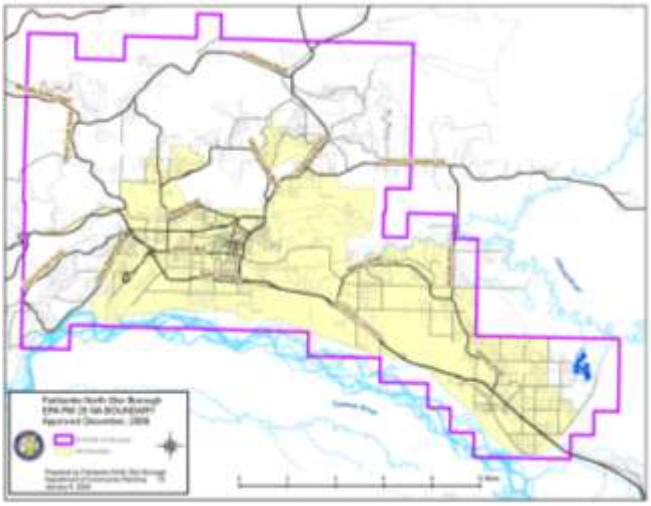


Figure 2: Map of PM2.5 non-attainment area in Fairbanks North Star Borough
Purple lines indicate boundary

This EEWR follows the steps outlined in the Exceptional Events Rule and includes:

- a brief description of the event,
- evidence supporting the natural origin of the events,
- evidence that the events could not have been reasonably controlled or prevented,
- data showing that the event affected air quality,
- data showing that the $PM_{2.5}$ concentrations exceeded historical fluctuations,
- evidence supporting a clear, causal relationship between the events and air quality impacts, and
- evidence that there would not have been an exceedance(s) but for the events.

Description of the Event

The event began in early July 2009 and lasted through early August 2009. Samples collected by FNSB staff from the Federal reference Method (FRM) monitor every three days according to EPA's national monitoring schedule document the impacts to the area caused by the event. The FRM at the State Office Building (SOB) site in downtown Fairbanks collected samples that had elevated $PM_{2.5}$ concentrations on nine of twelve sample days beginning July 6, 2009 and ending August 8, 2009. Table 1 lists the nine dates and the $PM_{2.5}$ concentrations from those dates.

Table 1: 24-hour $PM_{2.5}$ concentrations in µg/m3 at the Fairbanks SOB site

Date	$PM_{2.5}$ concentration
07/06/2009	**44.1**
07/09/2009	19.3
07/15/2009	**75.3**
07/24/2009	17.7
07/27/2009	25.6
07/30/2009	**159.5***
08/02/2009	**89.7**
08/05/2009	**127.7****
08/08/2009	**61.0**
Exceedances indicated in bold font. * and ** denote sampling times of 16.75 hours and 19 hours respectively. Sampling stopped on because filters were clogged by excessive particulate loading and the instrument shut down. The daily concentrations were calculated using the sampling time only.	

While not all nine 24-hour concentrations exceeded the 24-hour of National Ambient Air Quality Standard (NAAQS), all were at least twice as high as levels typical of times with no wildland fire smoke. During low-wildfire summer months in the Fairbanks area, maximum 24 hour average $PM_{2.5}$ concentrations range between 3 and 6µg/m^3. ADEC flagged all concentrations above 15µg/m^3 during this period. Some of the fires impacting the interior of the state ignited at the beginning of the two-month period and continued to burn throughout the entire period. Because smoke from multiple fires caused the elevated $PM_{2.5}$ concentrations, ADEC decided to treat all the days listed in Table 1 as one event. Daily $PM_{2.5}$ concentrations varied with meteorological conditions and fire growth or suppression. Wind direction was the most important component but wind speed, precipitation, type of fuel, and the number and sizes of newly started fires also contributed to the variability. Although the $PM_{2.5}$ concentrations varied, the cause of the elevated $PM_{2.5}$ levels throughout the entire period was wildland fire smoke.

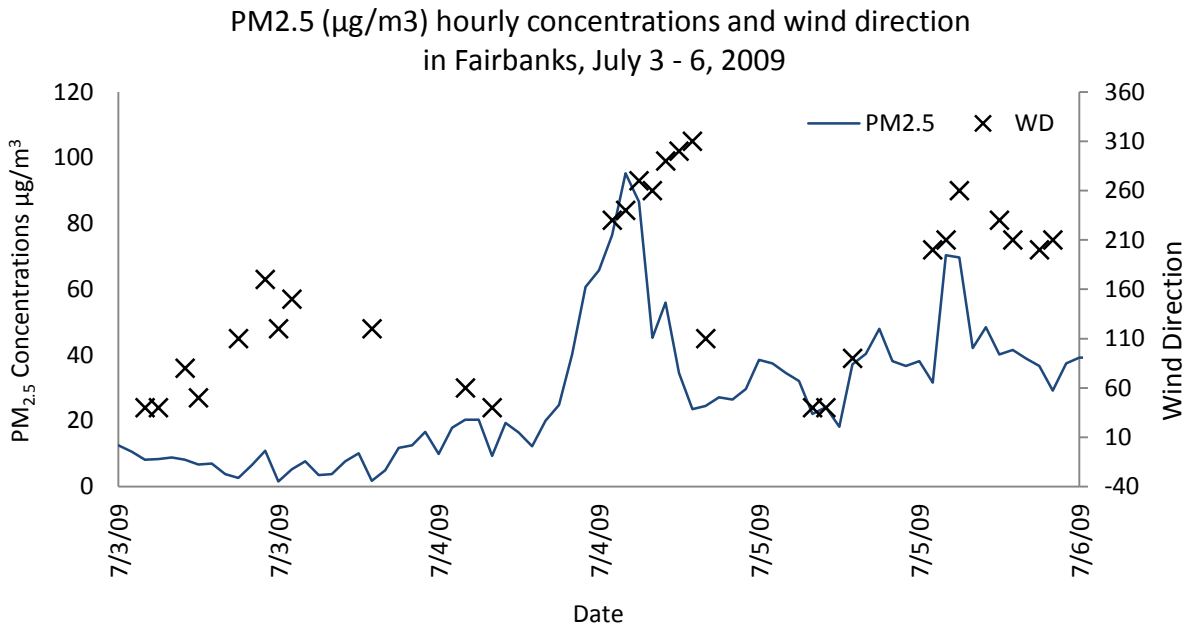


Figure 3: $PM_{2.5}$ hourly concentrations and wind direction in Fairbanks, July 3 - 6, 2009

Figure 3 shows hourly $PM_{2.5}$ concentrations measured by a Met One BAM 1020 sampler and wind direction for the beginning of the event (July 3, 2009 through July 7, 2009). Additionally, MODIS imagery (Figure 4, Figure 5 and Figure 6) and the HYSPLIT model smoke forecast (Figure 7) shows smoke covering large areas of the state. (MODIS imagery and HYSPLIT web links can be found in the reference section). During the summer wildland fire season in 2009, the Fairbanks North Star Borough operated two separate technologies to measure $PM_{2.5}$ concentrations at the SOB, the Federal Reference Method (FRM) Thermo Electron Partisol 2000 and a semi continuous Met One BAM 1020. The concentrations displayed in Figure 3 are hourly concentrations measured with a Met One BAM 1020. The instrument did not meet the EPA's Federal Equivalent Method criteria, so the data cannot be used for regulatory actions. ADEC and the Fairbanks North Star Borough staff mainly use the BAM 1020 data for issuing air quality advisories. For this analysis, the data from the BAM 1020 are only used for a qualitative discussion of the event and are considered supporting documentation. The FRM sampler collects a 24-hour integrated averaged, while the semi continuous BAM 1020 records hourly averages. The hourly data were correlated to the FRM data for coincident 24 consecutive hours i.e., midnight to midnight local standard time for days when the FRM was operated. During the summer months both instruments showed an excellent correlation, with a correlation coefficient r^2 of 98.6(Appendix C).

At the onset of the event (July 3, 2009, 0200 Alaska Standard Time (AST)) to July 4, 2009, 11:00 AST) the winds came from the east, slowly changed to the southeast, then to the south, back to the southeast, to east, and then calm. Since the primary fire on this date burned to the southwest of Fairbanks, these winds did not bring any significant smoke into the area. On July 4,

2009, 11:00 AST, the wind direction switched to the southwest and the speed increased from 3 mph to 16 mph. This brought dense smoke from the fire over the Fairbanks area as indicated by the spike in $PM_{2.5}$ concentrations.

MODIS imagery also clearly shows the onset of the event. Figure 4, MODIS imagery from July 3, 2009, shows an uncontrolled fire southwest of Fairbanks. This fire and others became part of the Railbelt Complex Fire, which encompassed 631,194 acres by the end of the summer. The wind flow is from the northeast toward the southwest – away from Fairbanks, as can be seen by the plume from the fire in the lower left hand corner of Figure 4. Figure 5, MODIS imagery from July 4, 2009, shows that the fire had increased in size and that the wind had shifted from the southwest to northeast, blowing the smoke towards Fairbanks, again evident in the extent and direction of the plume. At this time, the $PM_{2.5}$ concentrations began to increase (Table 1, Figure 3 and Appendix C). Figure 6, MODIS satellite imagery from July 5, 2009, and Figure 7, the HYSPLIT smoke forecast, both show dense smoke over Fairbanks. On July 6, 2009, the first FRM sampling date during the event, the $PM_{2.5}$ concentration was 44.1µg/m^3. Between July 9 and 11 the winds were westerly (Appendix D) and continued to be favorable for smoke advection into Fairbanks.

Figure 4: MODIS image 7/3/09 12:11 PM AST

Figure 5: MODIS image 7/4/09 12:54 PM AST

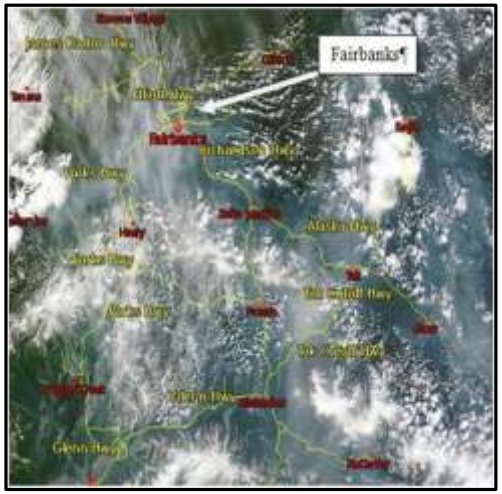


Figure 6: MODIS image 7/5/09 12:59 PM A

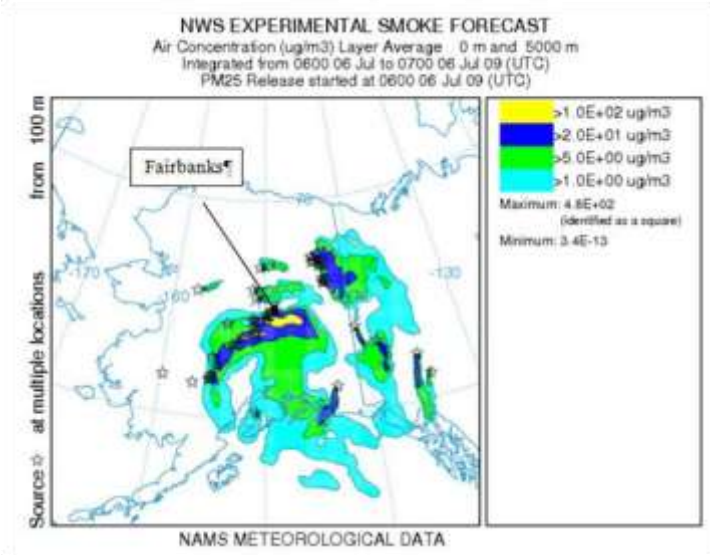


Figure 7: HYSPLIT model smoke forecast 7/6/09 9:00 PM AST

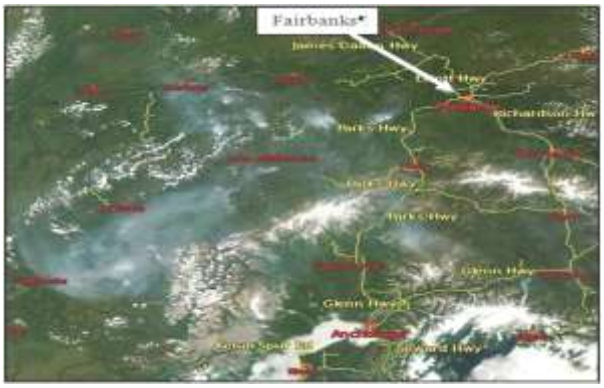


Figure 8:MODIS image 7/12/09 1:15 PM AST

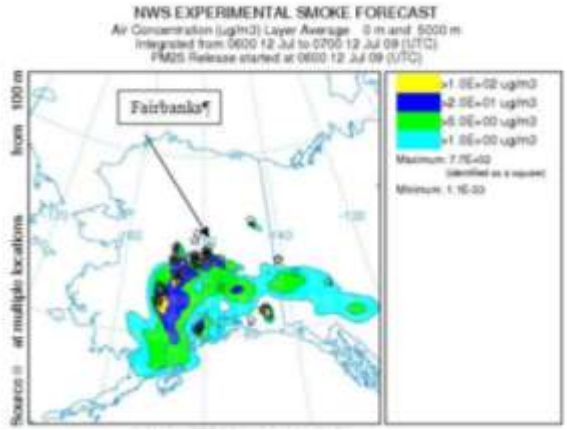


Figure 9: HYSPLIT model smoke forecast 7/12/09 9:00 PM AST

On the evening of July 11, 2009, a wind shift to the east moved the smoke away from the Fairbanks area. The MODIS imagery and the HYSPLIT smoke forecast for July 12, 2009 (Figure 8, Figure 9) show that, although fires continued to burn to the southwest of Fairbanks, the smoke had moved away from the area. The 24-hour FRM sampler data in Appendix C1 show that the $PM_{2.5}$ concentration dropped to 8.4µg/m^{3}on July 12, 2009.

The highest concentrations recorded in 2009 occurred later in the five week time period of the event as smoke built up in the area. By midsummer, fires surrounded Fairbanks and filled the air with fine particulate matter from smoke regardless of the wind direction. For example, the July 30, 2009 MODIS imagery and HYSPLIT smoke forecast (Figure 10, Figure 11) show that, not only had the smoke has moved back over the Fairbanks area but has increased in area and density due to the long period of time the fires have been burning. There are also more and larger fires burning. 24 hour $PM_{2.5}$ concentrations on July 30, 2009 increased to 159.5µg/m^3. ADEC detail the event with a discussion of the fire extend, daily meteorology, smoke impact and $PM_{2.5}$ concentrations for almost every day of the five week event in Section F.

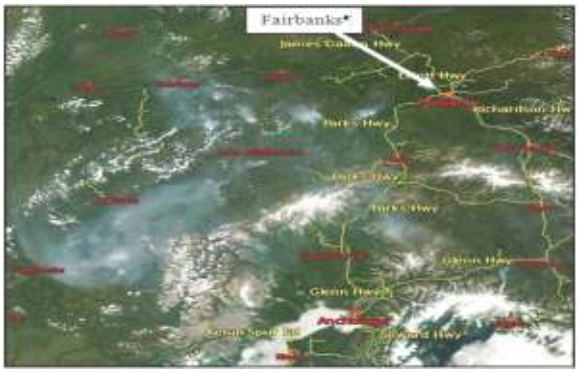


Figure 10: MODIS image 7/30/09 12:53 PM AST

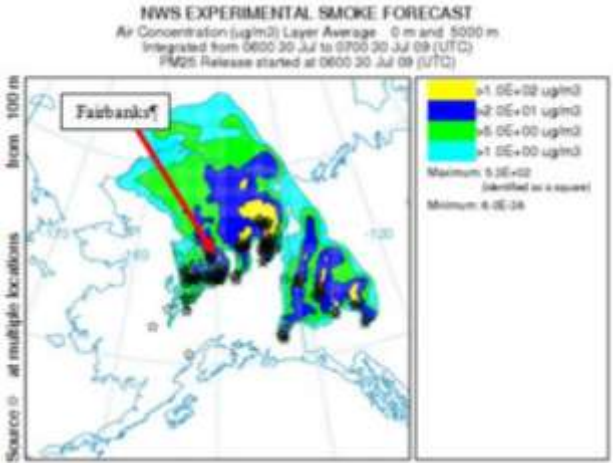


Figure 11: HYSPLIT model smoke forecast 7/30/09 9:00 PM AST

Summer 2009 Weather Summary

In April, the climate indices showed a La Nina pattern, which means cooler than normal sea surface temperatures in the Eastern Pacific along the equator. This weather pattern has most frequently been associated with weaker than normal fire seasons in Alaska. Early spring forecasts showed the weak La Nina pattern persisting through the summer. In fact, the La Nina pattern transitioned rapidly in early summer to an El Nino, with warmer sea temperatures. It is likely that the feedback from these changes led to the difference in Alaska's fire weather. Initially, the weather in Interior Alaska for the summer of 2009 started off highly variable and not supportive of much extensive fire activity, but culminated with one long period of hot, dry weather in July that was extremely conducive to widespread fires. An extremely dry July in the Interior and Southeast Alaska was not forecast; however this dry weather was the major factor in a busy 2009 fire season.

July 2009 was one of the driest July's in the history of Fairbanks (since record keeping). The dry meteorological conditions favored explosive fire development for any fires already burning or that would be started during the summer. These conditions led to a total of 527 fires across the state that burned 2,951,592 acres. Figure 11 shows a map of the Interior with the location and extent of the fires marked by green areas. Blue dots indicate temporary flight restriction areas. Some of the largest fires were located near Fairbanks (Figure 12). (Alaska Fire Season 2009, Wildland Fire Summary and Statistics Annual Report – AICC)

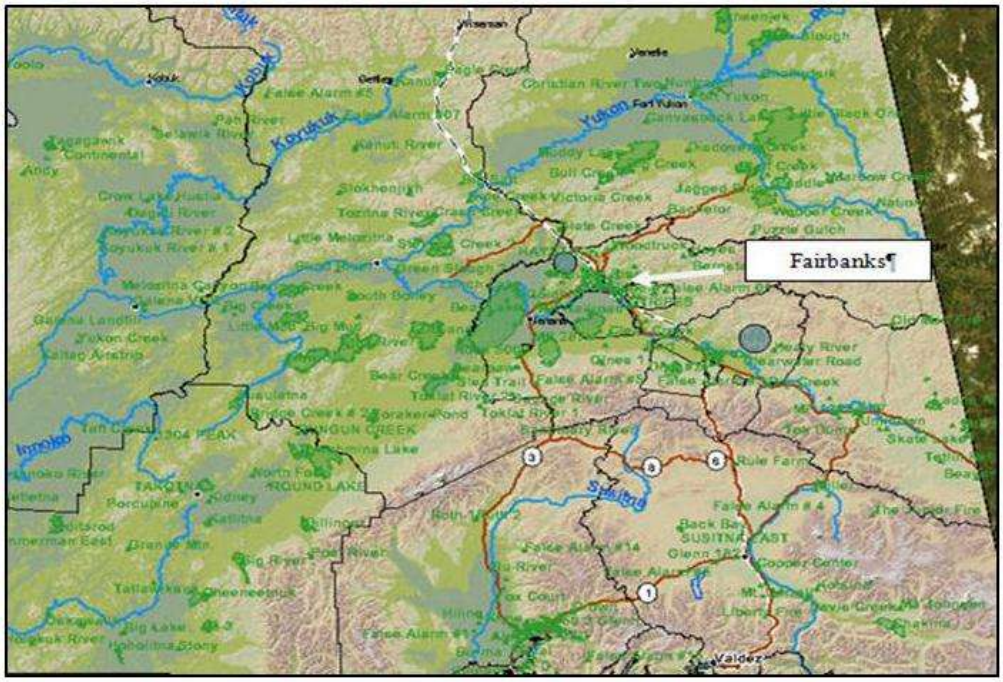


Figure 12: End of the season map of fires in a large part of Alaska[3]

[3] http://afsmaps.blm.gov/imf_firehistory/imf.jsp?site=firehistory

The Event was Natural

Wildfires are a common occurrence in Alaska where, on average, 932,823 acres burn annually. More than 90% of the area consumed lies in Interior Alaska, where the summers are relatively warm and dry and where wildfires ignited by lightning periodically burn the spruce, birch, and cottonwood dominated forests. Summers with above normal temperatures generate more convection, resulting in more thunderstorm development and more lightning strikes[4].

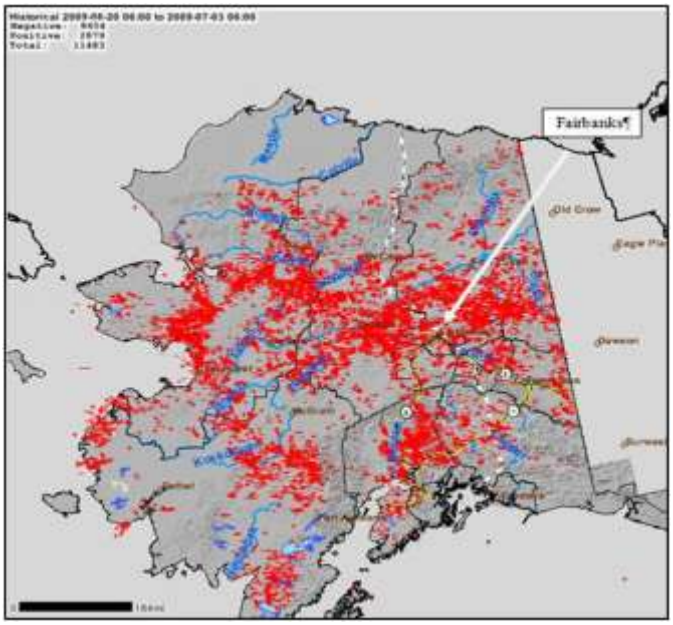


Figure 13: Lightning strikes in Alaska from 6/20/09 to 7/3/09[5]

The Alaska Fire Service determines the cause of each fire at the time the fire occurs and Alaska Interagency Coordination Center (AICC) Incident Reports document these findings. Over 8,500 cloud-to-ground strikes were recorded by lightning detection devices in a 13 day period from June 20 to July 3, 2009. Many of these lightning strikes were "dry" lightning strikes, i.e., with no accompanying precipitation. While this number is for the entire state, many of these lightning strikes were in the dry interior of Alaska (Figure 13). In very dry years such as 2009, these fires can burn out of control and become very large fires (AICC Incident Reports, see Appendix E).

Dry conditions necessitated greater restrictions on the prescribed/controlled burns that were permitted and conducted that year. According to the 2009 Alaska Wildfire Emissions Inventory, 2009 had only 172 tons of fuel measured as $PM_{2.5}$ removed by prescribed burns, the least $PM_{2.5}$ tonnage removed of any year since 2005. The tonnage removed by prescribed burns was only 0.01% of the total from wildfires that year. $PM_{2.5}$ tonnage removed is a more useful indicator of fire fuels removed than acreage because many acres of grass burn with a relatively small amount of duff removal. Table 2 lists comparative burn/removal statistics for other years and Table 3 lists multi-year averages of the number and extent of fires.

[4] G.Wendler, et al., Climatology of Alaskan wildfires with special emphasis on the extreme year 2004, Springer-Verlag 2010

[5] http://afsmaps.blm.gov/imf_lightning/imf.jsp?site=lightning

Table 2: Data from 2009 Alaska Wildfire Emissions Inventory

Year	2005	2006	2007	2008	2009
Prescribed Burns (acres)	626	9,110	21,761	4,081	3,740
Prescribed Burns ($PM_{2.5}$ tonnage removed)	231	200	8,230	454	172
Wildfires (acres)	4,663,802	260,142	649,415	103,649	2,951,598
Wildfires ($PM_{2.5}$ tonnage removed)	2,018,884	93,449	261,660	62,876	1,597,149

Some prescribed burns took place in the spring prior to the outbreak of the larger wildland fires. The Wildfire Emissions Inventory (ADEC, 2011) documents that prescribed fire emissions occurred prior to the $PM_{2.5}$ exceedances at Fairbanks.

Table 3: Multi Year Average Fire Information

	1999-2008		2000 - 2009		2009	
	# fires	acres	# fires	acres	# fires	acres
5-year average	512	2,451,813	476	1,724,101		
10-year average	462	1,702,277	467	1,896,894		
annual					527	2,951,592

Unseasonably warm Interior temperatures at the beginning and end of May sandwiched a much cooler stretch of weather. Temperatures reached 80° F in Fairbanks and precipitation was only 0.06 inches, making it the driest May in over 80 years. As June began, Interior conditions cooled and a potentially busy fire season appeared to settle down. The average temperature in Fairbanks was normal for that month, around 60° F. Precipitation was 0.15 inches above the normal 1.40 inches. As is common, late June lightning activity started a series of fires in the Upper Yukon and Tanana areas, most of which burned slowly at first. High pressure developed over eastern Alaska at the beginning of July and kept its grip on much of the state through the first week of August. It is during that five-week period that about 2.5 million acres burned.

The July average high temperature in Fairbanks, 78.6° F, was the highest ever recorded (normal average high is 73.0° F) and broke two daily high temperature records during July. Total rainfall of 0.06 inches made July 2009 the driest summer month ever measured in 105 years of observations in Fairbanks. Some new fires started later in the summer, but the majority of fires had begun in June, and became increasingly active as fuels dried out.

August began hot and dry in the Interior, with a huge ridge based along the west coast of the lower 48 contiguous states holding over the eastern part of Alaska for the first eight days. It gradually released its grip on the weather and some rain began in the Copper River Basin on. August 6, 2009. The rain worked its way north into the Upper Yukon region by August 9, 2009.

In Fairbanks, rainfall exceeded the August average of 1.74 inches by nearly one full inch and the average temperature, 54.5° F, was 1.7 degrees colder than normal.

During the peak of wildland fire activity at the end of July and beginning of August, smoke, at altitudes of more than 10,000 feet, blanketed the northern half of the state as far north as Deadhorse and Barrow, west to Kotzebue and Nome, south to the Alaska Range, and east into Canada. Southern portions of the state also experienced smoke, but generally for shorter periods of time and to a much smaller extent. The first half of September was the warmest on record at Fairbanks International Airport with an average high temperature of 68.9° F; 10.2 degrees above average. The exceptionally dry weather continued through December 2009.

The Event was not Reasonably Controllable or Preventable

The events described above were not reasonably controllable or preventable by the State for several reasons. First, authority over fire protection areas is split into three major jurisdictions (Figure 14, Table 4), so that smoke from fires outside the state's jurisdiction can impact state lands. Second, the events were caused by meteorological conditions (dry weather, high fuel load, lightning strikes) over which the State has no reasonable control.

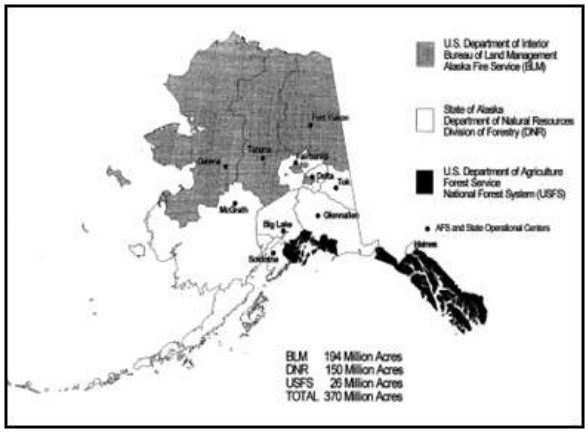


Figure 14: Alaska Wildland Fire Protection Areas

Statewide
Fires and Acres Burned by Protection Agency
and Management Option
2009

Zone		Critical	Full	Modified	Limited	Total
Alaska Fire Service	fires	11	35	15	91	152
	acres	45.4	9,044.1	211,336.9	1,605,149.6	1,826,576.1
State of Alaska	fires	210	54	11	44	330
	acres	1,374.5	41,445.5	1,364.4	1,080,610.6	1,124,995.0
U.S. Forest Service	fires	12	22	5	6	45
	acres	6.5	8.5	0.9	5.9	21.8
Total Fires		23	57	20	97	527
Total Acres Burned		52.9	9,052.7	212,337.8	1,605,155.5	2,952,592.9

Table 4: Fire statistics by protection agency and management option in 2009

The two major natural precursors to an extensive fire season in Alaska are some sort of natural ignition source and dry meteorological conditions. As pointed out the in section above, the large number of cloud-to-ground lightning strikes was the ignition source; and lightning cannot be reasonably controlled or prevented. Neither can the second precursor, dry meteorological conditions, be reasonably controlled or prevented. Interior Alaska experienced a severe drought in 2009. In fact, 2009 was one of the driest years in the history of Alaska. According to the Geophysical Institute, Alaska Climate Research Center of Alaska, "The average daily maximum temperature was the highest and the precipitation amount was the lowest ever recorded for July in Fairbanks."[6]

The AICC Incident Report of July 16, 2009 (Table 5) provides an indication of how extensive the fires were on that date. For a complete list, see AICC Incident Reports in Appendix E. These data demonstrate the vast number and size of the fires that impacted the Fairbanks area in 2009.

[6] http://climate.gi.alaska.edu/AkCityClimo/2009/Jul/Jul_2009.html

Table 5: Extract from AICC Incident Report listing fires that impacted Fairbanks area

Location	Ignition date	Cause	Acres burned 07/16/09	Total Acres burned
Kantishna River	5/23/09	Lightning	5,471.3	31,338
Tonclonukna Creek	5/23/09	Lightning	72,219.0	164,318
Lunch Lake	6/20/09	Lightning	4,515.0	12,802
Minto Flats South	6/21/09	Lightning	173,524.0	517,078
June Creek	July 11	Lightning	164	164
Wood River 1	July 12	Lightning	2,195.0	125,382
Rex Creek	Aug 2	Lightning	n/a	101,150

The very dry conditions, the large number of ignition sources (lightning) and the remoteness of Alaska make it nearly impossible to control these fires. Because of the remoteness and inaccessibility of most areas in Alaska, fire fighting is very expensive and time consuming and fires are often monitored only (NOA, Critical Weather patterns of US, 1999). In fact, many of these fires cannot be controlled or extinguished by human intervention and are only extinguished with the onset of wet weather.

The State, the federal land management agencies, and Alaskan tribes developed an interagency plan, the Alaska Interagency Wildland Fire Management Plan (AIWFMP), to address controlling wildland fires. The AIWFMP requires an annual, pre-season land manager(s)/owner(s) review of the fire protection needs on lands under their management authority. Once fire protection needs are determined, the lands are placed in the Critical, Full, Modified, or Limited management option. Option selections are based on land manager/owner(s) values to be protected as well as land and resource management objectives.

The fire management strategies selected vary from initial attack and sustained suppression efforts in the critical and full management areas to surveillance in the limited management areas. This categorization and ensuing prioritization ensures that: (1) human life, private property, and identified resources receive an appropriate level of protection with available firefighting resources, (2) the cost of the suppression effort is commensurate with values identified for protection, and (3) the ability of land manager(s)/owner(s) to achieve their individual management objectives is optimized.

The AIWFMP also stresses that lightning-caused wildland fires are an important component of the boreal forest and arctic tundra ecosystems, and the complete exclusion of these fires is neither ecologically sound nor economically feasible. The natural role of fire in the environment must be tempered by the need to protect human life and health, private property, developments, and certain valued natural and cultural resources.

During the fire season, availability of suppression resources may become limited due to commitments to numerous initial attack assignments and/or large fires. The pre-fire season assignment of management options establishes priorities for allocation of suppression forces and substantially improves the cost-effectiveness of wildland fire management.

A large portion of the state has been declared as Modified or Limited Maintenance. The Modified management option is intended to be the most flexible option available to land managers/owners. The intent of the Modified management option is to provide a higher level of protection when fire danger is high, probability of significant fire growth is high, and probability of containment is low. A lower level of protection is provided when fire danger decreases, potential for fire growth decreases, and the probability of containment increases. This option should reduce commitment of suppression resources when risks are low. This option also provides increased flexibility in the selection of suppression strategies when risks are high. The Modified option provides a management level between Full and Limited. Unlike Full management areas, the intent is not to minimize burned acres, but to balance acres burned with suppression costs and to accomplish land and resource management objectives.

The Limited management option allows for even less active fire intervention. This category recognizes areas where the cost of suppression may exceed the value of the resources to be protected, the environmental impacts of fire suppression activities may have more negative impacts on the resources than the effects of the fire, or the exclusion of fire may be detrimental to the fire-dependent ecosystem. The Limited management option reduces both long-term suppression risks and costs by reducing the frequency of large fires that may burn out of boundaries of Limited management regardless of the suppression effort. It also reduces current suppression costs and makes suppression goals more attainable in years of drought and intense fire activity. The Limited management option may also be chosen for areas where fire occurrence is essential to the biodiversity of the resources protected and the long-term ecological health of the land. Suppression actions may be initiated to keep a fire within the boundary of the management option or to protect identified higher value areas/sites. Site-specific areas that warrant higher levels of protection may occur within Limited management areas. Appropriate suppression actions to protect these sites will be taken when warranted, without compromising the intent of the Limited management area.

ADEC has implemented the following mitigation strategies to prevent fires and protect public health. Prior to the fire season, mitigation is carried out in accordance with the Alaska Enhanced Smoke Management Plan (ESMP) and ADEC 18 AAC 50, Air Quality Control. ADEC provides a clear and equitable regulatory basis for smoke management in Alaska through the ESMP. ADEC is responsible for reviewing controlled burns for resource management, for reviewing and approving land clearing applications, and for issuing controlled burn approvals. ADEC also ensures that controlled burn applications comply with state air quality regulations (18 AAC 50.065) and ESMP guidelines. While reduction of fuel loads is an important control factor, the ESMP clearly states:"Evaluating potential dispersion of smoke emissions from a project is the single most important component of an effective ESMP." All controlled burns for resource management or land clearing that are greater than 40 acres must have an approved burn permit. Further, the permit states that the Responsible Authority must notify ADEC at least 24 hours in advance, obtain a favorable dispersion forecast from the National Weather Service, and approval

from the ADEC meteorologist. The ADEC meteorologist is responsible for ensuring air quality standards are not violated during controlled burns. While these controlled burns reduce the fire fuels load, they cannot entirely eliminate the risk.

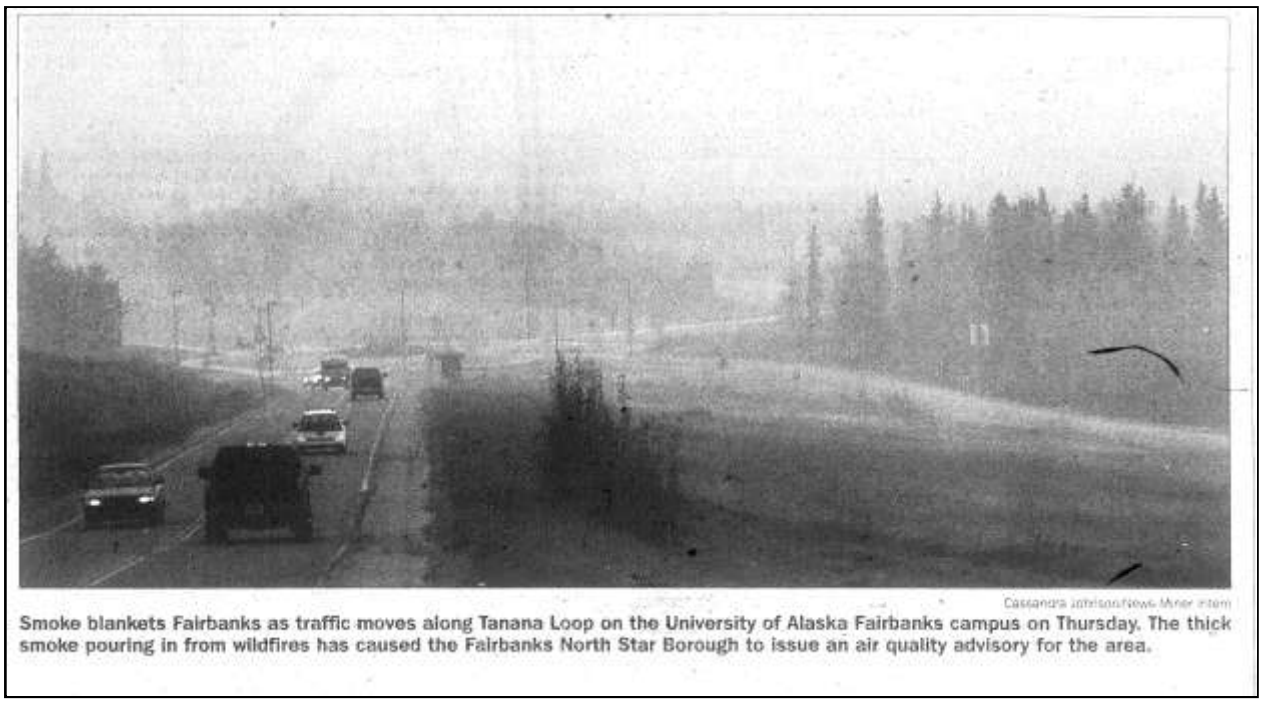
ADEC issues Air Quality Advisories in accordance with ADEC 18 AAC 50, Air Quality Control guidance to further protect public health during periods of poor air quality. The ADEC meteorologist issued 26 advisories related to wildland fire smoke between July 4 and August 6, 2009. ADEC issued 12 of these 26 advisories for the Central Interior, which includes Fairbanks. Other advisory areas included the south-central, the southeast, the western, and the northern areas of the state. (Appendix B)

The Event Affected Air Quality

The $PM_{2.5}$ 24-hour concentrations measured at the Fairbanks SOB site reflect the unusual fire conditions during the event. Table 6 lists the 24-hour $PM_{2.5}$ concentrations of samples collected by both the FRM and BAM air quality monitors from June through September; 2009.The $PM_{2.5}$ concentrations were significantly higher than the normal average of 3 to 6µg/m^3 for summer days without wildland fire smoke. The concentrations (as measured by the FRM) exceeded the 24-hour NAAQS six times between July 3 and August 8, 2009 at the Fairbanks SOB site. Three days had 24-hour averaged concentrations above 15µg/m^3 but below the NAAQS. During the month of July through September the $PM_{2.5}$ concentration was fluctuating from higher than average to extremely high concentrations (17.7-159.5 µg/m^3), with the highest value, 159.5µg/m^{3,} occurred on July 30, 2009. Refer to Figure 15 for a visual illustration of the poor air quality conditions in Fairbanks as published in the Fairbanks Daily News Miner on July 31, 2009.

Table 6: Fairbanks SOB site 24-hour $PM_{2.5}$ concentrations
Red font indicates an exceedance of the NAAQS, bold font indicates additional high values flagged by ADEC.

Date	$PM_{2.5}$ concentration [µg/m^3]	Date	$PM_{2.5}$ concentration [µg/m^3]
June, 2009		*July, 2009*	
3	8.5	3	8.0
6	3.9	6	**44.1**
9	19.5	9	**19.3**
12	9.9	12	8.4
15	5.0	15	**75.3**
18	6.6	18	10.3
21	3.7	21	7.7
24	3.4	24	**17.7**
27	3.1	27	**25.6**
30	4.1	30	**159.5**
August, 2009		*September , 2009*	
2	**89.7**	1	2.6
5	**127.7**	4	6.4
8	**61.0**	7	5.0
11	3.2	10	4.0
14	5.1	13	3.4
17	4.7	16	3.2
20	3.5	19	1.2
23	4.1	22	2.0
27	4.4	28	2.1
30	4.1		



Cassandra Johnson/News-Miner intern

Smoke blankets Fairbanks as traffic moves along Tanana Loop on the University of Alaska Fairbanks campus on Thursday. The thick smoke pouring in from wildfires has caused the Fairbanks North Star Borough to issue an air quality advisory for the area.

Figure 15: Smoke in Fairbanks on July 30th 2009 (Fairbanks Daily News Miner 7/31/2009)

$PM_{2.5}$ Concentrations Exceeded Historical Fluctuations (HF)

By the end of July, 2009, 468 fires (115% of normal) had burned 2,081,295 acres, 186% of a low fire year. By the end of August, 511 fires had burned 2,934,455 acres, 171% compared to the ten year average from 1999 to 2009 (Table 3). The totals for the year were 2,951,593 acres burned by 527 fires) (Figure 16).

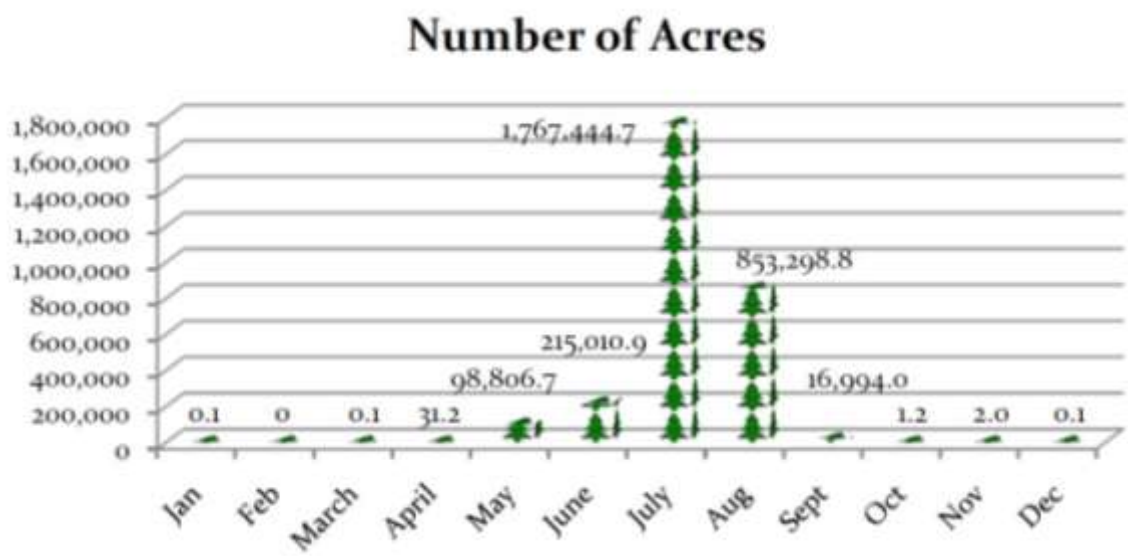


Figure 16: Acreage burned by wildland fires in 2009
(2009 Fire Season, Wildland Fire Summary and Statistics Annual report –AICC)

As a result of frequent and large wildland fires, in 2009, the average summer $PM_{2.5}$ levels measured at the SOB site in Fairbanks were abnormally high (19.5µg/m^3) in comparison to low fire years of 2001(6.0 µg/m^3) and 2008 (3.2 µg/m^3) (Table 7).

Table 7: Average $PM_{2.5}$ concentration from June-September for select years

Year	Average $PM_{2.5}$ concentration June-September (µg/m^3)
2001	6.0
2008	3.2
2009	19.5

Wildfires occur in Alaska every year, primarily between June and September. The number of wildfires and the area burned each year vary due to meteorological conditions and locations of fires. Wildfires are at a minimum during years of wet meteorological conditions and can be quite extensive in years with dry to exceptionally dry conditions. Long periods of dry conditions in May and June set the system in motion by allowing extensive areas of wild lands to accumulate

fire fuels. The high fuel loads and dry conditions lead to wildfires when a weather front approaches the interior and numerous lightning strikes occur.
Wildland fires are a recurring event in Interior Alaska. In the last 10 years the average acreage burned by wildfire in Alaska is 1,438,104 acres each year. However, the average acreage burnt can vary greatly, from as low as 43,965 in 1995 to 6,523,816 in 2004 (Table 8).

Table 8: Wildfire History of Alaska 2000 – 2009
Last 10 years fire data from Alaska Fire Season 2009 Wildland Fire Summary and Statistics Annual

Year	Acres burned	# Fires
1995	43,965	N/A
2000	756,296	369
2001	218,113	351
2002	2,186,682	544
2003	602,146	465
2004	6,523,816	696
2005	4,649,597	624
2006	270,539	305
2007	649,411	506
2008	103,299	368
2009	2,951,592	527

According the July 2001 Climate Summary from the University of Fairbanks Geophysical Institute, "Fairbanks experienced cooler temperatures but above normal precipitation in July. The average temperature of 59.9°F is 2.5°F below normal. The high of 53°F on the 8th was the lowest high temperature for that day, breaking the record of 55°F that was set in 1981. The maximum for the month was 82°F (19th) and the minimum was 40°F (9th). A daily precipitation record of 0.50 inch on the 28th eclipsed the previous record of 0.37 inch, which was set in 1967. Total precipitation of 2.46 inches is 32 percent above normal."[7]

In contrast the July 2009 Climate Summary stated "the average daily maximum temperature was the highest and the precipitation amount was the lowest ever recorded for July in Fairbanks. The record base is extended with more than a century of data. 15 days had a temperature maximum of 80°F or higher; and the highest temperature was observed on 8 July (91°F), followed by 13 July (88°F). These are new records for these specific days. On average, the temperature was 4.1°F above normal. Very light rainfall occurred on 15 and 31 July; the total was 0.06 inch. The high temperatures combined with the drought enhanced area wildfires, and particularly for the second half of the month the beautiful summer weather was disturbed by smoke which moved to the Fairbanks area from a number of different wildfires."[8]

[7] http://climate.gi.alaska.edu/AkCityClimo/2001/Jul/Jul_2001.html
[8] http://climate.gi.alaska.edu/AkCityClimo/2009/Jul/Jul_2009.html

Figure 17 is a comparison of the $PM_{2.5}$ concentrations for each fire season for the years 2000 to 2011. ADEC defined the fire season as the period from June 1st through August 31st for each year since these dates included all $PM_{2.5}$ exceedances and the major fire periods.
"Fire years" or those years where there are many fires happened on more than one occasion during this period. These fires impact the $PM_{2.5}$ concentrations in Fairbanks, Alaska. The summer of 2004 was the worst fire year, since record keeping, in Alaska. The data are not completely displayed on this graph since it is such an outlier. If the data were displayed the upper (green) box would be over 280 and the whisker would be well over 700. This would make all other years of data virtually unreadable due to the small size the other boxes would be when displayed.

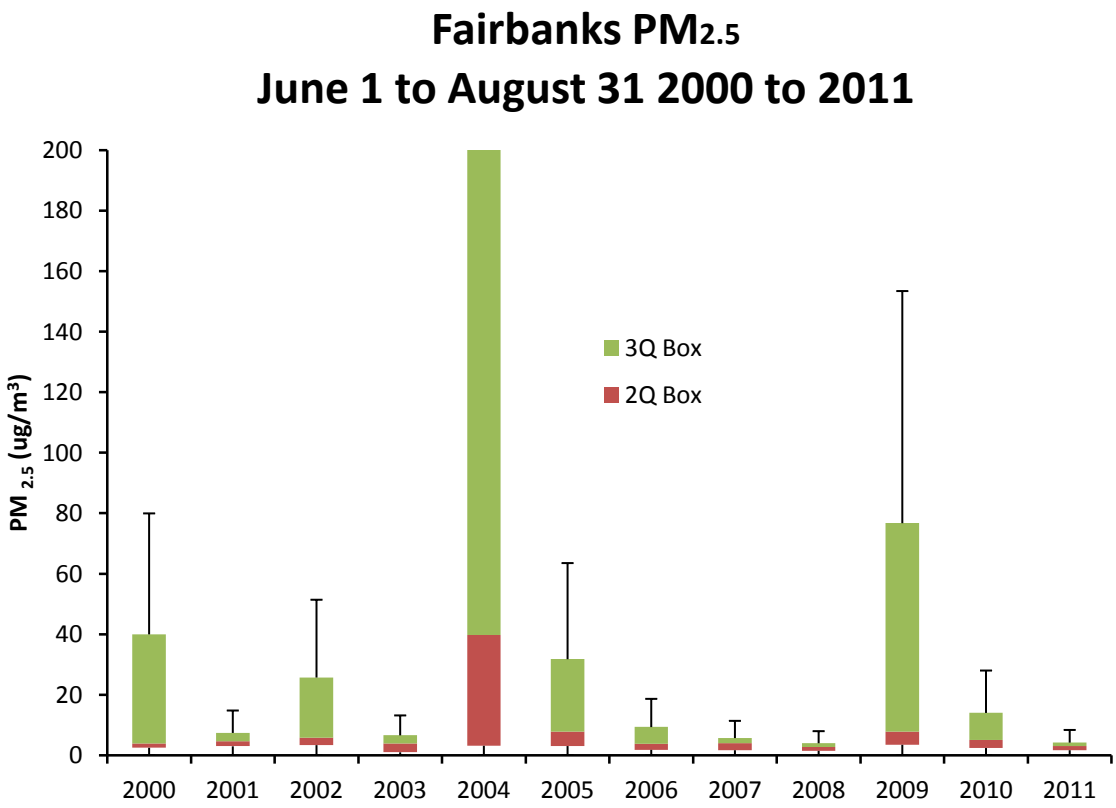


Figure 17: Fairbanks PM2.5 for the fire seasons for the years 2000 to 2011.
The upper box (green) represents data from the median to the 90 percentile. The lower (red) boxes represent data from the median down to the 10th percentile.

2009 is the second largest impact year during this period. Years with little or small fires can be seen in 2001, 2003, 2008 and 2011. Even among years where there were large fires such as 2000, 2002 and 2005, the year 2009 stands out with the $PM_{2.5}$ 90th percentile value approximately 2 to 3 times the value of the other years. The "whiskers" indicate the values between the top (bottom) of the box, 90th (10th) percentile to the highest (lowest) values.

Clear Casual Relationship

This section establishes the clear casual relationship between the smoke from the wildland fires in the Interior of Alaska during the summer of 2009 and the $PM_{2.5}$ concentrations in Fairbanks measured between July 6, 2009 and August 8, 2009. Section bellow will outline total summer fire size and dates the major fires impacting air quality in Fairbanks were burning and the location in relation to Fairbanks. Section bellow will provide a daily description that includes fire location, measured $PM_{2.5}$ concentrations, HYSPLIT backward trajectory forecasts, meteorological observations and other pertinent data for each day as need to show origin and extent of fire smoke. These products will be arranged in chronological order on a day-to-day basis and shown for each day of the event when significant changes occurred in the $PM_{2.5}$ levels. Along with these products will be a narrative detailing the development or changes from one day to the next.

Description of major fires

The number of fires in Alaska in the summer of 2009 – 527 fires – and the total acreage burned – 2,951,592 acres – were both in the top 4 highest in the last 10 years. The number of fires, the large amount of acreage burned, and the proximity to Fairbanks lead to high levels of $PM_{2.5}$.in the Fairbanks area. The largest fires that impacted the air quality in Fairbanks were the Railbelt Complex fires (made up of the Minto Flats fire, the June Creek fire, the Lunch Lake fire, and the Rex Creek fire) and the Wood River and Little Black One fires (Table 9). See the Alaska Fire Season 2009, Wildland Fire Summary and Statistics Annual Report – AICC for detailed descriptions of these fires Table 9 provides a summary of the dates the fires were burning and the total acreage burned by the end of the summer. Figure 18 is a map overview of where the fires were located in relation to Fairbanks.

The Minto Flats fire west-southwest of Fairbanks was the largest fire of the summer of 2009 at 517,078 acres (shown in Figure 18 as red). These fires burned between Jun 20 to late August with “explosive growth” around July 13 (Alaska Fire Season 2009, Wildland Fire Summary and Statistics Annual Report – AICC). By July 15 total acreage was 442,447 acres.

The Wood River fire ignited July 12, 2009 and was active until Aug 16, 2009. Total acreage burned was 125,381 acres (shown in Figure 18 as blue).

The Little Black One fire to the northeast of Fairbanks was ignited on June 20, 2009. The fire was active until August 23, 2009 and had a total acreage of 349,530 acres.

The combined area of these three fires was 991989 acres or 1,550 square miles – larger than the state of Rhode Island.

Table 9: Major fires in the vicinity of Fairbanks, Alaska, summer 2009

Fire Name	Ignite Date	Out Date	Total Acreage
Railbelt Complex			
Minto Flats	June 21, 2009	August 23, 2009	517,078
June Creek	July 11, 2009	July 28, 2009	164
Lunch Creek	June 20, 2009	July 27, 2009	12,802
Rex Creek	August 2, 2009	August 20, 2009	101,150
		Total Railbelt Fires	631,194
Wood River	July 12, 2009	August 16, 2009	125,381
Little Black One	June 20, 2009	August 23, 2009	349,530

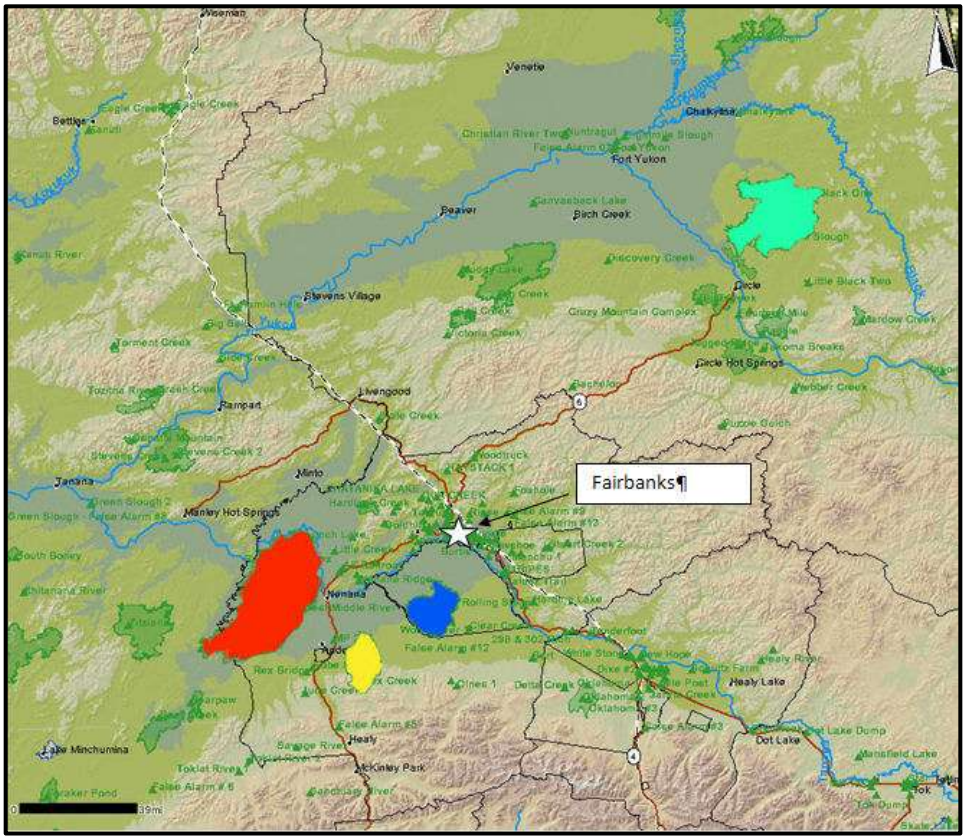


Figure 18: Outlines of major fires in the Fairbanks area, summer 2009
Red = Railbelt, Yellow = Rex Creek, Blue = Wood River, Light Green = Little Black One, Dark Green=Other fires from the AICC display [9]

[9] http://afsmaps.blm.gov/imf_firehistory/imf.jsp?site=firehistory

DAILY BREAKDOWN OF THE EVENT

This daily changes in $PM_{2.5}$ concentrations in Fairbanks for the period July 3 – August 10, 2009 are described by terrain maps, satellite imagery and modeling. The evidence presented for each day includes Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery, Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model backwards trajectory forecasts overlaid on terrain maps and also overlaid on the MODIS imagery, and hourly $PM_{2.5}$ concentrations for each day. Supporting evidence from observational $PM_{2.5}$ data, meteorology and firefighting effort (manmade and natural) are used to describe each day in the period.

Observational $PM_{2.5}$ concentrations are from the State Office Building Federal Reference Monitor (FRM) and the co-located beta attenuation monitor (BAM). The FRM data are $PM_{2.5}$ 24 hour averaged filters run on a 1-in-3 day schedule. The co-located BAM data are hurly $PM_{2.5}$ concentrations used on non-FRM days

All weather observation data was downloaded from the National Climate Data Center (NCDC) and was subject to their quality control. (http://www7.ncdc.noaa.gov/CDO/dataproduct). The MODIS imagery was downloaded from: http://www.gina.alaska.edu/data/gina-modis-images/2009-modis-images. The HYSPLIT model information and model runs are available on line (http://www.arl.noaa.gov/HYSPLIT_info.php).

$PM_{2.5}$ data underwent quality assurance and control by FNSB and ADEC staff and meet the requirements as defined in the State Quality Assurance Plan. ADEC provides oversight of FNSB data collection, processing, QA, and certifying all Fairbanks data entered into AQS, EPA's national ambient air monitoring database.

For this event, the first 24-hour $PM_{2.5}$ FRM concentration that exceeded standard occurred on July 6, 2009. The July 6, 2009 $PM_{2.5}$ 24-hour FRM filter sample data at the Fairbanks State Office sampler was 44.1µg/m^3 on July 6, 2009. See Appendix C for all available $PM_{2.5}$ data. Elevated $PM_{2.5}$ concentrations were recorded on 9 of 12 FRM sample days between July 6, 2009 and August 8, 2009 due to smoke impacts from wildfires. Some of these fires were ignited at the beginning of the event and continued to burn throughout the period. Of these nine days, five days exceeded the 24-hour $PM_{2.5}$ NAAQS.

All days with $PM_{2.5}$ concentrations above 15µg/m^3 from July 6 through August 8, 2009 are being submitted as one exceptional event. Although the $PM_{2.5}$ concentrations varied, the cause of the increased $PM_{2.5}$ concentrations throughout the entire period remained wildfire smoke. Daily $PM_{2.5}$ concentrations varied depending on meteorological conditions and fire development or suppression. At the onset, wind direction (WD) was the most important component but after the area was saturated with smoke WD could not be used to predict the onset or duration of the

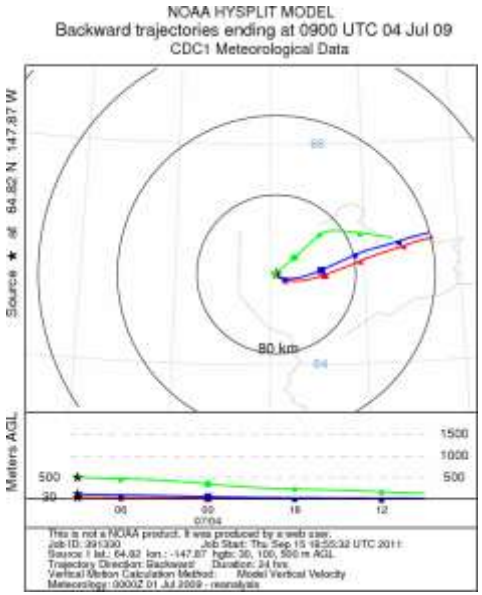
smoke impacts. Wind speed (WS), precipitation, type of fuel in fires and newly started fires also contributed to the variability of $PM_{2.5}$ concentrations.

July 3, 2009

Although the first flagged daily concentration associated with this exceptional event was measured on July 6, 2009 the $PM_{2.5}$ concentrations actually began to increase on July 4, 2009. Figure 19 a-d, and Table 10, July 3, 2009 show the overall situation one day prior to the onset of dense smoke in Fairbanks: The July 3, 2009 MODIS imagery clearly shows the fire locations, smoke, and direction of smoke movement. The MODIS imagery shows three fires southwest of Fairbanks. These fires would become part of the Railbelt Complex which, by the end of the summer, totaled 631,194 acres burned. The MODIS imagery and Table 2, July 3, 2009 observations from Fairbanks International Airport both show evidence of the smoke from the fires being blown from the E – NE to the W – SW – away from Fairbanks. There is also some residual smoke aloft to the east to northeast of Fairbanks. On this date FRM 24 HR $PM_{2.5}$ was 8.0µg/m^3. Secondary $PM_{2.5}$ 24 HR average was measured to be 7.73 µg/m^3.

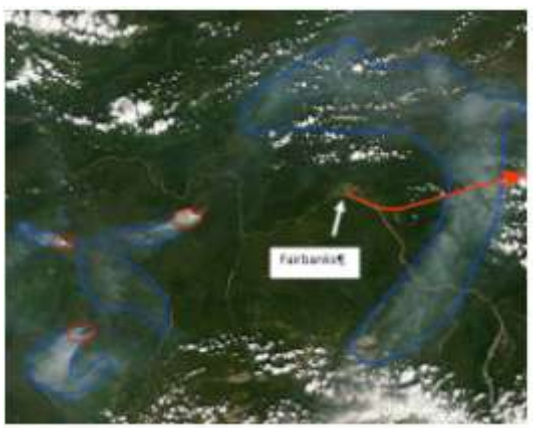
Figure 19a and b are the HYSPLIT Trajectory model output. The flow at all levels is from the NE to the SW. Even though there is some residual smoke aloft to the NE of Fairbanks, it has not moved over the city.

Table 10 summarizes the hourly observations for each day. The code breakdown for these data is contained in Appendix D.



A. HYSPLIT Backwards Trajectory Forecast from July 4, 2009, 00LST backward to July 3, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 3, 2009, 12:11 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn)

3-Jul	HRLY PM2.5
0:00	12.6
1:00	10.6
2:00	8.2
3:00	8.4
4:00	8.9
5:00	8.2
6:00	6.7
7:00	7.0

3-Jul	HRLY PM2.5
8:00	3.8
9:00	2.6
10:00	6.5
11:00	10.9
12:00	1.6
13:00	5.3
14:00	7.7
15:00	3.5

3-Jul	HRLY PM2.5
16:00	3.8
17:00	7.7
18:00	10.1
19:00	1.8
20:00	5.0
21:00	11.8
22:00	12.6
23:00	16.7

D. Hourly $PM_{2.5}$ for July 3, 2009

Figure 19 July 3, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 10: Hourly Observations for Fairbanks International Airport, July 3, 2009

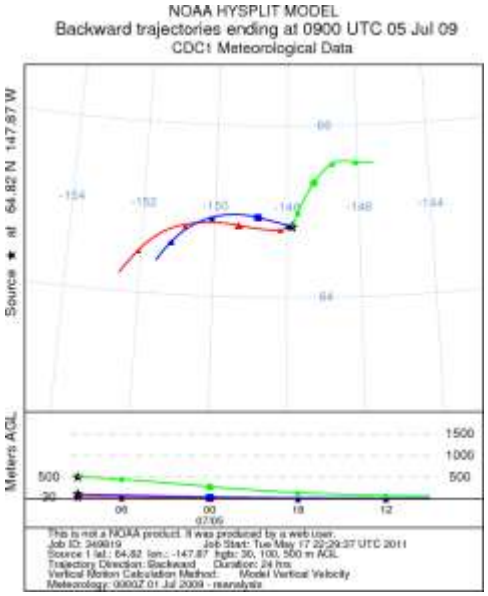
USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907022353	***	0	***	10	**	**
702610	26411	200907030053	***	0	***	10	**	**
702610	26411	200907030153	***	0	***	10	**	**
702610	26411	200907030253	40	3	***	10	**	**
702610	26411	200907030353	40	3	***	10	**	**
702610	26411	200907030453	***	0	***	10	**	**
702610	26411	200907030553	80	5	***	10	**	**
702610	26411	200907030653	50	6	***	10	**	**
702610	26411	200907030753	***	0	***	10	**	**
702610	26411	200907030853	***	0	***	10	**	**
702610	26411	200907030953	110	3	***	10	**	**
702610	26411	200907031053	***	0	***	10	**	**
702610	26411	200907031153	170	3	***	10	**	**
702610	26411	200907031253	120	3	***	10	**	**
702610	26411	200907031353	150	3	***	10	**	**
702610	26411	200907031453	990	3	***	10	**	**
702610	26411	200907031553	***	0	***	10	**	**
702610	26411	200907031653	***	0	***	10	**	**
702610	26411	200907031753	***	0	***	10	**	**
702610	26411	200907031853	***	0	***	10	**	**
702610	26411	200907031953	120	5	***	10	**	**
702610	26411	200907032053	***	0	***	10	**	**
702610	26411	200907032153	***	0	***	10	**	**
702610	26411	200907032253	***	0	***	10	**	**

July 4, 2009

Figure 20 indicates the change in wind flow on July 4, 2009 that will move smoke into the Fairbanks area. Figure 20 a, b and c shows the change in the wind direction in the lower levels (30 and 100 m). The table in Figure 20 d 4 shows that the $PM_{2.5}$ concentrations increased from 9.9 µg/m^{3}at in the middle of the night to a peak of 95.3 µg/m^3 by 14:00 L (2PM). Concentrations then slowly decreased, ending the day at 29.7µg/m^3.

Hourly observations at the Fairbanks International Airport indicate smoke beginning at noon and lasting until 7PM.

The July 4, 2009 HYSPLIT Trajectory model output indicate that the flow at the two lower levels, 30m in red, and 100m in blue, have now switched from NE to WSW, bringing smoke from the fire toward Fairbanks. FRM filter, 24 HR $PM_{2.5}$ data is not available for this date. Secondary $PM_{2.5}$ 24 HR average was 32.88µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 5, 2009, 00LST backward to July 4, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. July 4, 2009, 12:54 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.)

4-Jul	HRLY PM2.5
0:00	9.9
1:00	17.9
2:00	20.4
3:00	20.4
4:00	9.4
5:00	19.4
6:00	16.5
7:00	12.3

4-Jul	HRLY PM2.5
8:00	20.1
9:00	24.8
10:00	40.2
11:00	60.7
12:00	65.8
13:00	76.5
14:00	95.3
15:00	86.6

4-Jul	HRLY PM2.5
16:00	45.3
17:00	56.0
18:00	34.6
19:00	23.6
20:00	24.5
21:00	27.2
22:00	26.5
23:00	29.7

D. Hourly $PM_{2.5}$ for July 4, 2009

Figure 20 July 4, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 11: Hourly Observations for Fairbanks International Airport, July 4, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907032353	***	0	***	10	**	**
702610	26411	200907040053	***	0	***	10	**	**
702610	26411	200907040153	***	0	***	10	**	**
702610	26411	200907040253	60	7	***	10	**	**
702610	26411	200907040353	***	0	***	10	**	**
702610	26411	200907040453	40	5	***	10	**	**
702610	26411	200907040553	***	0	***	10	**	**
702610	26411	200907040653	***	0	***	10	**	**
702610	26411	200907040753	***	0	***	10	**	**
702610	26411	200907040853	***	0	***	9.1	**	**
702610	26411	200907040953	***	0	***	9.1	**	**
702610	26411	200907041053	***	0	***	7	**	**
702610	26411	200907041153	***	0	***	5	4 (Smoke)	**
702610	26411	200907041253	990	3	***	5	4 (Smoke)	**
702610	26411	200907041353	990	9	***	5	4 (Smoke)	**
702610	26411	200907041453	240	9	***	4	4 (Smoke)	**
702610	26411	200907041553	270	11	20	4	4 (Smoke)	**
702610	26411	200907041653	260	16	***	4	4 (Smoke)	**
702610	26411	200907041753	290	10	***	6	4 (Smoke)	**
702610	26411	200907041853	300	8	***	6	4 (Smoke)	**
702610	26411	200907041953	310	7	***	7	**	**
702610	26411	200907042053	110	6	***	7	**	**
702610	26411	200907042153	***	0	***	7	**	**
702610	26411	200907042253	***	0	***	7	**	**

Figure 21 shows the relationship of the fires, wind direction, and $PM_{2.5}$ concentrations at the onset of the event. Beginning July 3, 2009, the winds were either calm or from the easterly direction. Since the fires were located to the SW of Fairbanks at this time, easterly winds would not advect smoke into the city. Between July 4, 2009, 0000hrs and 1200 hours, the winds switched to southwest and increased in speed from 3 mph to 6 mph. Smoke was rapidly advected into Fairbanks when the wind shifted. By 12:00 hours the $PM_{2.5}$ reading was 65.8µg/m^3.

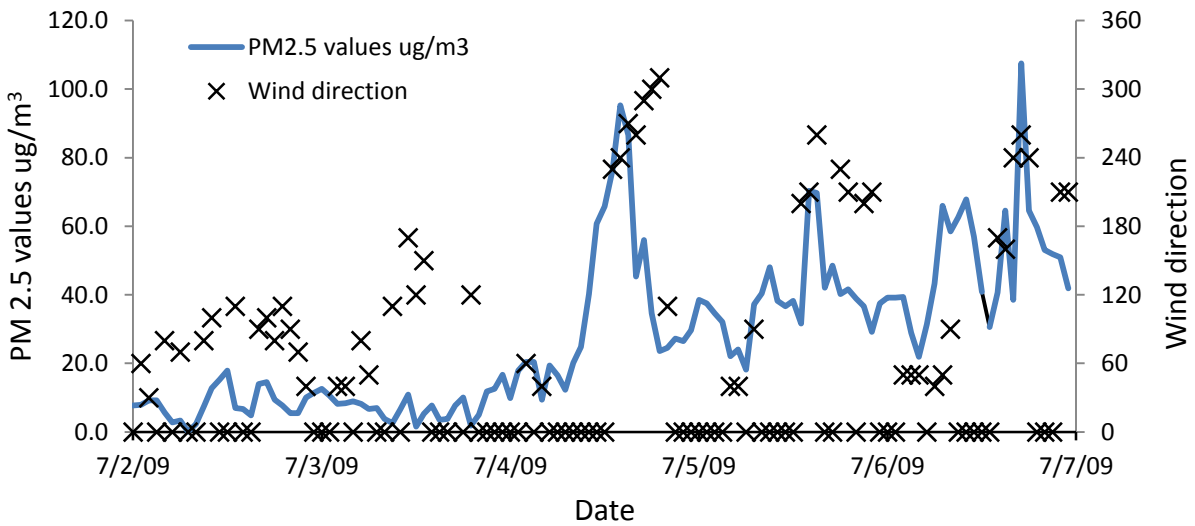
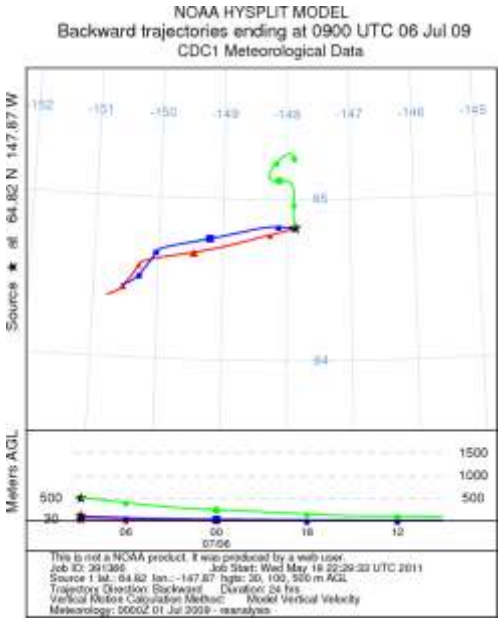


Figure 21 PM $_{2.5}$ concentrations and wind direction July 3 - 6, 2009

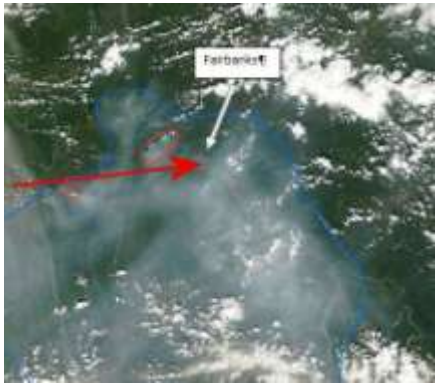
July 5, 2009

Figure 22 July 5, 2009, shows that the upper flow (green line) is from the north but the lower levels (red and blue lines) are from the west. The 30m (red line) as drawn on the MODIS imagery shows the air coming through the area of smoke transporting it into the Fairbanks area. The hourly $PM_{2.5}$ concentrations remained high throughout the day, ranging from a low of 18.2µg/m^3 to a high of 69.7µg/m^3.

Table 12 Fairbanks International Airport hourly observations for July 5, 2009, indicate smoke remained in the area. July 5 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 35.39µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 6, 2009, 00LST backward to July 5, 2009, 00LST.



C. July 5, 2009, 12:54 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn)

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

5-Jul	HRLY PM2.5
0:00	38.5
1:00	37.5
2:00	34.6
3:00	32.1
4:00	22.1
5:00	24.1
6:00	18.2
7:00	37.2

5-Jul	HRLY PM2.5
8:00	40.4
9:00	48.0
10:00	38.2
11:00	36.7
12:00	38.2
13:00	31.6
14:00	70.4
15:00	69.7

5-Jul	HRLY PM2.5
16:00	42.1
17:00	48.5
18:00	40.2
19:00	41.6
20:00	38.9
21:00	36.7
22:00	29.2
23:00	37.5

D. Hourly $PM_{2.5}$ for July 5, 2009

Figure 22 July 5, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

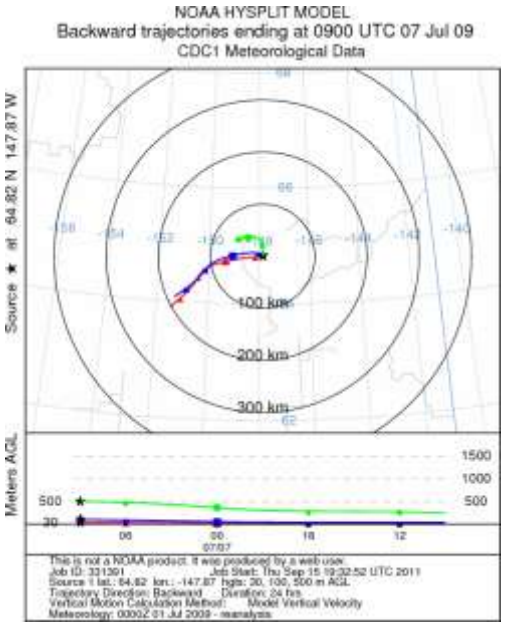
Table 12: Hourly Observations for Fairbanks International Airport, July 5, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907042353	***	0	***	7	**	**
702610	26411	200907050053	***	0	***	8	**	**
702610	26411	200907050153	***	0	***	8	**	**
702610	26411	200907050253	***	0	***	8	**	**
702610	26411	200907050353	***	0	***	7	**	**
702610	26411	200907050453	40	3	***	7	**	**
702610	26411	200907050553	40	5	***	8	**	**
702610	26411	200907050653	***	0	***	9.1	**	**
702610	26411	200907050753	90	3	***	9.1	**	**
702610	26411	200907050853	***	0	***	8	**	**
702610	26411	200907050953	***	0	***	7	**	**
702610	26411	200907051053	***	0	***	6	4 (Smoke)	**
702610	26411	200907051153	***	0	***	7	**	**
702610	26411	200907051253	***	0	***	7	**	**
702610	26411	200907051353	200	5	***	6	4 (Smoke)	**
702610	26411	200907051453	210	7	***	4	4 (Smoke)	**
702610	26411	200907051553	260	7	***	3	4 (Smoke)	**
702610	26411	200907051653	990	7	***	6	4 (Smoke)	**
702610	26411	200907051753	990	7	***	6	4 (Smoke)	**
702610	26411	200907051853	230	3	***	6	4 (Smoke)	**
702610	26411	200907051953	210	3	***	6	4 (Smoke)	**
702610	26411	200907052053	***	0	***	7	**	**
702610	26411	200907052153	200	3	***	7	**	**
702610	26411	200907052253	210	5	***	7	**	**

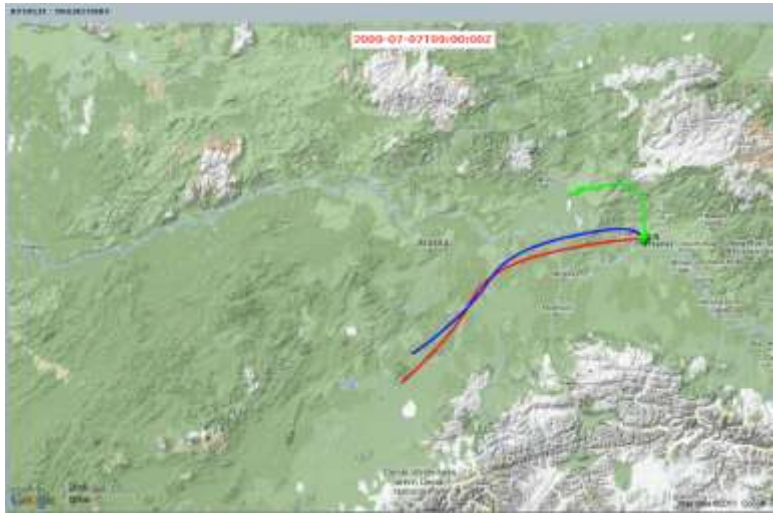
July 6, 2009

Figure 23 July 6, 2009, shows extensive areas of smoke. There is also some upper clouds moving into the area from the SW. These clouds obscure the view of the fires beneath them so the only fire circled on the MODIS imagery is to the NW of Fairbanks. While the actual location of the fires may be obscured by the cloud, the trajectory is still through a large area of smoke.

Table 13 hourly Observations for Fairbanks International Airport, July 6, 2009Fairbanks International Airport hourly observations for July 6, 2009, indicate smoke throughout the day. Winds began north easterly (050) then switched to south westerly. There was enough smoke in the area by that by this day the variable winds did not dissipate the smoke. July 6 is the first FRM filter day since the onset of the smoke event. FRM filter, 24 hour $PM_{2.5}$ concentration was 44.1µg/m^3. Secondary $PM_{2.5}$ 24 hour average concentration was 45.28µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 7, 2009, 00LST backward to July 6, 2009, 00LST.



B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. July 6, 2009, 12:42 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke. Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand draw.

6-Jul	HRLY PM2.5
0:00	39.2
1:00	39.2
2:00	39.4
3:00	28.9
4:00	21.9
5:00	31.4
6:00	43.3
7:00	66.0

6-Jul	HRLY PM2.5
8:00	58.5
9:00	62.6
10:00	67.8
11:00	57.0
12:00	40.9
13:00	30.6
14:00	40.7
15:00	64.6

6-Jul	HRLY PM2.5
16:00	38.5
17:00	107.5
18:00	64.6
19:00	59.7
20:00	53.1
21:00	51.9
22:00	50.9
23:00	41.9

D. Hourly $PM_{2.5}$ for July 6, 2009

Figure 23 July 6, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 13: Hourly Observations for Fairbanks International Airport, July 6, 2009

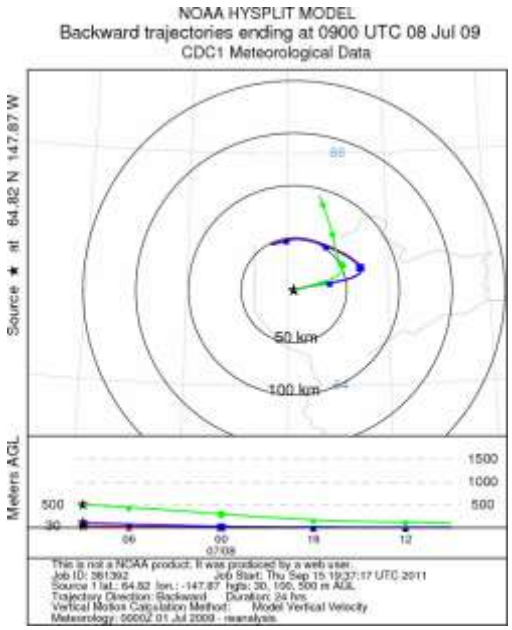
USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907052353	***	0	***	7	**	**
702610	26411	200907060053	***	0	***	7	**	**
702610	26411	200907060153	***	0	***	6	4 (Smoke)	**
702610	26411	200907060253	50	3	***	8	**	**
702610	26411	200907060353	50	6	***	10	**	**
702610	26411	200907060453	50	5	***	10	**	**
702610	26411	200907060553	***	0	***	7	**	**
702610	26411	200907060653	40	3	***	7	**	**
702610	26411	200907060753	50	3	***	6	4 (Smoke)	**
702610	26411	200907060853	90	3	***	5	4 (Smoke)	**
702610	26411	200907060953	***	0	***	4	4 (Smoke)	**
702610	26411	200907061053	***	0	***	4	4 (Smoke)	**
702610	26411	200907061153	***	0	***	5	4 (Smoke)	**
702610	26411	200907061253	***	0	***	5	4 (Smoke)	**
702610	26411	200907061353	990	3	***	6	4 (Smoke)	**
702610	26411	200907061453	170	6	***	5	4 (Smoke)	**
702610	26411	200907061553	160	5	***	6	4 (Smoke)	**
702610	26411	200907061653	240	6	***	5	4 (Smoke)	**
702610	26411	200907061753	260	8	***	5	4 (Smoke)	**
702610	26411	200907061853	240	5	***	3	4 (Smoke)	**
702610	26411	200907061953	990	3	***	4	4 (Smoke)	**
702610	26411	200907062053	***	0	***	5	4 (Smoke)	**
702610	26411	200907062153	***	0	***	6	4 (Smoke)	**
702610	26411	200907062253	210	3	***	6	4 (Smoke)	**

July 7, 2009

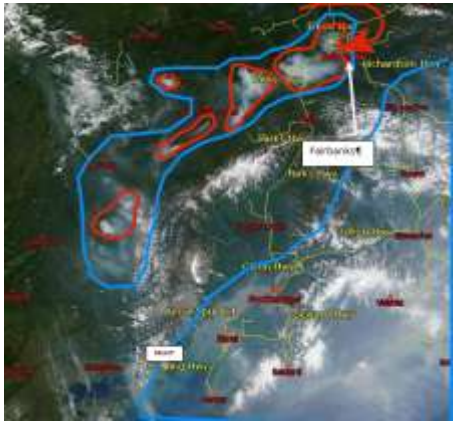
Figure 24 D, July 7, 2009, discussion. The fires continue to burn to the southwest of Fairbanks. Figure 24 D shows that the hourly $PM_{2.5}$ concentrations varied from 10.4µg/m^3 to 67.8µg/m^3. The HYSPLIT backward trajectory indicates the air flow at 30 meters over the 24hr period was from the west changing to the east but the MODIS imagery show the smoke from the fires moving to the southeast. The difference between the MODIS imagery and the HYSPLIT is caused by different temporal scales. At the time the MODIS was captured, the wind flow was still out of the west – southwest as indicated in Figure 24. This would have advected the smoke into Fairbanks and resulted in higher $PM_{2.5}$ concentrations even after the wind shifted as some time would elapse before the smoke cleared. With winds this light and variable, it is possible that the direction the fire smoke moved was more driven by the heat of the fire versus the synoptic meteorological situation.

Although the observed direction changes match the HYSPLIT trajectory forecast, the winds were so light, and variable that the smoke was not moved away from Fairbanks. Table 14 shows that observed winds were calm on 13 of the 24 hourly observations, 3 MPH reported on 5 more hours and variable on one observation (code 990).

July 7 was not a scheduled sampling day, so FRM data are not available for this day. The secondary $PM_{2.5}$ 24 hour average concentration was 38.16µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 8, 2009, 00LST backward to July 7, 2009, 00LST.



C. July 7, 2009, 13:45 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke. Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

7-Jul	HRLY PM2.5
0:00	37.2
1:00	12.8
2:00	11.1
3:00	30.2
4:00	17.0
5:00	10.4
6:00	36.3
7:00	67.0

7-Jul	HRLY PM2.5
8:00	67.5
9:00	67.8
10:00	47.7
11:00	17.2
12:00	34.3
13:00	30.4
14:00	38.2
15:00	47.0

7-Jul	HRLY PM2.5
16:00	58.0
17:00	57.0
18:00	53.1
19:00	49.0
20:00	47.5
21:00	51.9
22:00	55.8
23:00	62.9

D. Hourly $PM_{2.5}$ for July 7, 2009

Figure 24 July 7, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

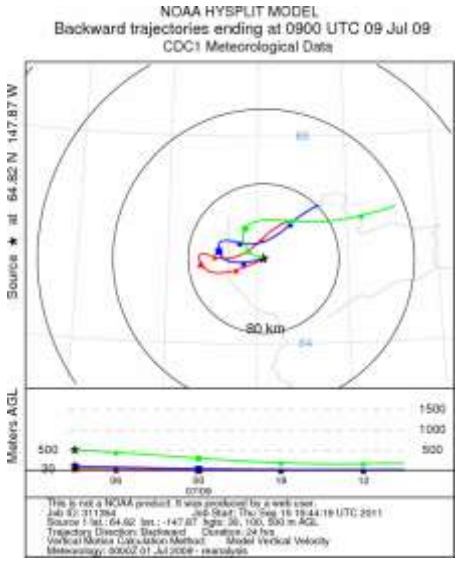
Table 14: Hourly Observations for Fairbanks International Airport, July 7, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907062353	210	6	***	6	4 (Smoke)	**
702610	26411	200907070053	***	0	***	6	4 (Smoke)	**
702610	26411	200907070153	***	0	***	6	4 (Smoke)	**
702610	26411	200907070253	***	0	***	6	4 (Smoke)	**
702610	26411	200907070353	140	5	***	7	**	**
702610	26411	200907070453	30	3	***	10	**	**
702610	26411	200907070553	***	0	***	8	**	**
702610	26411	200907070653	***	0	***	7	**	**
702610	26411	200907070753	***	0	***	6	4 (Smoke)	**
702610	26411	200907070853	***	0	***	5	4 (Smoke)	**
702610	26411	200907070950	***	0	***	5	4 (Smoke)	**
702610	26411	200907071050	990	5	***	6	4 (Smoke)	**
702610	26411	200907071153	***	0	***	8	**	**
702610	26411	200907071253	***	0	***	9.1	**	**
702610	26411	200907071350	190	3	***	9.1	**	**
702610	26411	200907071453	***	0	***	7	**	**
702610	26411	200907071553	990	3	***	5	4 (Smoke)	**
702610	26411	200907071653	170	6	***	5	4 (Smoke)	**
702610	26411	200907071753	***	0	***	5	4 (Smoke)	**
702610	26411	200907071853	210	5	***	5	4 (Smoke)	**
702610	26411	200907071953	210	5	***	5	4 (Smoke)	**
702610	26411	200907072053	210	3	***	6	4 (Smoke)	**
702610	26411	200907072153	***	0	***	6	4 (Smoke)	**
702610	26411	200907072253	***	0	***	6	4 (Smoke)	**

July 8, 2009

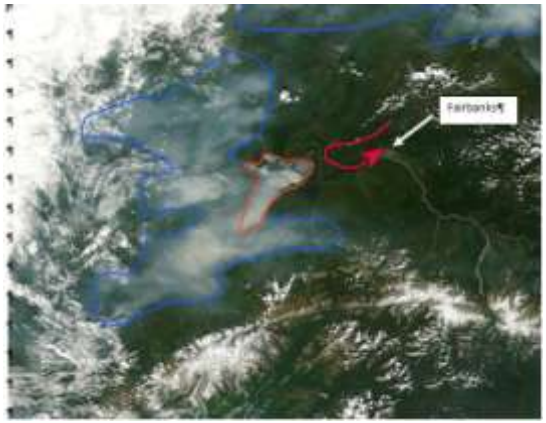
Figure 25, July 8, 2009, discussion: The 12:29 LST MODIS imagery shows the fires still burning to the southwest. Based on the HYSPLIT 30m flow (red line) the smoke should clear from midnight to the time of the image, around noon. Figure 25 D, Hourly $PM_{2.5}$, reflects this improvement in air quality. The 13:00 LST (1:00 PM) $PM_{2.5}$ concentrations are down to 17.7 $\mu g/m^3$. The wind flow then becomes westerly to south-westerly as verified by the HYSPLIT backwards trajectory and the hourly observations. This brings smoke back into the Fairbanks area. This is reflected in the $PM_{2.5}$ concentrations at 19:00 LST (7:00 PM) when the concentrations are back up to 58.0 $\mu g/m^3$.

July 8 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 36.20$\mu g/m^3$.



A. HYSPLIT Backwards Trajectory Forecast from July 9, 2009, 00LST backward to July 8, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 8, 2009, 12:29 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke. Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand

8-Jul	HRLY PM2.5
0:00	65.6
1:00	53.6
2:00	55.5
3:00	59.9
4:00	46.0
5:00	51.4
6:00	53.6
7:00	41.1

8-Jul	HRLY PM2.5
8:00	37.5
9:00	59.5
10:00	48.2
11:00	30.4
12:00	38.7
13:00	17.7
14:00	12.3
15:00	17.5

8-Jul	HRLY PM2.5
16:00	18.9
17:00	19.9
18:00	32.8
19:00	58.0
20:00	41.9
21:00	27.5
22:00	23.6
23:00	42.9

D. Hourly $PM_{2.5}$ for July 8, 2009

Figure 25 July 8, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 15: Hourly Observations for Fairbanks International Airport, July 8, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907072353	***	0	***	6	4 (Smoke)	**
702610	26411	200907080053	***	0	***	6	4 (Smoke)	**
702610	26411	200907080153	60	6	***	4	4 (Smoke)	**
702610	26411	200907080253	60	3	***	4	4 (Smoke)	**
702610	26411	200907080353	***	0	***	4	4 (Smoke)	**
702610	26411	200907080453	***	0	***	5	4 (Smoke)	**
702610	26411	200907080553	50	3	***	5	4 (Smoke)	**
702610	26411	200907080653	40	3	***	5	4 (Smoke)	**
702610	26411	200907080753	***	0	***	5	4 (Smoke)	**
702610	26411	200907080853	60	5	***	7	**	**
702610	26411	200907080953	60	5	***	7	**	**
702610	26411	200907081053	100	3	***	6	4 (Smoke)	**
702610	26411	200907081153	***	0	***	5	4 (Smoke)	**
702610	26411	200907081253	160	3	***	6	5 (Haze)	4 (Smoke)
702610	26411	200907081353	***	0	***	7	**	**
702610	26411	200907081453	***	0	***	10	**	**
702610	26411	200907081553	990	7	***	10	**	**
702610	26411	200907081653	990	5	***	10	**	**
702610	26411	200907081753	***	0	***	10	**	**
702610	26411	200907081853	10	14	***	10	**	**
702610	26411	200907081953	360	11	***	6	4 (Smoke)	**
702610	26411	200907082053	250	11	18	6	4 (Smoke)	**
702610	26411	200907082153	***	0	***	6	4 (Smoke)	**
702610	26411	200907082253	200	6	***	8	**	**

July 9, 2009

Figure 26, the NWS surface analysis for July 9, 2009; 15:00 (3 PM), indicates a Low pressure system approaching the Fairbanks area. This front will increase the winds and greatly enhance mixing of the lower atmosphere. The arrival of this weather system can also be seen in the MODIS imagery (Figure 27 C) as a band of clouds that cover the Fairbanks area. Since the wind direction with the front is from the south-west, for at least a short period of time, the smoke is brought in from the fire areas and increases but then rapidly decreases as the mixing of the lower atmosphere become the dominate factor. By 7:00 AM LST the mixing is strong enough for the air quality to improve to the "Good" category of $PM_{2.5}$ less than 15.5 µg/m^3. FRM 24 hour $PM_{2.5}$ concentration was measured at 19.3µg/m^3. Secondary $PM_{2.5}$ 24 hour average was 19.50µg/m^3.

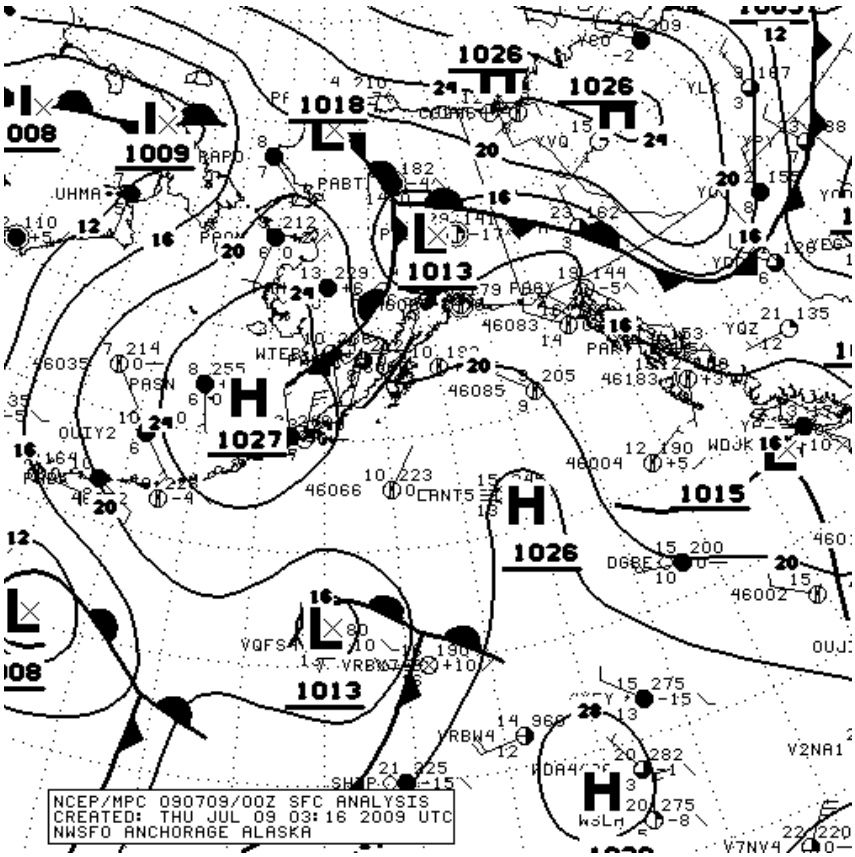
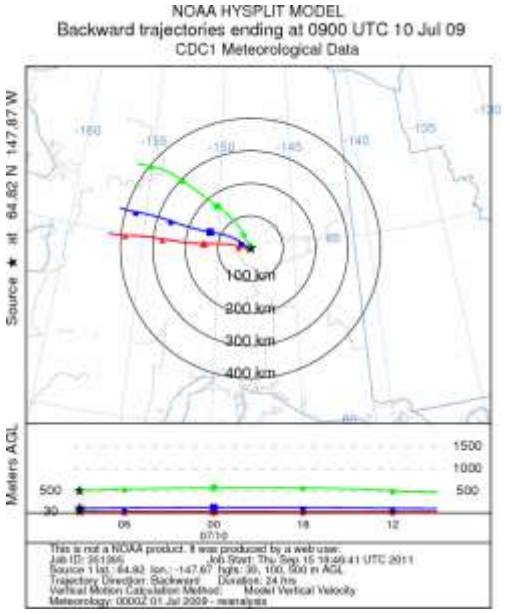
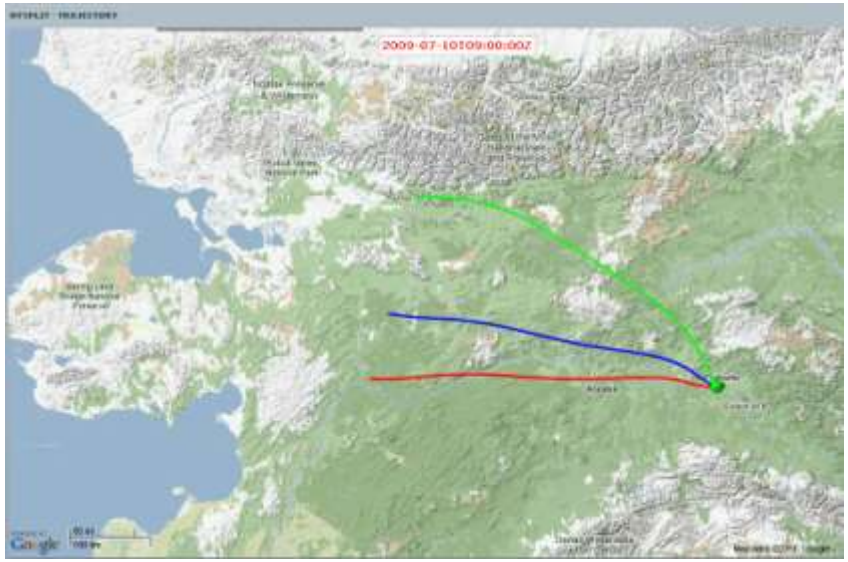


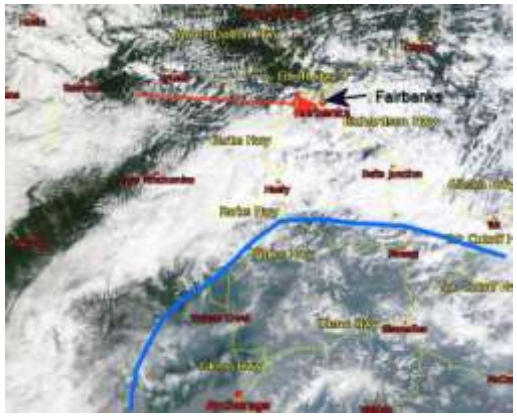
Figure 26: NWS Surface Analysis, July 9, 2009, 00UTC (July 8, 2009, 15:00 (3:00 PM) LST)



A. HYSPLIT Backwards Trajectory Forecast from July 10, 2009, 00LST backward to July 9, 2009, 00LST.



B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 9, 2009, 13:12 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

9-Jul	HRLY PM2.5
0:00	58.7
1:00	55.5
2:00	77.3
3:00	77.3
4:00	78.7
5:00	21.1
6:00	16.0
7:00	13.1

9-Jul	HRLY PM2.5
8:00	10.1
9:00	3.8
10:00	14.5
11:00	6.0
12:00	7.2
13:00	8.4
14:00	8.9
15:00	9.2

9-Jul	HRLY PM2.5
16:00	8.2
17:00	6.5
18:00	2.6
19:00	3.1
20:00	3.5
21:00	2.1
22:00	4.8
23:00	4.3

D. Hourly $PM_{2.5}$ for July 9, 2009

Figure 27 July 9, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 16: Hourly Observations for Fairbanks International Airport, July 9, 2009

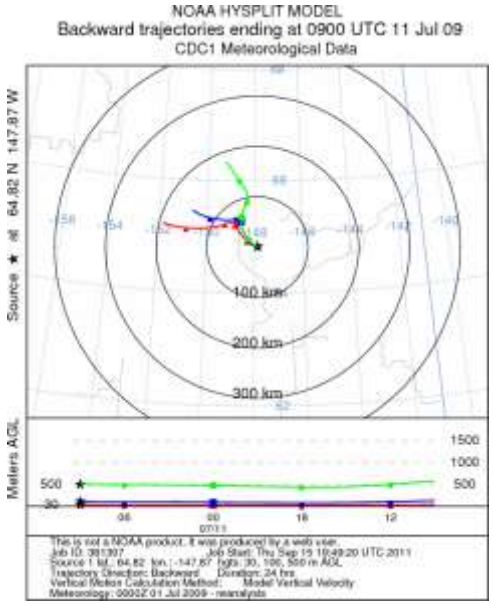
USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907082353	990	5	***	8	**	**
702610	26411	200907090053	280	18	29	6	4 (Smoke)	**
702610	26411	200907090153	***	0	***	6	4 (Smoke)	**
702610	26411	200907090253	230	3	***	6	4 (Smoke)	**
702610	26411	200907090353	250	5	***	5	4 (Smoke)	**
702610	26411	200907090453	210	5	***	2	4 (Smoke)	**
702610	26411	200907090553	260	10	***	6	4 (Smoke)	**
702610	26411	200907090653	230	6	***	10	**	**
702610	26411	200907090753	990	8	***	10	**	**
702610	26411	200907090853	240	9	***	10	**	**
702610	26411	200907090953	260	13	***	10	**	**
702610	26411	200907091053	990	9	***	10	**	**
702610	26411	200907091153	270	10	17	10	**	**
702610	26411	200907091253	290	11	***	10	**	**
702610	26411	200907091353	990	11	22	10	**	**
702610	26411	200907091453	260	11	18	10	**	**
702610	26411	200907091553	990	13	***	10	**	**
702610	26411	200907091653	270	13	21	10	**	**
702610	26411	200907091753	260	10	***	10	**	**
702610	26411	200907091853	240	8	17	10	**	**
702610	26411	200907091953	270	8	***	10	**	**
702610	26411	200907092053	280	10	20	10	**	**
702610	26411	200907092153	290	14	***	10	**	**
702610	26411	200907092253	280	11	***	10	**	**

July 10, 2009

Figure 28, the passage of the frontal system the day before (7/9/2009) reduced the size of the fires. This can be seen in a comparison of Figure 25 C and Figure 27 C MODIS imagery. While this weather system helped reduce the extent of the fires and mixed the smoke into the atmosphere, it was not strong enough to put out the fires. In fact, no precipitation was recorded at Fairbanks International Airport. In spite of the lack of precipitation, the cooler temperatures which were mostly in the 60s versus the 80s on previous days along with the increased relative humidity contributed to more effective fire suppression.

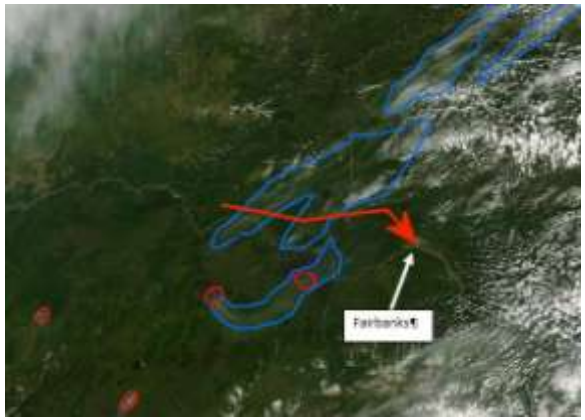
The HYSPLIT backward trajectory shows that the air moved from the west to east through an area of much reduced smoke and fires. The $PM_{2.5}$ concentrations remained in the below 15.5 $\mu g/m^3$ throughout the 24 hour period.

July 10 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 7.91$\mu g/m^3$.



A. HYSPLIT Backwards Trajectory Forecast from July 11, 2009, 00LST backward to July 10, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 10, 2009, 12:29 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

10Jul	HRLY PM2.5
0:00	3.5
1:00	6.5
2:00	6.2
3:00	5.3
4:00	5.5
5:00	4.5
6:00	6.7
7:00	8.9

10Jul	HRLY PM2.5
8:00	14.3
9:00	12.3
10:00	
11:00	5.3
12:00	14.8
13:00	8.7
14:00	11.6
15:00	11.6

10Jul	HRLY PM2.5
16:00	9.6
17:00	8.7
18:00	6.2
19:00	4.5
20:00	2.6
21:00	2.6
22:00	6.2
23:00	13.1

D. Hourly $PM_{2.5}$ for July 10, 2009

Figure 28 July 10, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 17: Hourly Observations for Fairbanks International Airport, July 10, 2009

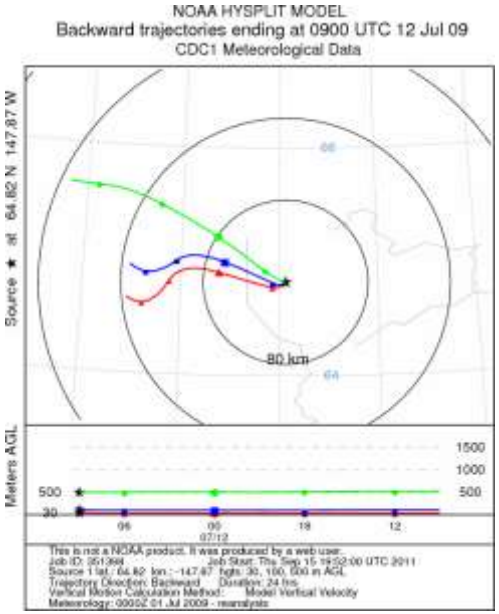
USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907092353	290	7	***	10	**	**
702610	26411	200907100053	280	3	***	10	**	**
702610	26411	200907100153	260	5	***	10	**	**
702610	26411	200907100253	270	5	***	10	**	**
702610	26411	200907100353	***	0	***	10	**	**
702610	26411	200907100453	180	3	***	10	**	**
702610	26411	200907100553	***	0	***	10	**	**
702610	26411	200907100653	990	5	***	8	**	**
702610	26411	200907100753	***	0	***	10	**	**
702610	26411	200907100853	250	5	***	10	**	**
702610	26411	200907100953	***	0	***	10	**	**
702610	26411	200907101053	190	8	***	10	**	**
702610	26411	200907101153	160	6	***	10	**	**
702610	26411	200907101253	***	0	***	10	**	**
702610	26411	200907101353	990	6	***	10	**	**
702610	26411	200907101453	130	3	***	10	**	**
702610	26411	200907101553	990	3	***	10	**	**
702610	26411	200907101653	***	0	***	10	**	**
702610	26411	200907101753	170	5	***	10	**	**
702610	26411	200907101853	160	3	***	10	**	**
702610	26411	200907101953	160	3	***	10	**	**
702610	26411	200907102053	180	3	***	10	**	**
702610	26411	200907102153	***	0	***	10	**	**
702610	26411	200907102253	***	0	***	10	**	**

July 11, 2009

Figure 29, there are many individual fires visible in Figure 29 C MODIS imagery to the southwest of Fairbanks. There is also one large fire (the Railbelt Complex) to the southwest but a little further away. Figure 29 A and B and Table 18**Error! Reference source not found.** show the wind flow to be more of a westerly direction so the smoke was not blown into Fairbanks. $PM_{2.5}$ concentrations remained below 15.5µg/m^3 for another day.

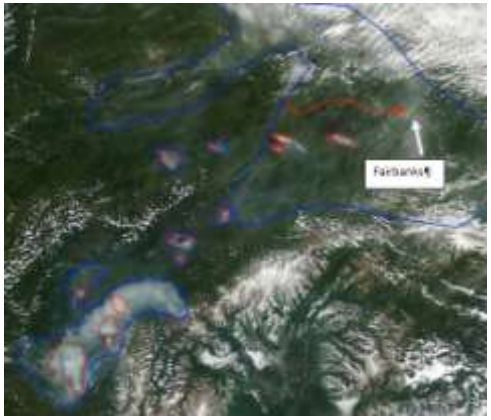
On this date, the Fire Service created the Railbelt Complex fire category and this complex included the Minto Flats Fire #320, the June Creek Fire #423 and the Lunch Lake Fire # 312. The Rex Creek fire was added to the complex on August 3, 2009.

July 11 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average concentration was 8.81µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 12, 2009, 00LST backward to July 11, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 11, 2009, 13:19 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

11-Jul	HRLY PM2.5
0:00	13.1
1:00	8.9
2:00	6.7
3:00	11.8
4:00	12.3
5:00	7.7
6:00	6.7
7:00	10.1

11-Jul	HRLY PM2.5
8:00	13.1
9:00	8.2
10:00	11.4
11:00	10.4
12:00	13.8
13:00	8.9
14:00	6.7
15:00	6.5

11-Jul	HRLY PM2.5
16:00	10.1
17:00	2.3
18:00	2.1
19:00	3.5
20:00	6.2
21:00	4.8
22:00	14.3
23:00	11.8

D. Hourly $PM_{2.5}$ for July 11, 2009

Figure 29 July 11, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 18: Hourly Observations for Fairbanks International Airport, July 11, 2009

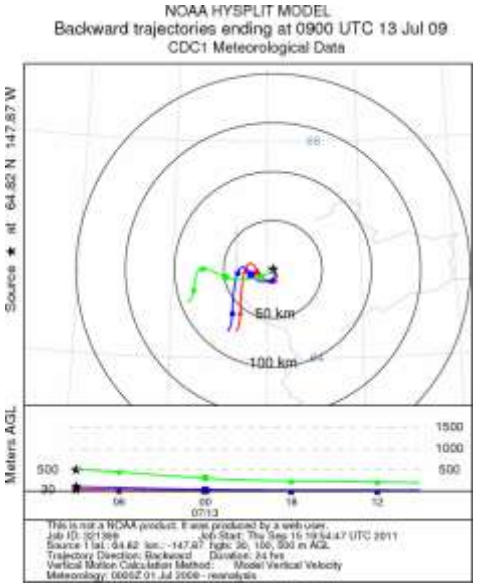
USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW	WW
702610	26411	200907102353	***	0	***	10	**	**	**
702610	26411	200907110053	***	0	***	10	**	**	**
702610	26411	200907110153	***	0	***	10	**	**	**
702610	26411	200907110253	***	0	***	10	**	**	**
702610	26411	200907110353	***	0	***	10	**	**	**
702610	26411	200907110453	40	3	***	10	**	**	**
702610	26411	200907110553	***	0	***	10	**	**	**
702610	26411	200907110653	***	0	***	10	**	**	**
702610	26411	200907110753	***	0	***	10	**	**	**
702610	26411	200907110853	***	0	***	10	**	**	**
702610	26411	200907110953	***	0	***	10	**	**	**
702610	26411	200907111053	***	0	***	10	**	**	**
702610	26411	200907111153	90	3	***	10	**	**	**
702610	26411	200907111253	280	7	***	10	**	**	**
702610	26411	200907111353	300	5	***	10	**	**	**
702610	26411	200907111453	270	8	***	10	**	**	**
702610	26411	200907111553	280	8	***	10	**	**	**
702610	26411	200907111653	260	5	***	10	**	**	**
702610	26411	200907111753	***	0	***	10	**	**	**
702610	26411	200907111853	***	0	***	10	**	**	**
702610	26411	200907111953	***	0	***	10	**	**	**
702610	26411	200907112053	30	3	***	10	**	**	**
702610	26411	200907112153	***	0	***	10	**	**	**
702610	26411	200907112253	***	0	***	10	**	**	**

July 12, 2009

Figure 30, the MODIS imagery from July 12, 2009, 12:05PM LST shows the fire areas to the west of Fairbanks increasing in size. In the Railbelt area the fires are also growing after the cool days on the 9th and 10th.

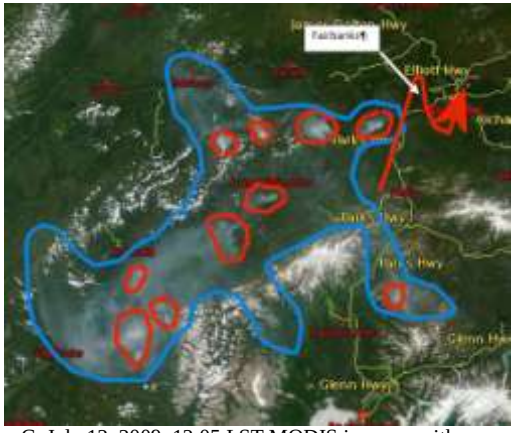
The HYSPLIT backward trajectory shows the wind primarily from the south and, although close to the fires smoke, the flow is not directly from the fire/smoke area.

FRM filter, 24 hour $PM_{2.5}$ was 8.4µg/m^3. Secondary $PM_{2.5}$ 24 hour average was 8.09µg/m^3. The $PM_{2.5}$ concentrations remained below the 15.5 µg/m^3 except for the period 8:00 AM -10:00 AM when hourly concentrations peaked at 20.6µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 13, 2009, 00LST backward to July 12, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 12, 2009, 12:05 LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

12-Jul	HRLY PM2.5
0:00	4.5
1:00	5.3
2:00	5.7
3:00	7.0
4:00	5.5
5:00	5.5
6:00	6.2
7:00	4.5

12-Jul	HRLY PM2.5
8:00	20.6
9:00	19.4
10:00	20.4
11:00	7.0
12:00	7.9
13:00	6.7
14:00	6.0
15:00	6.5

12-Jul	HRLY PM2.5
16:00	6.5
17:00	7.5
18:00	7.0
19:00	7.0
20:00	3.5
21:00	4.3
22:00	8.4
23:00	8.9

D. Hourly $PM_{2.5}$ for July 12, 2009

Figure 30 July 12, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 19: Hourly Observations for Fairbanks International Airport, July 12, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907112353	***	0	***	10	**	**
702610	26411	200907120053	***	0	***	10	**	**
702610	26411	200907120153	***	0	***	10	**	**
702610	26411	200907120253	***	0	***	10	**	**
702610	26411	200907120353	50	6	***	10	**	**
702610	26411	200907120453	80	3	***	10	**	**
702610	26411	200907120553	***	0	***	10	**	**
702610	26411	200907120653	50	3	***	10	**	**
702610	26411	200907120753	40	3	***	10	**	**
702610	26411	200907120853	***	0	***	10	**	**
702610	26411	200907120953	***	0	***	10	**	**
702610	26411	200907121053	***	0	***	10	**	**
702610	26411	200907121153	***	0	***	10	**	**
702610	26411	200907121253	***	0	***	10	**	**
702610	26411	200907121353	170	5	***	10	**	**
702610	26411	200907121453	***	0	***	10	**	**
702610	26411	200907121553	50	6	***	10	**	**
702610	26411	200907121653	170	3	***	10	**	**
702610	26411	200907121753	990	3	***	10	**	**
702610	26411	200907121853	***	0	***	10	**	**
702610	26411	200907121953	150	3	***	10	**	**
702610	26411	200907122053	120	3	***	10	**	**
702610	26411	200907122153	***	0	***	10	**	**
702610	26411	200907122253	***	0	***	10	**	**

July 13, 2009

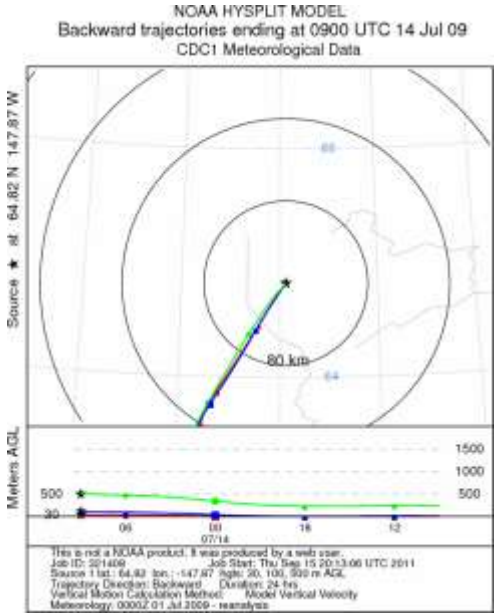
Figure 31, MODIS imagery shows the numerous fires to the west of Fairbanks increasing in size and a significant increase in the smoke to the northwest of the fires. The stage has now been set for a significant change in the fires.

The ALASKA FIRE SEASON 2009, Wildland Fire Summary and Statistics Annual Report – AICC, pg. 19 described the situation on July 13, 2009 as "Continuous high temperatures and low humidity with extremely dry fuels were hampering firefighting efforts, and placing a drain on resources." On the next page (pg 20) of that report the upcoming week was described as "The Minto South fire was absorbed into the Railbelt Complex (#898) on 07/13/09. Later that week ***explosive*** fire growth, due to continued warmer and drier weather, was observed. (emphasis added).

HYSPLIT backwards trajectory continues to show the air movement direction as primarily out of the south and not through the main area of fires.

Table 19 observational data show the winds as easterly, although light, during the first part of this 24 hour period. However after 18:53 (6:53 PM) LST the winds are calm or very light. This allows the smoke to begin to infiltrate the Fairbanks area. The $PM_{2.5}$ concentrations begin to slowly increase and by the end of the period the $PM_{2.5}$ concentration is 24.3µg/m^3.

July 13 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 12.52µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 14, 2009, 00LST backward to July 13, 2009, 00LST.

C. July 13, 2009, 12:48 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke).Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

13-Jul	HRLY PM2.5
0:00	12.1
1:00	7.0
2:00	5.0
3:00	6.0
4:00	16.7
5:00	7.7
6:00	13.6
7:00	12.1

13-Jul	HRLY PM2.5
8:00	18.7
9:00	2.6
10:00	4.0
11:00	10.6
12:00	6.7
13:00	7.9
14:00	8.7
15:00	13.3

13-Jul	HRLY PM2.5
16:00	16.5
17:00	17.0
18:00	17.9
19:00	18.7
20:00	17.5
21:00	23.1
22:00	18.4
23:00	24.3

D. Hourly $PM_{2.5}$ for July 13, 2009

Figure 31 July 13, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 20: Hourly Observations for Fairbanks International Airport, July 13, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907122353	***	0	***	10	**	**
702610	26411	200907130053	***	0	***	10	**	**
702610	26411	200907130153	990	3	***	10	**	**
702610	26411	200907130253	60	3	***	10	**	**
702610	26411	200907130353	***	0	***	10	**	**
702610	26411	200907130453	***	0	***	10	**	**
702610	26411	200907130553	***	0	***	10	**	**
702610	26411	200907130653	60	6	***	10	**	**
702610	26411	200907130753	***	0	***	10	**	**
702610	26411	200907130853	60	3	***	10	**	**
702610	26411	200907130953	***	0	***	10	**	**
702610	26411	200907131053	990	3	***	10	**	**
702610	26411	200907131153	150	3	***	10	**	**
702610	26411	200907131253	80	3	***	10	**	**
702610	26411	200907131353	90	7	***	10	**	**
702610	26411	200907131453	***	0	***	10	**	**
702610	26411	200907131553	60	5	***	10	**	**
702610	26411	200907131653	***	0	***	10	**	**
702610	26411	200907131753	130	5	***	10	**	**
702610	26411	200907131853	990	3	***	10	**	**
702610	26411	200907131953	***	0	***	10	**	**
702610	26411	200907132053	***	0	***	8	**	**
702610	26411	200907132153	***	0	***	7	**	**
702610	26411	200907132253	***	0	***	7	**	**

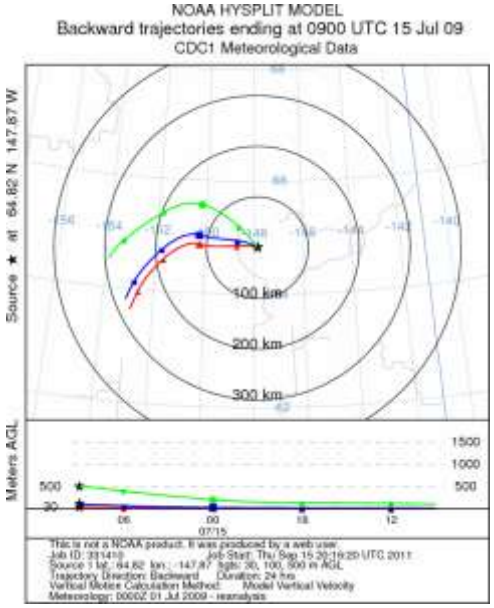
July 14, 2009

Figure 32, smoke covers most of the area around Fairbanks, with extremely dense smoke to the north of the city. In order to give a sense of the extent of the smoke, a green line was overlaid onto the MODIS imagery. This green line begins at Tok, Alaska in the south and runs to the northeast to Wiseman, Alaska, a distance of 347 miles "as-the-crow-flies." This is the same distance as New York City to Ottawa, Canada, or Washington D.C. to the center of Lake Erie north of Ohio.

HYSPLIT backwards trajectory shows that the air travels through a large portion of the smoke prior to reaching Fairbanks. The Table 20 observational data show smoke increasing and visibility decreasing to 1 mile by late morning.

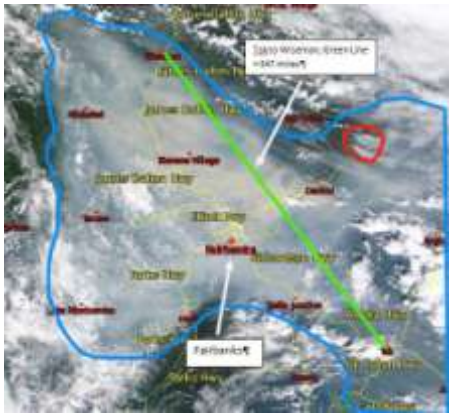
Figure 32 D show the $PM_{2.5}$ concentrations climbing rapidly from early morning until 1 PM when the highest hourly value of 258.7 $\mu g/m^3$ occurred. Concentrations then slowly drop. However, the $PM_{2.5}$ value at the end of the day was still 84/1$\mu g/m^3$.

July 14 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average concentration was 83.48$\mu g/m^3$.



A. HYSPLIT Backwards Trajectory Forecast from July 15, 2009, 00LST backward to July 14, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 14, 2009, 12:54 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

14-Jul	HRLY PM2.5
0:00	23.8
1:00	23.1
2:00	20.1
3:00	25.3
4:00	24.8
5:00	24.8
6:00	19.9
7:00	38.7

14-Jul	HRLY PM2.5
8:00	50.9
9:00	131.5
10:00	167.9
11:00	217.2
12:00	232.8
13:00	258.7
14:00	222.3
15:00	155.2

14-Jul	HRLY PM2.5
16:00	97.1
17:00	82.6
18:00	79.5
19:00	68.2
20:00	62.6
21:00	58.2
22:00	66.3
23:00	84.1

D. Hourly $PM_{2.5}$ for July 14, 2009

Figure 32 July 14, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 21: Hourly Observations for Fairbanks International Airport, July 14, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907132353	***	0	***	7	**	**
702610	26411	200907140053	40	3	***	8	**	**
702610	26411	200907140153	60	8	***	8	**	**
702610	26411	200907140253	***	0	***	10	**	**
702610	26411	200907140353	***	0	***	9.1	**	**
702610	26411	200907140453	180	5	***	8	**	**
702610	26411	200907140553	***	0	***	8	**	**
702610	26411	200907140653	50	5	***	7	**	**
702610	26411	200907140753	***	0	***	5	4 (Smoke)	**
702610	26411	200907140853	***	0	***	5	4 (Smoke)	**
702610	26411	200907140953	***	0	***	3	4 (Smoke)	**
702610	26411	200907141053	260	3	***	1.8	4 (Smoke)	**
702610	26411	200907141153	250	7	***	1.5	4 (Smoke)	**
702610	26411	200907141253	240	6	***	1	4 (Smoke)	**
702610	26411	200907141353	220	3	***	1	4 (Smoke)	**
702610	26411	200907141453	240	7	***	1	4 (Smoke)	**
702610	26411	200907141553	260	10	***	1	4 (Smoke)	**
702610	26411	200907141653	280	7	***	1.3	4 (Smoke)	**
702610	26411	200907141753	340	6	***	2	4 (Smoke)	**
702610	26411	200907141853	***	0	***	2	4 (Smoke)	**
702610	26411	200907141953	280	10	***	3	4 (Smoke)	**
702610	26411	200907142053	270	5	***	3	4 (Smoke)	**
702610	26411	200907142153	250	3	***	5	4 (Smoke)	**
702610	26411	200907142253	200	3	***	5	4 (Smoke)	**

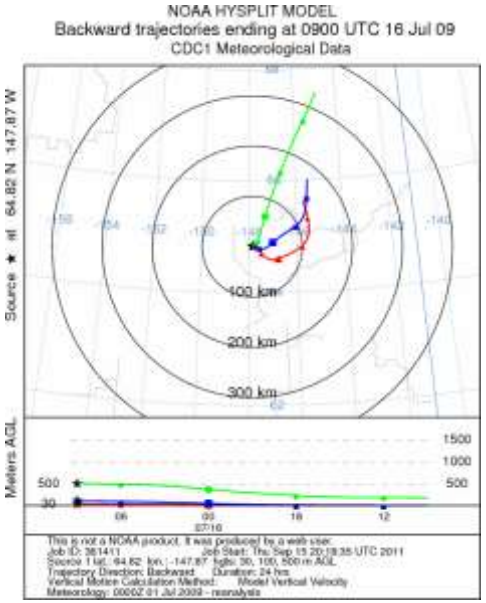
July 15, 2009

Figure 33, the 10:58AM MODIS image shows extensive clouds associated with a weather front over the Fairbanks area. Upper level flow is from the NE to the SW so most smoke aloft is visible at the lower left of the image. There are some fires still burning to the N and NE of Fairbanks.

HYSPLIT backwards trajectory brings the flow at the lower levels from a northerly direction, switching to come from the southeast

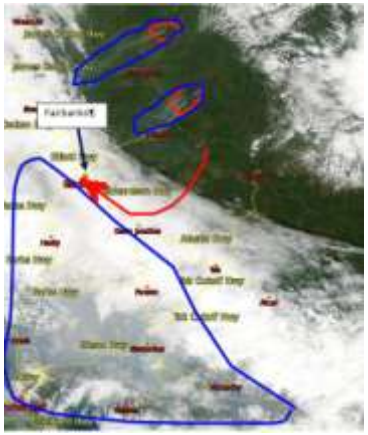
Observations at the Fairbanks airport report visibility restricted by smoke early in the morning. However, by the time of the MODIS imagery at mid morning the rain begins and visibility begins to increase.

FRM 24 hour $PM_{2.5}$ concentration was 75.3µg/m^3. Secondary $PM_{2.5}$ 24 hour average was 76.85µg/m^3. Although the 24 hour concentrations exceeded the NAAQS, by the end of the day the air quality was good.



A. HYSPLIT Backwards Trajectory Forecast from July 16, 2009, 00LST backward to July 15, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 15, 2009, 10:58 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

15-Jul	HRLY PM2.5
0:00	50.9
1:00	58.0
2:00	148.8
3:00	290.7
4:00	248.9
5:00	219.1
6:00	221.3
7:00	200.1

15-Jul	HRLY PM2.5
8:00	215.7
9:00	126.6
10:00	48.2
11:00	14.0
12:00	18.4
13:00	22.8
14:00	23.6
15:00	15.8

15-Jul	HRLY PM2.5
16:00	24.5
17:00	16.0
18:00	17.5
19:00	14.5
20:00	20.4
21:00	22.3
22:00	9.6
23:00	7.9

D. Hourly $PM_{2.5}$ for July 15, 2009

Figure 33 July 15, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 22: Hourly Observations for Fairbanks International Airport, July 15, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907142353	200	6	***	5	4 (Smoke)	**
702610	26411	200907150053	270	11	***	5	4 (Smoke)	**
702610	26411	200907150153	280	10	17	6	4 (Smoke)	**
702610	26411	200907150253	190	11	***	3	4 (Smoke)	17 (TSTM no Precip)
702610	26411	200907150353	220	5	***	3	4 (Smoke)	17 (TSTM no Precip)
702610	26411	200907150453	180	7	***	1.3	4 (Smoke)	**
702610	26411	200907150553	210	3	***	1	4 (Smoke)	**
702610	26411	200907150653	250	10	***	1	4 (Smoke)	**
702610	26411	200907150753	340	5	***	1	4 (Smoke)	**
702610	26411	200907150853	340	6	***	4	61 (R-)	4 (Smoke)
702610	26411	200907150953	20	5	***	5	4 (Smoke)	**
702610	26411	200907151053	350	8	***	2	61 (R-)	4 (Smoke)
702610	26411	200907151153	360	9	***	7	**	**
702610	26411	200907151253	350	11	***	10	61 (R-)	**
702610	26411	200907151353	340	7	***	10	61 (R-)	**
702610	26411	200907151453	310	6	***	9.1	61 (R-)	**
702610	26411	200907151553	300	5	***	10	**	**
702610	26411	200907151653	240	6	***	10	**	**
702610	26411	200907151753	190	7	***	10	**	**
702610	26411	200907151853	210	5	***	10	**	**
702610	26411	200907151953	990	3	***	10	**	**
702610	26411	200907152053	210	5	***	10	**	**
702610	26411	200907152153	200	6	***	10	**	**
702610	26411	200907152253	200	6	***	10	**	**

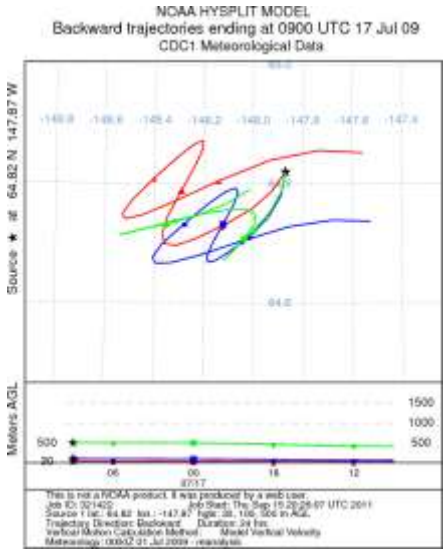
July 16, 2009

Figure 34, the wind flow had changed directions with the passage of the weather front the day before. On the MODIS imagery for July 16, 2009, 11:41AM LST, green arrows were added near each fire complex to indicate the current direction that the smoke is moving. It can be seen that the wind flow is changing with distance. The wind is from the SW in the most northern area, from the ENE just to the east of Fairbanks, and from the NW near the fires in Canada (lower right side of the imagery). Although the flow is from the fires to the ENE of Fairbanks towards the city at this particular point in time, the flow varies enough and there is enough mixing due to frontal passage and enough suppression due to rain fall that the $PM_{2.5}$ levels remain below exceedance criteria.

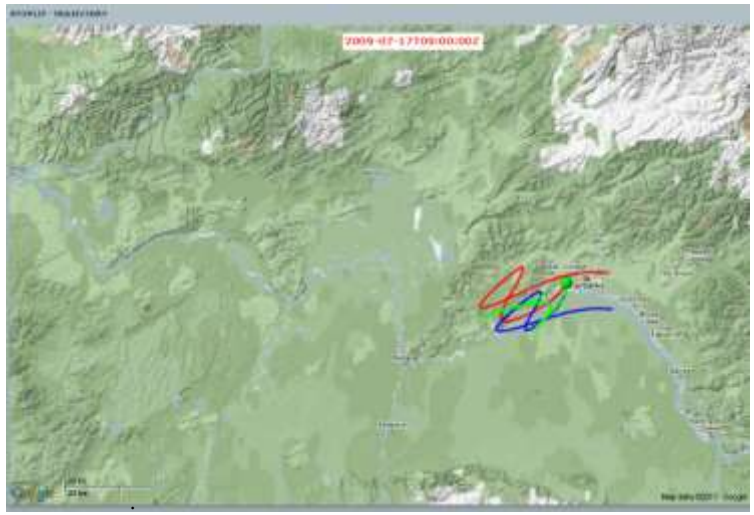
The HYSPLIT backwards trajectory reflects the frontal passage with winds switching direction throughout the day.

Observations at the Fairbanks airport indicate early morning patchy fog and haze, improving by the afternoon when the winds increase and enhance mixing through the atmosphere.

July 16 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 17.26µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 17, 2009, 00LST backward to July 16, 2009, 00LST.



HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. July 16, 2009, 11:41 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

16-Jul	HRLY PM2.5
0:00	3.5
1:00	5
2:00	14.1
3:00	10.7
4:00	8.7
5:00	19.7
6:00	20.8
7:00	20.1

16-Jul	HRLY PM2.5
8:00	27
9:00	28.1
10:00	41.1
11:00	36.6
12:00	25.4
13:00	19.1
14:00	11.9
15:00	11.9

16-Jul	HRLY PM2.5
16:00	17.7
17:00	11.5
18:00	15
19:00	15
20:00	6.9
21:00	13.2
22:00	12.2
23:00	19.1

D. Hourly $PM_{2.5}$ for July 16, 2009

Figure 34 July 16, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 23: Hourly Observations for Fairbanks International Airport, July 16, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907152353	***	0	***	10	**	**
702610	26411	200907160053	***	0	***	10	**	**
702610	26411	200907160153	***	0	***	10	**	**
702610	26411	200907160253	***	0	***	10	**	**
702610	26411	200907160353	30	3	***	10	41 (F Patchy)	**
702610	26411	200907160453	***	0	***	10	41 (F Patchy)	**
702610	26411	200907160553	***	0	***	2	10 (Mist)	**
702610	26411	200907160653	30	6	***	6	41 (F Patchy)	**
702610	26411	200907160753	40	3	***	5	41 (F Patchy)	**
702610	26411	200907160853	***	0	***	7	**	**
702610	26411	200907160953	140	5	***	7	**	**
702610	26411	200907161053	***	0	***	10	**	**
702610	26411	200907161153	***	0	***	10	**	**
702610	26411	200907161253	990	3	***	10	**	**
702610	26411	200907161353	***	0	***	10	**	**
702610	26411	200907161453	***	0	***	10	**	**
702610	26411	200907161553	100	3	***	10	**	**
702610	26411	200907161653	120	5	***	7	**	**
702610	26411	200907161753	130	5	***	10	**	**
702610	26411	200907161853	130	6	***	10	**	**
702610	26411	200907161953	***	0	***	10	**	**
702610	26411	200907162053	***	0	***	10	**	**
702610	26411	200907162153	***	0	***	10	**	**
702610	26411	200907162253	***	0	***	10	**	**

Analysis for July 17 - 21, 2009. No daily analysis is provided for the next 3 days because the daily $PM_{2.5}$ concentrations were low. The days for which ADEC is requesting exception have a $PM_{2.5}$ 24 hour average of at least 17µg/m^3. Evaluations are not included for any dates that have 24 hour $PM_{2.5}$ concentrations less than 17µg/m^3. The next date has a value greater than 17µg/m^3 is July 20, 2009.

July 17	14.50µg/m^3
July 18	10.2 µg/m^3
July 19	7.25µg/m^3
July 20	17.51µg/m^3. See discussion below
July 21	6.50µg/m^3

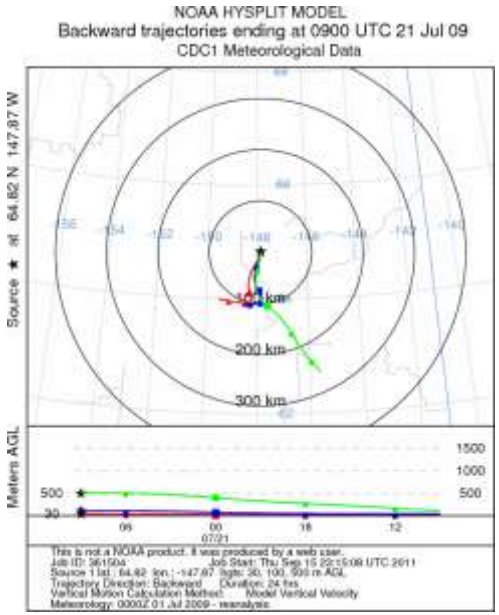
July 20, 2009

Figure 35, a daily analysis is presented for July 20, 2009 since the overall particulate concentration exceeds 17µg/m^3. The 11:16 AM MODIS imagery shows smoke over most of the area. The fire to the southwest of Fairbanks (Railbelt Complex) is mostly obscured by clouds. Most of the smoke appears to have been mixed or is less dense due to dispersion.

The HYSPLIT backwards trajectory: The trajectory is from the northwest and then from the southwest. This trajectory brings some smoke into Fairbanks.

Observations at the Fairbanks airport report the strongest winds are from the southeast in the afternoon hours.

July 16 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 17.51µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 21, 2009, 00LST backward to July 20, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. July 20, 2009, 11:16 AM LST MODIS imagery with 30m trajectory(red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

20-Jul	HRLY PM2.5
0:00	5.0
1:00	15.5
2:00	10.9
3:00	19.4
4:00	20.1
5:00	23.8
6:00	24.8
7:00	19.4

20-Jul	HRLY PM2.5
8:00	15.3
9:00	17.9
10:00	17.9
11:00	19.7
12:00	17.2
13:00	13.1
14:00	17.7
15:00	9.2

20-Jul	HRLY PM2.5
16:00	17.0
17:00	21.9
18:00	25.0
19:00	20.4
20:00	22.1
21:00	25.8
22:00	23.8
23:00	24.1

D. Hourly $PM_{2.5}$ for July 20, 2009,

Figure 35 July 20, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 24: Hourly Observations for Fairbanks International Airport, July 20, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907192353	***	0	***	10	**	**
702610	26411	200907200053	***	0	***	10	**	**
702610	26411	200907200153	40	7	***	10	**	**
702610	26411	200907200253	50	8	***	10	**	**
702610	26411	200907200353	***	0	***	10	**	**
702610	26411	200907200453	***	0	***	10	**	**
702610	26411	200907200553	40	5	***	10	**	**
702610	26411	200907200653	***	0	***	10	**	**
702610	26411	200907200753	***	0	***	10	**	**
702610	26411	200907200853	***	0	***	10	**	**
702610	26411	200907200953	***	0	***	10	**	**
702610	26411	200907201053	170	3	***	10	**	**
702610	26411	200907201153	***	0	***	10	**	**
702610	26411	200907201253	180	3	***	10	**	**
702610	26411	200907201353	170	6	***	10	**	**
702610	26411	200907201453	170	5	***	10	**	**
702610	26411	200907201553	130	7	***	10	**	**
702610	26411	200907201653	90	3	***	10	**	**
702610	26411	200907201753	140	6	***	10	**	**
702610	26411	200907201853	110	3	***	10	**	**
702610	26411	200907201953	160	7	***	10	**	**
702610	26411	200907202053	160	3	***	10	**	**
702610	26411	200907202153	50	5	***	10	**	**
702610	26411	200907202253	110	3	***	10	**	**

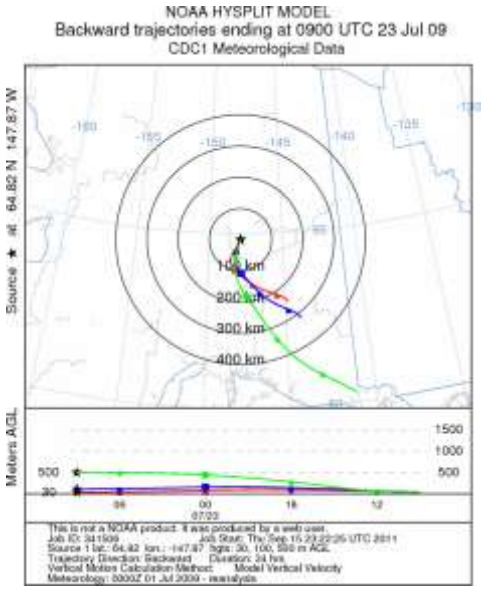
July 22, 2009

Figure 36, the 12:42 PM MODIS imagery shows fires to the southwest of Fairbanks and smoke to the west of Fairbanks.

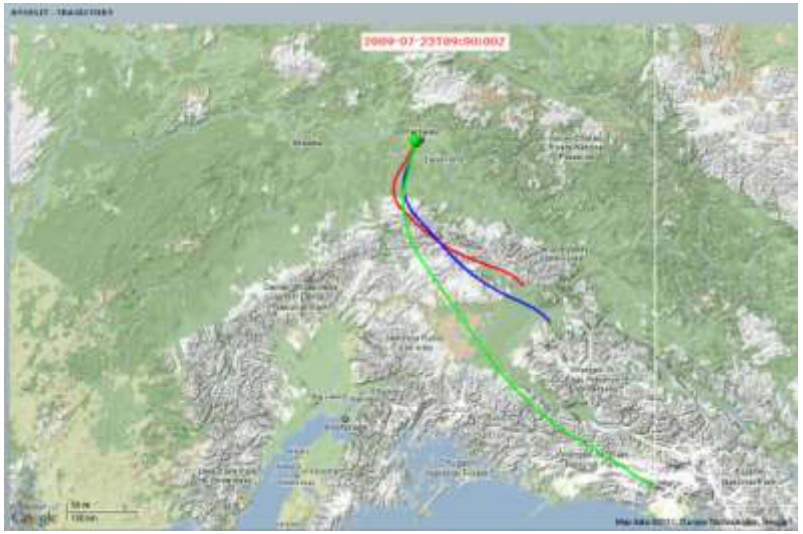
The HYSPLIT backwards trajectory: The trajectory shows 30 meter winds from the southeast turning more southerly through the day.

Observations at the Fairbanks airport indicate the surface winds were more westerly in the afternoon and evening hours. With the smoke in place throughout the day to the west of Fairbanks, these westerly wind brought smoke into the city. $PM_{2.5}$ reading increased rapidly after 3PM LST.

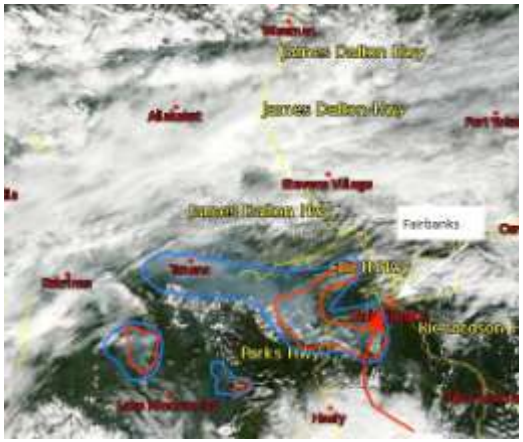
July 22 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 22.27µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 23, 2009, 00LST backward to July 22, 2009, 00LST.



B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 22, 2009, 12:42 PM LST MODIS imagery with 30m trajectory(red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

22-Jul	HRLY PM2.5
0:00	6.0
1:00	7.2
2:00	7.7
3:00	6.0
4:00	7.0
5:00	12.3
6:00	10.9
7:00	3.8

22-Jul	HRLY PM2.5
8:00	3.1
9:00	0.9
10:00	0.9
11:00	0.4
12:00	10.4
13:00	5.3
14:00	5.5
15:00	3.5

22-Jul	HRLY PM2.5
16:00	36.7
17:00	124.9
18:00	93.9
19:00	57.3
20:00	58.7
21:00	42.9
22:00	36.0
23:00	35.0

D. Hourly $PM_{2.5}$ for July 22, 2009,

Figure 36 July 22, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 25: Hourly Observations for Fairbanks International Airport, July 22, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907212353	130	14	22	10	**	**
702610	26411	200907220053	100	5	***	10	**	**
702610	26411	200907220153	***	0	***	10	**	**
702610	26411	200907220253	50	3	***	10	**	**
702610	26411	200907220353	***	0	***	10	**	**
702610	26411	200907220453	40	3	***	10	**	**
702610	26411	200907220553	***	0	***	10	**	**
702610	26411	200907220653	***	0	***	10	**	**
702610	26411	200907220753	30	5	***	10	**	**
702610	26411	200907220853	110	6	***	10	**	**
702610	26411	200907220953	120	5	***	10	**	**
702610	26411	200907221053	100	5	***	10	**	**
702610	26411	200907221153	80	6	***	10	**	**
702610	26411	200907221253	990	5	***	10	**	**
702610	26411	200907221353	80	6	***	10	**	**
702610	26411	200907221453	990	6	***	10	**	**
702610	26411	200907221553	80	7	***	10	**	**
702610	26411	200907221653	***	0	***	10	**	**
702610	26411	200907221753	250	7	***	3	4 (Smoke)	**
702610	26411	200907221853	250	13	***	3	4 (Smoke)	**
702610	26411	200907221953	240	5	***	3	4 (Smoke)	**
702610	26411	200907222053	***	0	***	10	**	**
702610	26411	200907222153	350	6	***	10	**	**
702610	26411	200907222253	***	0	***	10	**	**

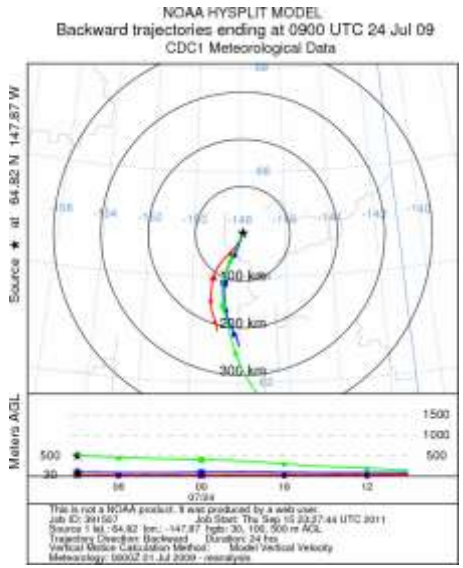
July 23, 2009

Figure 37, the MODIS imagery shows fires to the southwest of Fairbanks and smoke moving over Fairbanks. To the northwest of Fairbanks there is an extensive area of smoke.

The HYSPLIT backwards trajectory shows 30 meter winds from the south-southeast.

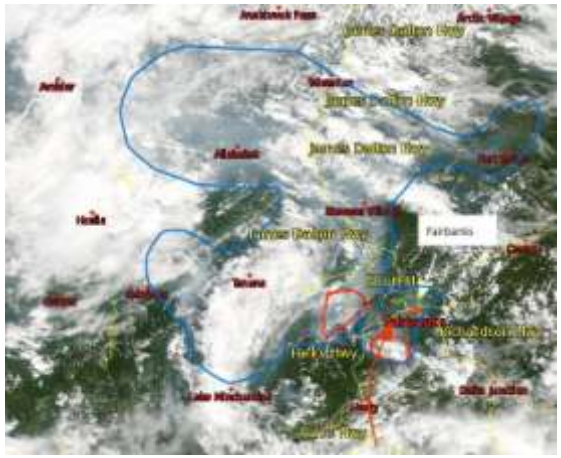
Observations at the Fairbanks airport indicate the winds were variable and the $PM_{2.5}$ concentrations reflect this. The $PM_{2.5}$ concentrations were elevated but went up and down depending on the direction of the wind.

July 23 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 17.46µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 24, 2009, 00LST backward to July 23, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 23, 2009, 12:42 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

23-Jul	HRLY PM2.5
0:00	34.8
1:00	29.9
2:00	27.7
3:00	23.8
4:00	22.8
5:00	20.6
6:00	27.0
7:00	28.4

23-Jul	HRLY PM2.5
8:00	35.8
9:00	18.7
10:00	17.7
11:00	24.1
12:00	48.2
13:00	47.5
14:00	27.2
15:00	54.3

23-Jul	HRLY PM2.5
16:00	44.3
17:00	28.2
18:00	13.6
19:00	17.2
20:00	27.7
21:00	29.2
22:00	16.2
23:00	36.5

D. Hourly $PM_{2.5}$ for July 23, 2009,

Figure 37 July 23, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 26: Hourly Observations for Fairbanks International Airport, July 23, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907222353	***	0	***	10	**	**
702610	26411	200907230053	40	3	***	10	**	**
702610	26411	200907230153	50	3	***	10	**	**
702610	26411	200907230253	***	0	***	10	**	**
702610	26411	200907230353	***	0	***	10	**	**
702610	26411	200907230453	***	0	***	10	**	**
702610	26411	200907230553	***	0	***	10	**	**
702610	26411	200907230653	***	0	***	10	**	**
702610	26411	200907230753	***	0	***	10	**	**
702610	26411	200907230853	***	0	***	10	**	**
702610	26411	200907230953	***	0	***	10	**	**
702610	26411	200907231053	990	3	***	10	**	**
702610	26411	200907231153	***	0	***	10	**	**
702610	26411	200907231253	***	0	***	7	**	**
702610	26411	200907231353	***	0	***	6	4 (Smoke)	**
702610	26411	200907231453	***	0	***	6	4 (Smoke)	**
702610	26411	200907231553	270	9	***	6	4 (Smoke)	**
702610	26411	200907231653	990	3	***	6	4 (Smoke)	**
702610	26411	200907231753	210	3	***	6	4 (Smoke)	**
702610	26411	200907231853	210	7	***	6	4 (Smoke)	**
702610	26411	200907231953	200	6	***	8	**	**
702610	26411	200907232053	180	6	***	7	**	**
702610	26411	200907232153	***	0	***	7	**	**
702610	26411	200907232253	***	0	***	7	**	**

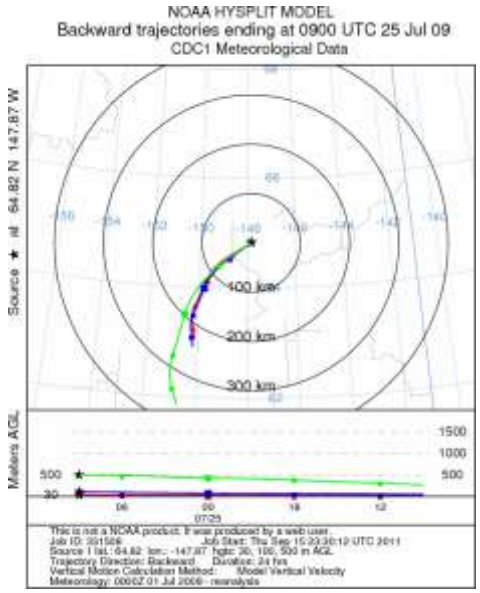
July 24, 2009

Figure 38, not all fires are visible in the MODIS imagery due to cloudiness. There is still a large area of smoke from the northwest to the north to the northeast.

The HYSPLIT backwards trajectory: The trajectory shows 30 meter winds from the south-southeast.

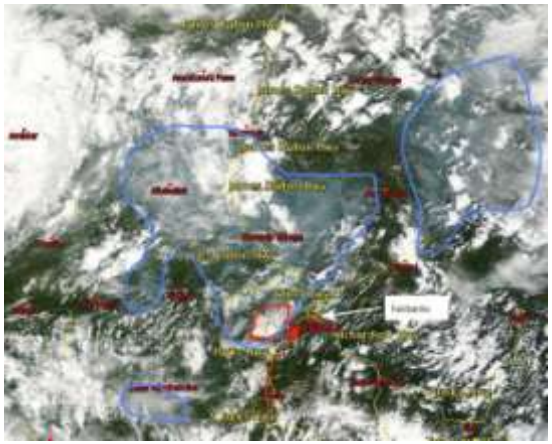
Observations at the Fairbanks airport: Winds at the surface during the day were westerly until 5PM. The wind then shifted to come from the southeast. At that time the PM concentrations increased for a 3-hr period and then dropped off significantly after 8PM when the winds shifted back around to the south.

FRM 24 hour $PM_{2.5}$ concentration was 17.70µg/m^3 for this date. Secondary $PM_{2.5}$ 24 hour average was 17.46µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 25, 2009, 00LST backward to July 24, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 24, 2009, 12:29 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

24-Jul	HRLY PM2.5
0:00	19.9
1:00	27.2
2:00	17.9
3:00	22.8
4:00	25.8
5:00	26.3
6:00	23.6
7:00	14.3

24-Jul	HRLY PM2.5
8:00	10.4
9:00	16.2
10:00	9.2
11:00	13.3
12:00	9.4
13:00	6.5
14:00	4.0
15:00	5.7

24-Jul	HRLY PM2.5
16:00	7.2
17:00	12.1
18:00	54.8
19:00	63.6
20:00	42.6
21:00	7.5
22:00	2.8
23:00	2.6

D. Hourly $PM_{2.5}$ for July 24, 2009,

Figure 38 July 24, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 27: Hourly Observations for Fairbanks International Airport, July 24, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907232353	180	6	***	8	**	**
702610	26411	200907240053	30	3	***	10	**	**
702610	26411	200907240153	40	7	***	10	**	**
702610	26411	200907240253	90	3	***	10	**	**
702610	26411	200907240353	***	0	***	10	**	**
702610	26411	200907240453	40	3	***	10	**	**
702610	26411	200907240553	***	0	***	10	**	**
702610	26411	200907240653	***	0	***	10	**	**
702610	26411	200907240753	***	0	***	10	**	**
702610	26411	200907240853	***	0	***	10	**	**
702610	26411	200907240953	150	5	***	10	**	**
702610	26411	200907241053	990	3	***	10	**	**
702610	26411	200907241153	250	8	***	10	**	**
702610	26411	200907241253	280	10	***	10	**	**
702610	26411	200907241353	250	8	***	10	**	**
702610	26411	200907241453	990	7	***	10	**	**
702610	26411	200907241553	260	9	***	10	**	**
702610	26411	200907241653	260	9	***	10	**	**
702610	26411	200907241753	160	7	***	10	**	**
702610	26411	200907241853	130	6	***	10	**	**
702610	26411	200907241953	140	7	***	5	4 (Smoke)	**
702610	26411	200907242053	180	5	***	5	4 (Smoke)	**
702610	26411	200907242153	200	3	***	7	**	**
702610	26411	200907242253	210	5	***	10	**	**

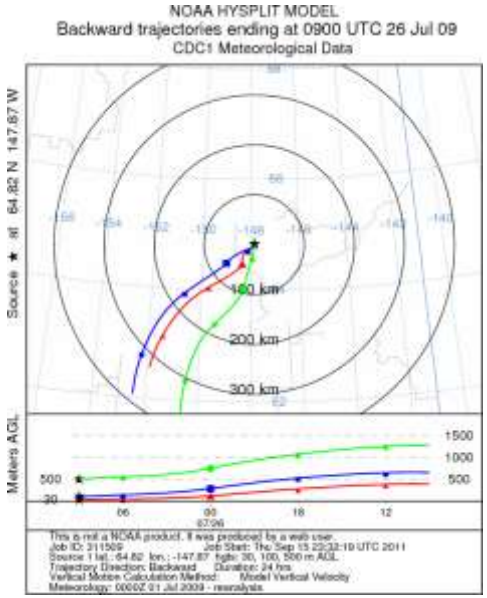
July 25, 2009

Figure 39, the MODIS imagery shows that the total area of smoke continues to increase across the interior.

The HYSPLIT backwards trajectory: The trajectory shows 30 meter winds are from the southwest. With the increase in the area of smoke around Fairbanks, the trajectory is becoming less definitive for predicting $PM_{2.5}$ concentrations. However, the consistent and increasing easterly winds did eventually push the smoke to the west of Fairbanks as seen in the lower concentrations in the late afternoon and evening.

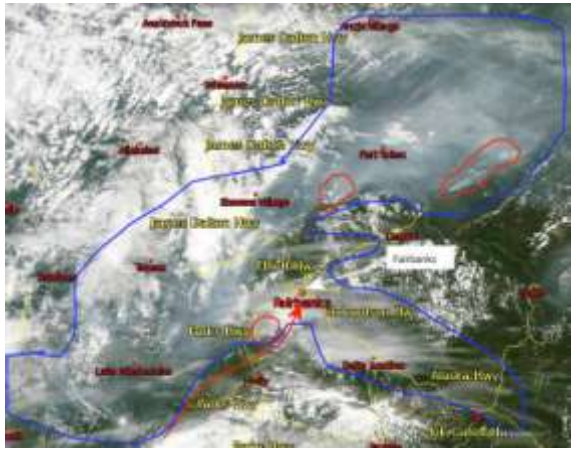
Observations at the Fairbanks airport: As noted above there was a significant decrease in $PM_{2.5}$ concentrations in the late afternoon and evening.

July 25 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average concentration was 22.79µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 26, 2009, 00LST backward to July 25, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 25, 2009, 11:34 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

25-Jul	HRLY PM2.5
0:00	6.5
1:00	27.2
2:00	35.8
3:00	49.4
4:00	36.5
5:00	32.6
6:00	29.2
7:00	48.2

25-Jul	HRLY PM2.5
8:00	63.1
9:00	62.9
10:00	34.3
11:00	56.5
12:00	28.4
13:00	20.9
14:00	15.3
15:00	5.3

25-Jul	HRLY PM2.5
16:00	3.3
17:00	5.5
18:00	7.9
19:00	5.0
20:00	3.3
21:00	2.3
22:00	4.0
23:00	7.0

D. Hourly $PM_{2.5}$ for July 25, 2009,

Figure 39 July 25, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 28: Hourly Observations for Fairbanks International Airport, July 25, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907242353	***	0	***	10	**	**
702610	26411	200907250053	***	0	***	10	**	**
702610	26411	200907250153	70	3	***	10	**	**
702610	26411	200907250253	***	0	***	10	**	**
702610	26411	200907250353	70	3	***	10	**	**
702610	26411	200907250453	***	0	***	8	**	**
702610	26411	200907250553	80	3	***	7	**	**
702610	26411	200907250653	50	3	***	7	**	**
702610	26411	200907250753	***	0	***	7	**	**
702610	26411	200907250853	***	0	***	6	4 (Smoke)	**
702610	26411	200907250953	80	3	***	6	4 (Smoke)	**
702610	26411	200907251053	90	6	***	6	4 (Smoke)	**
702610	26411	200907251153	120	6	***	7	**	**
702610	26411	200907251253	120	5	***	4	4 (Smoke)	**
702610	26411	200907251353	90	6	***	10	**	**
702610	26411	200907251453	80	6	***	10	**	**
702610	26411	200907251553	90	6	***	10	**	**
702610	26411	200907251653	90	7	***	10	**	**
702610	26411	200907251753	80	6	***	10	**	**
702610	26411	200907251853	70	7	***	10	**	**
702610	26411	200907251953	***	0	***	10	**	**
702610	26411	200907252053	40	9	***	10	**	**
702610	26411	200907252153	30	8	***	10	**	**
702610	26411	200907252253	30	7	***	10	**	**

July 26, 2009

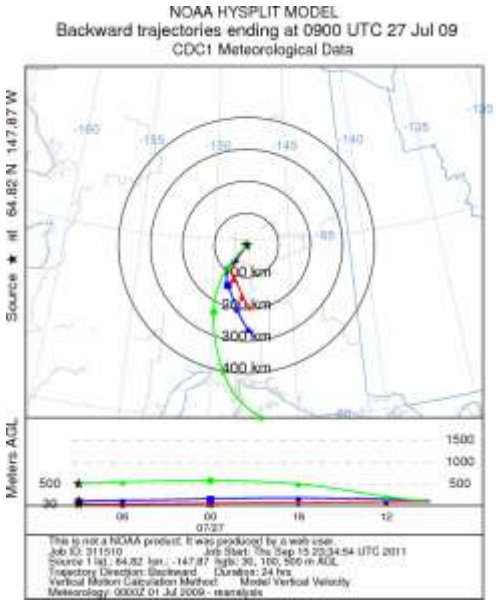
Figure 40, NOTE: July 26, 2009 was not an exceedance date and is only included in this report for meteorological continuity.

In the MODIS imagery some fires are not visible due to cloud cover. The most visible fire is the Little Black One Fire to the northeast of Fairbanks.

The HYSPLIT backwards trajectory shows the smoke is coming from the southeast where there is little fire activity at this time. Low $PM_{2.5}$ concentrations reflect this trajectory.

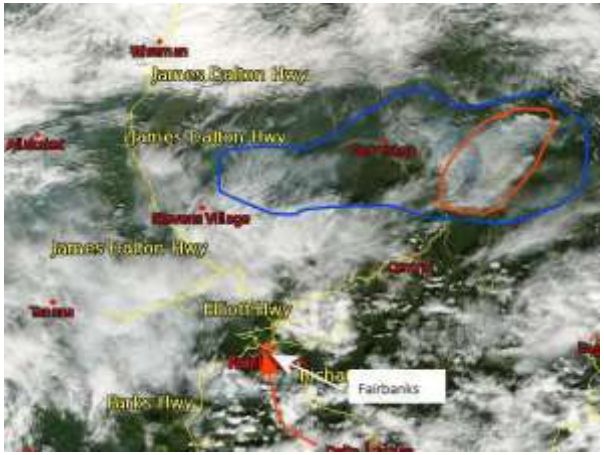
Observations at the Fairbanks airport indicate good visibility throughout the day.

July 26 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 14.29µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 27, 2009, 00LST backward to July 26, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 26, 2009, 12:17 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand

26-Jul	HRLY PM2.5
0:00	7.5
1:00	6.2
2:00	16.0
3:00	16.7
4:00	17.0
5:00	14.5
6:00	29.9
7:00	20.6

26-Jul	HRLY PM2.5
8:00	19.9
9:00	11.4
10:00	11.4
11:00	10.9
12:00	19.7
13:00	20.1
14:00	10.9
15:00	10.6

26-Jul	HRLY PM2.5
16:00	39.2
17:00	44.6
18:00	30.6
19:00	5.3
20:00	5.3
21:00	0.6
22:00	-5.0
23:00	-4.0

D. Hourly $PM_{2.5}$ for July 26, 2009,

Figure 40 July 26, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 29: Hourly Observations for Fairbanks International Airport, July 26, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907252353	30	7	***	10	**	**
702610	26411	200907260053	30	3	***	10	**	**
702610	26411	200907260153	60	5	***	10	**	**
702610	26411	200907260253	360	3	***	10	**	**
702610	26411	200907260353	***	0	***	10	**	**
702610	26411	200907260453	***	0	***	10	**	**
702610	26411	200907260553	40	6	***	10	**	**
702610	26411	200907260653	40	5	***	10	**	**
702610	26411	200907260753	30	3	***	9.1	**	**
702610	26411	200907260853	20	5	***	9.1	**	**
702610	26411	200907260953	90	7	***	10	**	**
702610	26411	200907261053	80	9	***	10	**	**
702610	26411	200907261153	990	3	***	10	**	**
702610	26411	200907261253	100	5	***	10	**	**
702610	26411	200907261353	110	6	***	10	**	**
702610	26411	200907261453	***	0	***	10	**	**
702610	26411	200907261553	***	0	***	10	**	**
702610	26411	200907261653	***	0	***	7	**	**
702610	26411	200907261753	***	0	***	7	**	**
702610	26411	200907261853	220	6	***	7	**	**
702610	26411	200907261953	210	3	***	7	**	**
702610	26411	200907262053	990	3	***	10	**	**
702610	26411	200907262153	990	6	***	10	**	**
702610	26411	200907262253	***	0	***	10	**	**

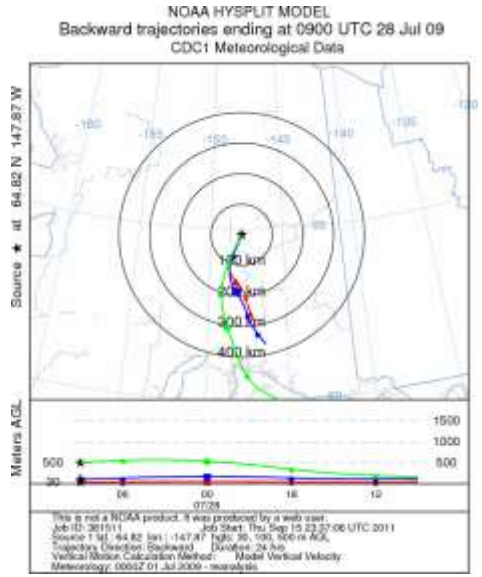
July 27, 2009

Figure 41, Note how extensive the smoke is becoming to the north and northeast of Fairbanks. Also note the new fires in Canada (lower right of image). The fire to the south of Fairbanks is not visible in the MODIS imagery due to cloud cover.

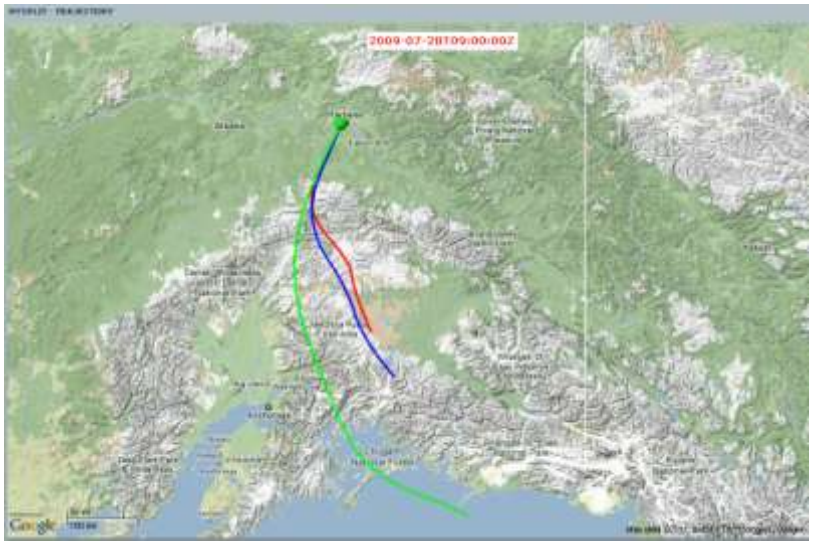
The HYSPLIT backwards trajectory shows the smoke coming from the south where the Wood River fire is located. The trajectory shows an easterly component during the first part of the day but becoming southerly later

Observations at the Fairbanks airport show that the winds shifted to a more southwesterly direction in the evening bringing smoke into Fairbanks. Visibility began to decrease at 8PM with smoke reported as an obstruction to visibility after 9PM. In addition to this wind shift, a shallow inversion formed by morning. In spite of the 24 hours of daylight, the lower atmosphere still cools at night and at times forms a shallow inversion. This happened the night of the 27th – 28th. A steep but shallow inversion formed overnight that concentrated the smoke at the surface. See Figure 42 The entire radiosonde graph is available in Appendix D. $PM_{2.5}$ concentrations increased rapidly after 9PM.

FRM 24 hour $PM_{2.5}$ concentration was 25.60µg/m^3 for this date. Secondary $PM_{2.5}$ 24 hour concentration was 27.35µg/m^3. Concentrations increased rapidly in the later hours as smoke moved over Fairbanks from the Wood river fires to the south.



A. HYSPLIT Backwards Trajectory Forecast from July 28, 2009, 00LST backward to July 27, 2009, 00LST.



B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. July 27 2009, 1:00 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

27-Jul	HRLY PM2.5
0:00	27.2
1:00	36.0
2:00	22.1
3:00	21.6
4:00	23.8
5:00	18.9
6:00	18.9
7:00	27.5

27-Jul	HRLY PM2.5
8:00	21.6
9:00	11.4
10:00	3.5
11:00	5.5
12:00	5.7
13:00	0.6
14:00	0.9
15:00	-0.1

27-Jul	HRLY PM2.5
16:00	-0.4
17:00	3.5
18:00	10.4
19:00	36.0
20:00	51.2
21:00	108.0
22:00	128.1
23:00	74.6

D. Hourly $PM_{2.5}$ for July 27, 2009,

Figure 41 July 27, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 30: Hourly Observations for Fairbanks International Airport, July 27, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907262353	140	6	***	10	**	**
702610	26411	200907270053	990	6	***	10	**	**
702610	26411	200907270153	***	0	***	7	**	**
702610	26411	200907270253	***	0	***	8	**	**
702610	26411	200907270353	130	3	***	9.1	**	**
702610	26411	200907270453	70	3	***	9.1	**	**
702610	26411	200907270553	***	0	***	9.1	**	**
702610	26411	200907270653	***	0	***	7	**	**
702610	26411	200907270753	***	0	***	10	**	**
702610	26411	200907270853	***	0	***	10	**	**
702610	26411	200907270953	40	3	***	10	**	**
702610	26411	200907271053	20	6	***	10	**	**
702610	26411	200907271153	120	3	***	10	**	**
702610	26411	200907271253	50	5	***	10	**	**
702610	26411	200907271353	60	5	***	10	**	**
702610	26411	200907271453	80	5	***	10	**	**
702610	26411	200907271553	120	9	***	10	**	**
702610	26411	200907271653	130	6	***	10	**	**
702610	26411	200907271753	150	6	***	10	**	**
702610	26411	200907271853	***	0	***	10	**	**
702610	26411	200907271953	***	0	***	8	**	**
702610	26411	200907272053	230	6	***	6	4 (Smoke)	**
702610	26411	200907272153	***	0	***	5	4 (Smoke)	**
702610	26411	200907272253	240	3	***	4	4 (Smoke)	**

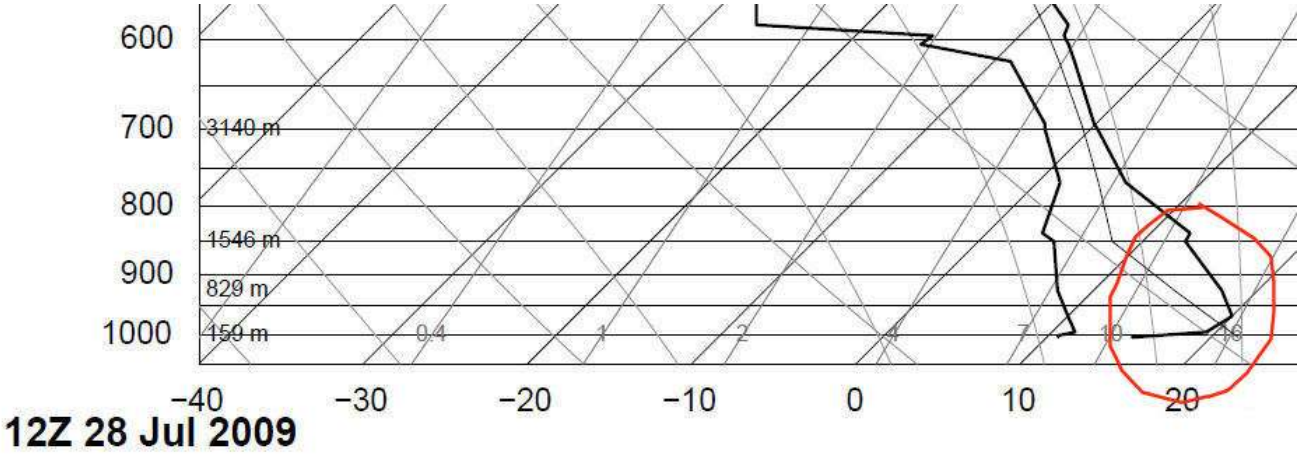


Figure 42: Lower portion of Fairbanks Radiosonde graphic
Note trace of temperature (circled in red) showing increasing temperature as the balloon ascended, indicating a temperature inversion.

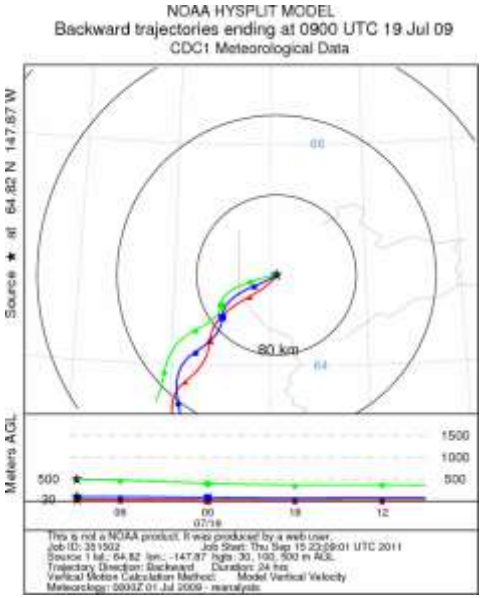
July 28, 2009

Figure 43, the two most striking features on this day's MODIS image are the increase in smoke across the entire area and the number of new fires in Canada (lower right). However not all visible smoke is at the surface.

The HYSPLIT backwards trajectory: The trajectory is through fires to the south of Fairbanks.

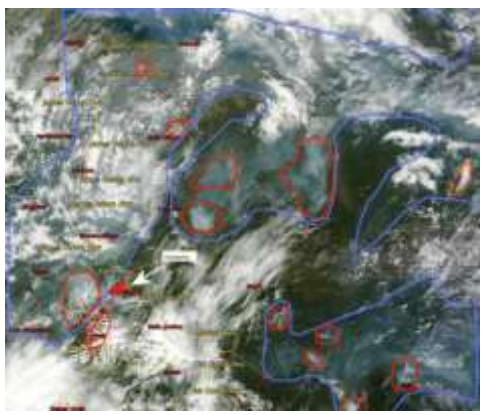
Observations at the Fairbanks airport indicate that the smoke was being advected into the area beginning in the first hours after midnight (LST). Smoke is reported as a restriction to visibility throughout July 27 2009.

July 28 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 HR average was 27.73µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 29, 2009, 00LST backward to July 28, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 28 2009, 12:05 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

28-Jul	HRLY PM2.5
0:00	74.1
1:00	78.5
2:00	67.5
3:00	46.8
4:00	52.6
5:00	43.8
6:00	46.5
7:00	35.3

28-Jul	HRLY PM2.5
8:00	23.1
9:00	23.8
10:00	17.5
11:00	13.8
12:00	17.9
13:00	13.3
14:00	18.7
15:00	20.9

28-Jul	HRLY PM2.5
16:00	22.6
17:00	17.5
18:00	17.5
19:00	13.1
20:00	12.3
21:00	15.5
22:00	13.3
23:00	18.2

D. Hourly $PM_{2.5}$ for July 28, 2009,

Figure 43 July 28, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 31: Hourly Observations for Fairbanks International Airport, July 28, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907272353	***	0	***	8	**	**
702610	26411	200907280053	140	6	***	6	4 (Smoke)	**
702610	26411	200907280153	***	0	***	6	4 (Smoke)	**
702610	26411	200907280253	130	6	***	7	**	**
702610	26411	200907280353	***	0	***	9.1	**	**
702610	26411	200907280453	***	0	***	9.1	**	**
702610	26411	200907280553	***	0	***	9.1	**	**
702610	26411	200907280653	10	3	***	10	**	**
702610	26411	200907280753	***	0	***	10	**	**
702610	26411	200907280853	150	7	***	10	**	**
702610	26411	200907280953	80	3	***	10	**	**
702610	26411	200907281053	***	0	***	10	**	**
702610	26411	200907281153	990	3	***	10	**	**
702610	26411	200907281253	***	0	***	10	**	**
702610	26411	200907281353	100	8	***	10	**	**
702610	26411	200907281453	90	8	***	10	**	**
702610	26411	200907281553	110	7	***	10	**	**
702610	26411	200907281653	***	0	***	10	**	**
702610	26411	200907281753	***	0	***	10	**	**
702610	26411	200907281853	***	0	***	10	**	**
702610	26411	200907281953	120	5	***	10	**	**
702610	26411	200907282053	100	6	***	10	**	**
702610	26411	200907282153	50	5	***	10	**	**
702610	26411	200907282253	***	0	***	10	**	**

July 29, 2009

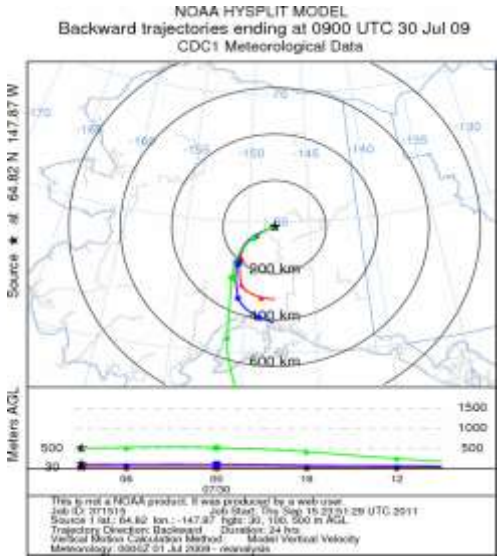
Figure 44, although the secondary $PM_{2.5}$ 24 hour concentration was low on this day at 10.27µg/m^3, a short discussion is presented in order to set the stage for July 30, the beginning of 10 straight days of exceedances.

The dashed black line on the MODIS imagery indicates an approaching front. This rapid moving front would increase the mixing of the smoke both horizontally and vertically, resulting is significantly lower PM concentrations. However, also notice that the winds seem to be fanning the fires in the area. The Wood River fire to the southwest of Fairbanks is obscured. However the Little Black One fire to the northwest can be seen and is producing dense smoke at or near the surface.

The HYSPLIT backwards trajectory map is the entire state of Alaska instead of just part of the state around Fairbanks. This is due to the very long trajectory over the 24-hour period – an indication of how rapid the winds were and how enhanced the mixing of the smoke.

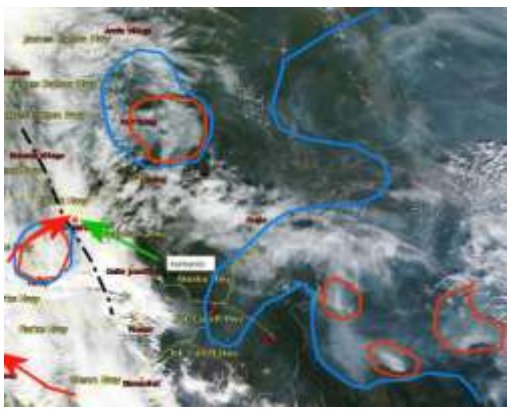
Observations at the Fairbanks airport record winds were up to 7 MPH during this period and no precipitation with this front.

July 29 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour average was 10.27µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from July 30, 2009, 00LST backward to July 29, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 29 2009, 12:48 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

29-Jul	HRLY PM2.5
0:00	14.3
1:00	11.8
2:00	9.4
3:00	12.1
4:00	9.9
5:00	11.8
6:00	10.1
7:00	10.4

29-Jul	HRLY PM2.5
8:00	10.6
9:00	7.7
10:00	7.0
11:00	11.4
12:00	9.6
13:00	8.4
14:00	4.3
15:00	4.5

29-Jul	HRLY PM2.5
16:00	5.5
17:00	11.8
18:00	19.4
19:00	4.3
20:00	14.8
21:00	25.3
22:00	13.6
23:00	2.8

D. Hourly $PM_{2.5}$ for July 29, 2009,

Figure 44 July 29, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 32: Hourly Observations for Fairbanks International Airport, July 29, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907282353	***	0	***	10	**	**
702610	26411	200907290053	40	5	***	10	**	**
702610	26411	200907290153	360	3	***	10	**	**
702610	26411	200907290253	40	5	***	10	**	**
702610	26411	200907290353	40	7	***	10	**	**
702610	26411	200907290453	***	0	***	10	**	**
702610	26411	200907290553	20	3	***	10	**	**
702610	26411	200907290653	20	6	***	10	**	**
702610	26411	200907290753	***	0	***	10	**	**
702610	26411	200907290853	***	0	***	10	**	**
702610	26411	200907290953	***	0	***	10	**	**
702610	26411	200907291053	990	5	***	10	**	**
702610	26411	200907291153	***	0	***	10	**	**
702610	26411	200907291253	***	0	***	10	**	**
702610	26411	200907291353	90	5	***	10	**	**
702610	26411	200907291453	130	7	***	10	**	**
702610	26411	200907291553	120	3	***	10	**	**
702610	26411	200907291653	***	0	***	10	**	**
702610	26411	200907291753	80	3	***	10	**	**
702610	26411	200907291853	70	3	***	10	**	**
702610	26411	200907291953	***	0	***	10	**	**
702610	26411	200907292053	230	6	***	10	**	**
702610	26411	200907292153	990	5	***	10	**	**
702610	26411	200907292253	220	6	***	10	**	**

July 30, 2009

Figure 45, MODIS imagery shows that smoke has spread across most of the area. The image shows only two areas not inundated with smoke. One area is located to the west and another to the southeast. The dashed line on the image indicates an area of very dense smoke to the northeast of Fairbanks.

The HYSPLIT backwards trajectory shows that the air passes through the fire to the southwest. Beginning on this day the trajectory would bring smoke into Fairbanks no matter what the wind direction.

Observations at the Fairbanks airport indicate smoke as a restriction to visibility beginning early in the morning and lasting throughout the day.

FRM 24 hour $PM_{2.5}$ concentration was 159.50µg/m^3 for this date. Secondary $PM_{2.5}$ 24 hour concentration was 153.53m^3. However it must be noted that these concentrations were computed for only 17 hours. The FRM filter data was only valid for 17 hours, most likely due to the load of particulate matter on the filter being too high. Although 24 hours of secondary data were available, only the same 17 hour period was used for comparison. When the entire 24 hour secondary data was analyzed, the $PM_{2.5}$ 24 hour concentration was 229.90µg/m^3.

AICC Incident report dated July 31, 2009, covering July 30 2009 events, is quoted (below) for the Minto Flats fire southwest of Fairbanks, Little Black One fire to the northeast of Fairbanks, and the Railbelt complex to the southwest of Fairbanks:

E03X	Lat:	**64:44:48**	Status:	**U/U**	Acres:	**335,360.0**	Option: **LIMITED**
911320	Lon:	**149:30:17**			Start Date:	6/21/09	Area: **FAS**
PNE03X	Legal:	2S 11W 14 F			Out Date:		Owner: STA
#320	Name:	**Minto Flats South**			Cause:	Lightning	Admin: REFU
Railbelt Compl	Narrative:	(Acreage Breakdowns: State Land - 321,971 / NCA - 22,032 / BLM - 11,357) With the SW winds, a smoke inversion has decreased fire behavior along the Northern perimeter. The SW perimeter exhibited 3-5 foot flame lengths at 1 Ch/Hr. The remaining perimeters displayed 1-3 foot flame lengths at a ROS of 3 Ch/Hr. The S perimeter was 90% active displaying a backing fire. Crews burned around allotments and cabins near H45 and along the Teklanika River. The fire received 2 T2 crews, 1 T3 Helo and 1 T2 Helo. Crews at H34 continued to construct indirect line in preparation for burnout operations. Resources will continue to perform the full array of fire management/suppression options along all flanks. Direct attack activities along the Teklanika and Tanana Rivers and on the E/SE flanks. Indirect attack will continue at Dune and Totek Lakes to include mop-up and line construction around cabins and allotments. Support the local area with Initial Attack resources. Acreage based on IR perimeter.					

E1N6	Lat:	**64:44:48**	Status:	**S/U**	Acres:	**0.0**	Option: **LIMITED**
911898	Lon:	**149:30:17**	Personnel:	277	Start Date:	6/21/09	Area: **FAS**
PNE1N6	Legal:	2S 10W 14 F			Out Date:		Owner: STA
#898	Name:	**Railbelt Complex**			Cause:	Lightning	Admin: FOR

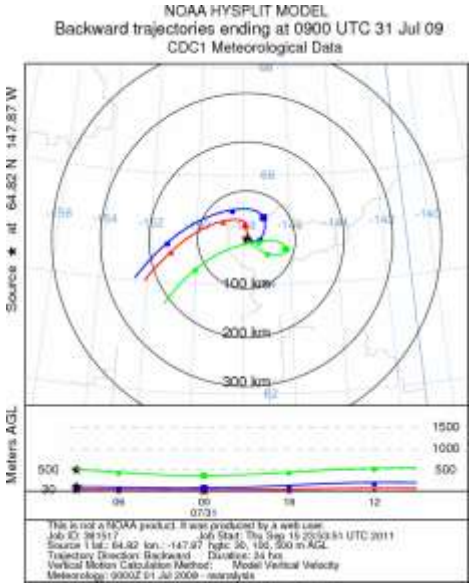
Narrative: The transition from the Type 3 to the Type 2 team was completed. The repeapter work was rescheduled for 7/31 due to the smoke inversion. Continued hot and dry weather and lack of precipitation in the fire area have prolonged site protection actions. With little or no predicted moisture, active spread on all flanks is expected to continue. Smoke has impacted crew movements by Helicopter. Strategic change; more direct suppression activites are planned.

Assigned Crews:		Assigned:
Augusta	T1	7/28
Chena IHC	T1	7/23
Delta #2	T2	7/21
Fairbanks #2	T2	7/23
Fairbanks #3	T2	7/13
Mindewin IHC	T1	7/30
USFS Interagency	T2IA	7/25
Upper Tanana 5	T2	7/25
Upper Tanana#3	T2	7/30
Yukon	T2IA	7/25

EZQ8	Lat:	**66:13:25**	Status:	**S/U**	Acres:	**257,478.3**	Option: **LIMITED**
	Lon:	**143:15:26**	Personnel:	60	Start Date:	6/20/09	Area: **UYD**
PDEZQ8	Legal:	16N 21E 11 F			Out Date:		Owner: FWS
#314	Name:	**Little Black One**			Cause:	Lightning - WFU	Admin: YFR

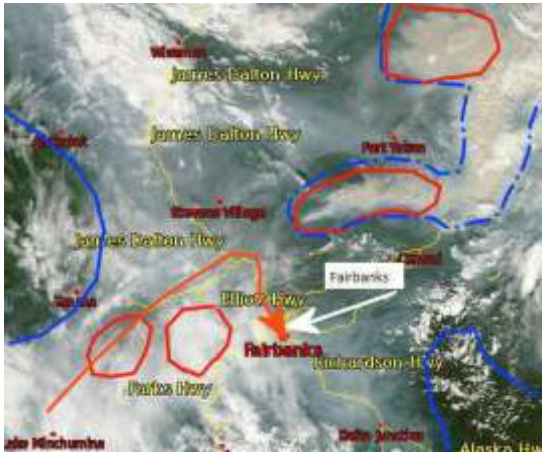
Narrative: Personnel were unable to map due to heavy smoke. Bears continue to be a concern in the area, and the distance between threatened values has presented a challenge. The area was too smokey to observe any fire behavior. Crews mopped up 20 feet inside the 12 Mile Bluff allotment and secured the southeast perimeter to the Yukon River with blackline. Personnel will mop in 50 feet around the 12 Mile Bluff allotment and burn out 500 feet from the southeast corner of the allotment to the Yukon River. An aerial reconassiance is planned along with repositioning the FWS #2 RAWS. One Type 2 Crew on order was diverted to a higher priority fire. The Midnight Sun IHC was also reassigned to a higher priority fire. Venetie #2 Type 2 Crew was demobed.

Assigned Crews:		Assigned:	
Ft. Yukon #1	T2	7/28	
Midnight Sun IHC	T1	7/21	Released: 7/30
Venetie #2	T2	7/15	Released: 7/30



A. HYSPLIT Backwards Trajectory Forecast from July 31, 2009, 00LST backward to July 30, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 30 2009, 11:53 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn

30-Jul	HRLY PM2.5
0:00	4.5
1:00	3.1
2:00	-1.1
3:00	0.4
4:00	38.7
5:00	147.6
6:00	128.3
7:00	248.7

30-Jul	HRLY PM2.5
8:00	298.5
9:00	291.9
10:00	312.9
11:00	286.3
12:00	283.8
13:00	274.1
14:00	269.9
15:00	220.3

30-Jul	HRLY PM2.5
16:00	220.3
17:00	147.3
18:00	145.4
19:00	174.2
20:00	166.4
21:00	159.3
22:00	178.6
23:00	147.3

D. Hourly $PM_{2.5}$ for July 30, 2009,

Figure 45 July 30, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 33: Hourly Observations for Fairbanks International Airport, July 30, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907292353	210	3	***	10	**	**
702610	26411	200907300053	240	5	***	10	**	**
702610	26411	200907300153	990	6	***	10	**	**
702610	26411	200907300253	210	7	***	10	**	**
702610	26411	200907300353	230	3	***	10	**	**
702610	26411	200907300453	200	7	***	10	**	**
702610	26411	200907300553	180	3	***	4	4 (Smoke)	**
702610	26411	200907300653	200	6	***	1.5	4 (Smoke)	**
702610	26411	200907300753	140	3	***	1.5	4 (Smoke)	**
702610	26411	200907300853	160	5	***	1	4 (Smoke)	**
702610	26411	200907300953	990	3	***	1	4 (Smoke)	**
702610	26411	200907301053	200	6	***	1	4 (Smoke)	**
702610	26411	200907301153	200	6	***	0.8	4 (Smoke)	**
702610	26411	200907301253	180	3	***	0.8	4 (Smoke)	**
702610	26411	200907301353	160	3	***	0.8	4 (Smoke)	**
702610	26411	200907301453	***	0	***	1	4 (Smoke)	**
702610	26411	200907301553	***	0	***	1	4 (Smoke)	**
702610	26411	200907301653	***	0	***	1	4 (Smoke)	**
702610	26411	200907301753	***	0	***	1.5	4 (Smoke)	**
702610	26411	200907301853	170	3	***	1.5	4 (Smoke)	**
702610	26411	200907301953	***	0	***	1.8	4 (Smoke)	**
702610	26411	200907302053	260	3	***	1.8	4 (Smoke)	**
702610	26411	200907302153	***	0	***	2.5	4 (Smoke)	**
702610	26411	200907302253	***	0	***	2.5	4 (Smoke)	**

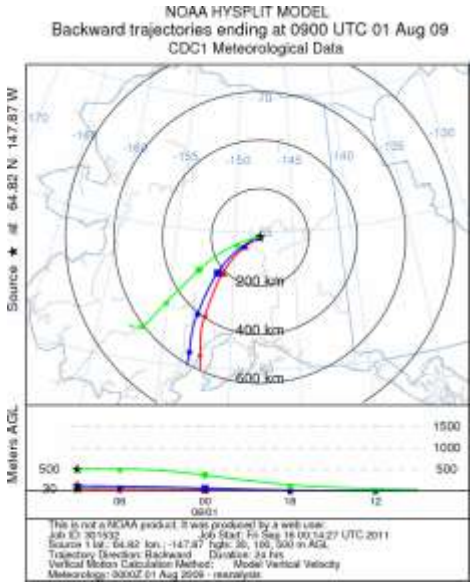
July 31, 2009

Figure 46, today's MODIS imagery shows dense smoke covering all but the most western and southern areas. Smoke is from fires in Alaska and in Canada. The trajectory drawn on the image shows the airflow from the fires that are burning to the south.

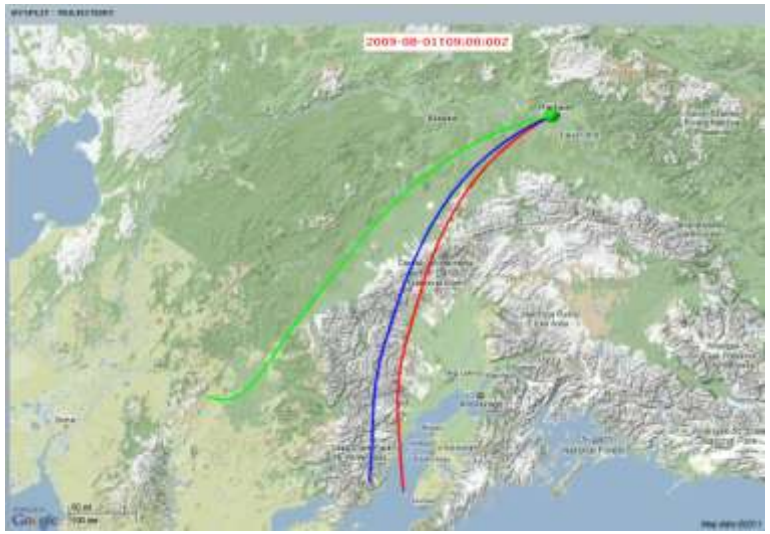
The HYSPLIT backwards trajectory path is still very long indicating stronger wind flow from the south but this flow is through a fire smoke area.

18 of 24 hourly observations report smoke as a restriction to visibility. There are two observations with light rain but even then the visibility does not improve – in fact the visibility goes from 4 miles to 1.3 miles.

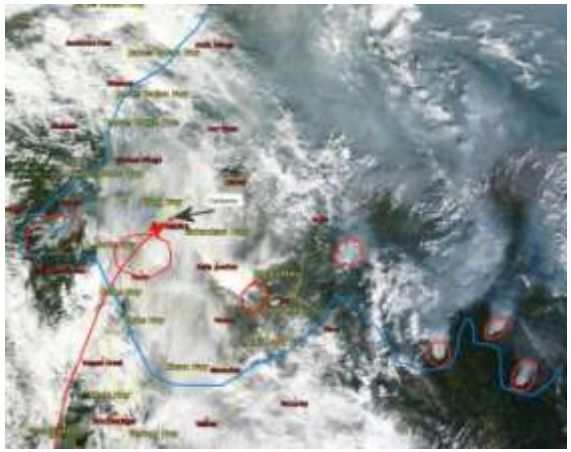
July 31 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 145.67µg/m^3. The hourly data shows PM concentrations between 471.3µg/m^3 to less than zero. During the afternoon when the PM concentrations dropped, the visibility also improved. The cause of the afternoon concentration decrease is unknown.



A. HYSPLIT Backwards Trajectory Forecast from August 1, 2009, 00LST backward to July 31, 2009, 00LST.



B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. July 31 2009, 12:36 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

31-Jul	HRLY PM2.5
0:00	353.4
1:00	471.3
2:00	385.4
3:00	297.0
4:00	226.9
5:00	175.7
6:00	100.7
7:00	154.2

31-Jul	HRLY PM2.5
8:00	82.6
9:00	62.1
10:00	10.6
11:00	17.9
12:00	121.0
13:00	75.3
14:00	62.6
15:00	-2.1

31-Jul	HRLY PM2.5
16:00	0.4
17:00	2.8
18:00	2.8
19:00	211.6
20:00	206.2
21:00	307.0
22:00	378.3
23:00	217.4

D. Hourly $PM_{2.5}$ for July 31, 2009,

Figure 46 July 31, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 34: Hourly Observations for Fairbanks International Airport, July 31, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907302353	40	8	***	1.8	4 (Smoke)	**
702610	26411	200907310053	30	6	***	2.5	4 (Smoke)	**
702610	26411	200907310153	70	8	***	1.5	4 (Smoke)	**
702610	26411	200907310253	80	6	***	1	4 (Smoke)	**
702610	26411	200907310353	250	3	***	1	4 (Smoke)	**
702610	26411	200907310453	30	5	***	0.5	4 (Smoke)	**
702610	26411	200907310553	***	0	***	0.5	4 (Smoke)	**
702610	26411	200907310653	***	0	***	0.8	4 (Smoke)	**
702610	26411	200907310753	***	0	***	1	4 (Smoke)	**
702610	26411	200907310853	***	0	***	1.3	4 (Smoke)	**
702610	26411	200907310953	***	0	***	2.5	4 (Smoke)	**
702610	26411	200907311053	240	17	22	7	**	**
702610	26411	200907311153	240	11	23	10	**	**
702610	26411	200907311253	240	15	26	2	4 (Smoke)	**
702610	26411	200907311353	250	15	28	3	4 (Smoke)	**
702610	26411	200907311453	250	9	21	3	4 (Smoke)	**
702610	26411	200907311553	220	10	20	10	**	**
702610	26411	200907311653	240	8	16	10	**	**
702610	26411	200907311753	240	9	***	10	**	**
702610	26411	200907311853	990	5	***	10	**	**
702610	26411	200907311953	240	8	17	4	61 (Lgt Rain)	4 (Smoke)
702610	26411	200907312053	260	23	31	1.3	61 (Lgt Rain)	4 (Smoke)
702610	26411	200907312153	990	11	20	1.5	4 (Smoke)	**
702610	26411	200907312253	990	7	***	0.8	4 (Smoke)	**

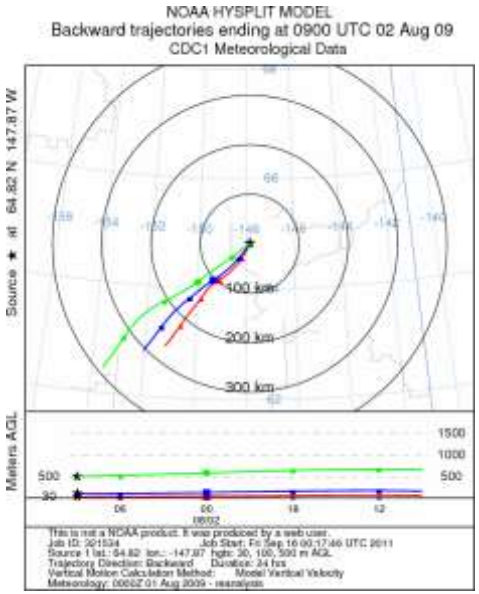
August 1, 2009

Figure 47, Cloud cover on the MODIS imagery makes it is difficult to see where the fires are located so some analysis and continuity from the previous day was needed to place fire locations. However, extensive smoke is quite visible across the entire state and parts of the Canada.

The HYSPLIT backwards trajectory indicates flow from the southwest. This trajectory is through the Minto Flats fire to the SW of Fairbanks. However, then entire area is saturated with smoke so a different trajectory may not have made a lot of difference.

Observations at the Fairbanks airport show that there was no relief from the smoke. Visibility at the start of the day was ½ mile with smoke indicated as the restriction to visibility. The visibility never exceeded three miles during this 24 hour period.

August 1 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 128.73µg/m^3. $PM_{2.5}$ concentrations were between 95µg/$m^3$and 258µg/m^3 the entire day.



A. HYSPLIT Backwards Trajectory Forecast from August 2, 2009, 00LST backward to August 1, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. August 1 2009, 11:59 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

1-Aug	HRLY PM2.5
0:00	258.2
1:00	220.1
2:00	231.1
3:00	187.9
4:00	109.0
5:00	111.7
6:00	189.8
7:00	114.9

1-Aug	HRLY PM2.5
8:00	128.1
9:00	116.8
10:00	108.3
11:00	95.1
12:00	101.7
13:00	119.5
14:00	110.2
15:00	102.4

1-Aug	HRLY PM2.5
16:00	116.3
17:00	145.6
18:00	141.0
19:00	148.6
20:00	153.7
21:00	155.2
22:00	153.7
23:00	143.2

D. Hourly $PM_{2.5}$ for August 1, 2009,

Figure 47 August 1, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 35: Hourly Observations for Fairbanks International Airport, August 1, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200907312353	200	5	***	0.8	4 (Smoke)	**
702610	26411	200908010053	240	8	***	0.8	4 (Smoke)	**
702610	26411	200908010153	240	7	***	0.8	4 (Smoke)	**
702610	26411	200908010253	250	5	***	0.8	4 (Smoke)	**
702610	26411	200908010353	180	3	***	0.8	4 (Smoke)	**
702610	26411	200908010453	200	5	***	1.5	4 (Smoke)	**
702610	26411	200908010553	***	0	***	2	4 (Smoke)	**
702610	26411	200908010653	260	10	***	1	4 (Smoke)	**
702610	26411	200908010753	220	3	***	2	4 (Smoke)	**
702610	26411	200908010853	***	0	***	2	4 (Smoke)	**
702610	26411	200908010953	230	6	***	3	4 (Smoke)	**
702610	26411	200908011053	200	7	***	3	4 (Smoke)	**
702610	26411	200908011153	240	7	***	3	4 (Smoke)	**
702610	26411	200908011253	280	8	***	3	4 (Smoke)	**
702610	26411	200908011353	240	6	***	3	4 (Smoke)	**
702610	26411	200908011453	190	8	***	2.5	4 (Smoke)	**
702610	26411	200908011553	240	6	***	2.5	4 (Smoke)	**
702610	26411	200908011653	270	5	***	2.5	4 (Smoke)	**
702610	26411	200908011753	270	6	***	2	4 (Smoke)	**
702610	26411	200908011853	280	5	***	2	4 (Smoke)	**
702610	26411	200908011953	320	3	***	2	4 (Smoke)	**
702610	26411	200908012053	***	0	***	2	4 (Smoke)	**
702610	26411	200908012153	***	0	***	2	4 (Smoke)	**
702610	26411	200908012253	***	0	***	2	4 (Smoke)	**

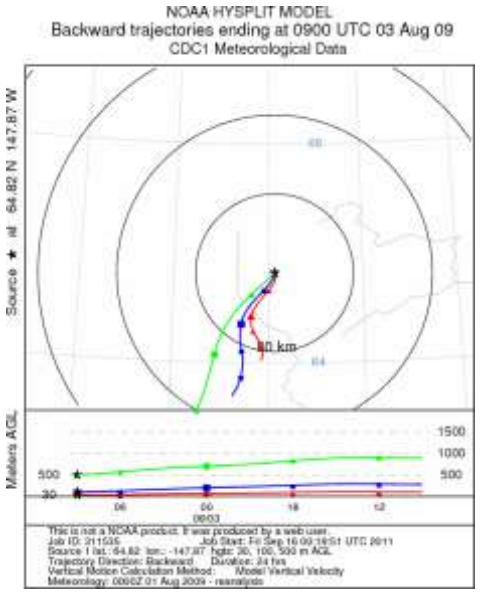
August 2, 2009

Figure 48, MODIS imagery shows the weather system has moved to the east and most fires are clearly visible. Smoke remains over much of the area, oriented west to east over Alaska but also expanding into Canada.

The HYSPLIT backwards trajectory continues to be from the south but the length is very short, indicative of lighter wind flow.

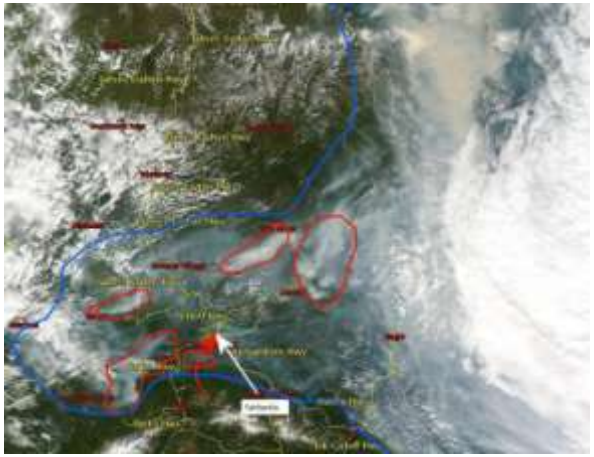
Observations at the Fairbanks airport indicate smoke settled in overnight but with some improvement in the daytime hours. Overall, there was a small improvement the last two days, from the Very Unhealthy category to Unhealthy category.

FRM 24 hour $PM_{2.5}$ concentration was 89.7µg/m^3. Secondary $PM_{2.5}$ 24 hour concentration was 8849 µg/m^3. The early hours of this day had the highest $PM_{2.5}$ concentrations. There was a partial clearing of the air during the day but then smoke increased again in the evening hours.



A. HYSPLIT Backwards Trajectory Forecast from August 3, 2009, 00LST backward to August 2, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. August 2 2009, 12:23 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

02-Aug	HRLY PM2.5
0:00	147.6
1:00	135.6
2:00	138.8
3:00	132.7
4:00	131.0
5:00	132.2
6:00	131.2
7:00	132.0

02-Aug	HRLY PM2.5
8:00	5.5
9:00	11.6
10:00	8.4
11:00	6.5
12:00	5.3
13:00	7.5
14:00	11.8
15:00	12.1

02-Aug	HRLY PM2.5
16:00	63.1
17:00	68.2
18:00	61.4
19:00	59.0
20:00	62.6
21:00	58.5
22:00	56.5
23:00	48.2

D. Hourly $PM_{2.5}$ for August 2, 2009,

Figure 48 August 2, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 36: Hourly Observations for Fairbanks International Airport, August 2, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200908012353	***	0	***	2	4 (Smoke)	**
702610	26411	200908020053	50	5	***	2	4 (Smoke)	**
702610	26411	200908020153	***	0	***	2	4 (Smoke)	**
702610	26411	200908020253	***	0	***	2	4 (Smoke)	**
702610	26411	200908020353	***	0	***	2	4 (Smoke)	**
702610	26411	200908020453	***	0	***	2	4 (Smoke)	**
702610	26411	200908020553	80	3	***	2	4 (Smoke)	**
702610	26411	200908020653	***	0	***	2	4 (Smoke)	**
702610	26411	200908020753	***	0	***	2	4 (Smoke)	**
702610	26411	200908020853	***	0	***	1.5	4 (Smoke)	**
702610	26411	200908020953	***	0	***	1.8	4 (Smoke)	**
702610	26411	200908021053	***	0	***	3	4 (Smoke)	**
702610	26411	200908021153	***	0	***	3	4 (Smoke)	**
702610	26411	200908021253	70	5	***	6	4 (Smoke)	**
702610	26411	200908021353	80	7	***	3	4 (Smoke)	**
702610	26411	200908021453	100	6	***	2.5	4 (Smoke)	**
702610	26411	200908021553	***	0	***	2.5	4 (Smoke)	**
702610	26411	200908021653	80	7	***	3	4 (Smoke)	**
702610	26411	200908021753	***	0	***	3	4 (Smoke)	**
702610	26411	200908021853	120	5	***	4	4 (Smoke)	**
702610	26411	200908021953	***	0	***	4	4 (Smoke)	**
702610	26411	200908022053	***	0	***	4	4 (Smoke)	**
702610	26411	200908022153	***	0	***	4	4 (Smoke)	**
702610	26411	200908022253	***	0	***	5	4 (Smoke)	**

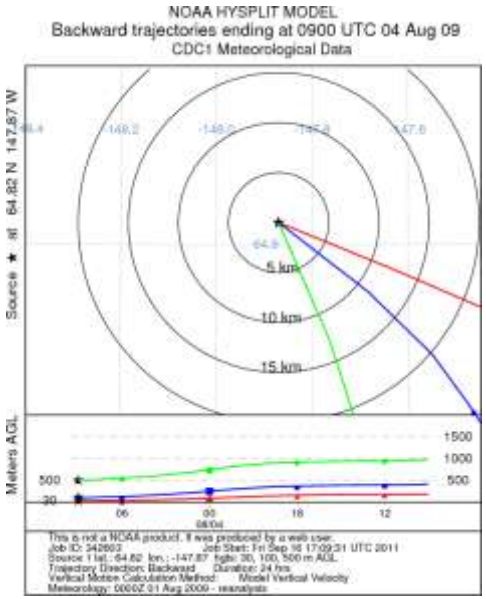
August 3, 2009

Figure 49, the 11:28AM MODIS image shows fires near Fairbanks in all directions except to the southeast. Smoke covers all areas of the image except the extreme southern portion.

The HYSPLIT backwards trajectory indicates that the airflow has shifted to an east-southeast direction. There are fires in that direction also, so the smoke continued through the day.

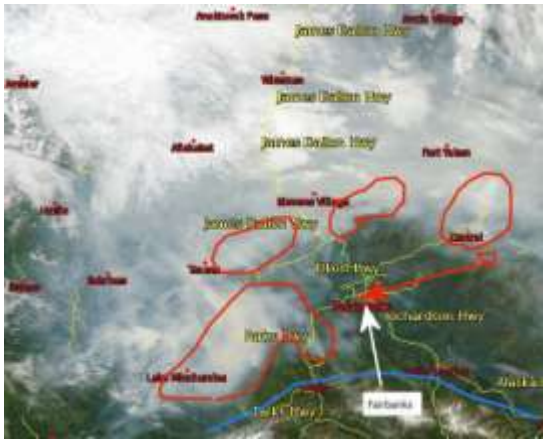
Observations at the Fairbanks airport show smoke reported throughout most of the day, but some improvement in the afternoon and evening hours. Overall reported visibility has improved today. This trend is also reflected in the $PM_{2.5}$ concentrations.

August 3 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 64.75µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from August 4, 2009, 00LST backward to August 3, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. August 3 2009, 11:28 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

03-Aug	HRLY PM2.5
0:00	48.0
1:00	45.8
2:00	53.4
3:00	46.0
4:00	46.8
5:00	60.2
6:00	118.3
7:00	128.5

03-Aug	HRLY PM2.5
8:00	105.8
9:00	102.4
10:00	88.0
11:00	66.5
12:00	66.8
13:00	65.6
14:00	22.8
15:00	25.5

03-Aug	HRLY PM2.5
16:00	22.8
17:00	22.8
18:00	23.3
19:00	29.4
20:00	22.3
21:00	133.2
22:00	154.4
23:00	229.1

D. Hourly $PM_{2.5}$ for August 3, 2009,

Figure 49 August 3, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 37: Hourly Observations for Fairbanks International Airport, August 3, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200908022353	***	0	***	6	4 (Smoke)	**
702610	26411	200908030053	***	0	***	6	4 (Smoke)	**
702610	26411	200908030153	100	3	***	6	4 (Smoke)	**
702610	26411	200908030253	***	0	***	6	4 (Smoke)	**
702610	26411	200908030353	40	5	***	6	4 (Smoke)	**
702610	26411	200908030453	50	3	***	6	4 (Smoke)	**
702610	26411	200908030553	***	0	***	3	4 (Smoke)	**
702610	26411	200908030653	***	0	***	2	4 (Smoke)	**
702610	26411	200908030753	***	0	***	2	4 (Smoke)	**
702610	26411	200908030853	***	0	***	2	4 (Smoke)	**
702610	26411	200908030953	***	0	***	2	4 (Smoke)	**
702610	26411	200908031053	***	0	***	2	4 (Smoke)	**
702610	26411	200908031153	100	6	***	3	4 (Smoke)	**
702610	26411	200908031253	990	6	***	4	4 (Smoke)	**
702610	26411	200908031353	100	6	***	5	4 (Smoke)	**
702610	26411	200908031453	90	5	***	5	4 (Smoke)	**
702610	26411	200908031553	120	6	***	7	**	**
702610	26411	200908031653	150	5	***	7	**	**
702610	26411	200908031753	150	6	***	7	**	**
702610	26411	200908031853	***	0	***	7	**	**
702610	26411	200908031953	***	0	***	7	**	**
702610	26411	200908032053	30	5	***	7	**	**
702610	26411	200908032153	***	0	***	7	**	**
702610	26411	200908032253	360	6	***	3	4 (Smoke)	**

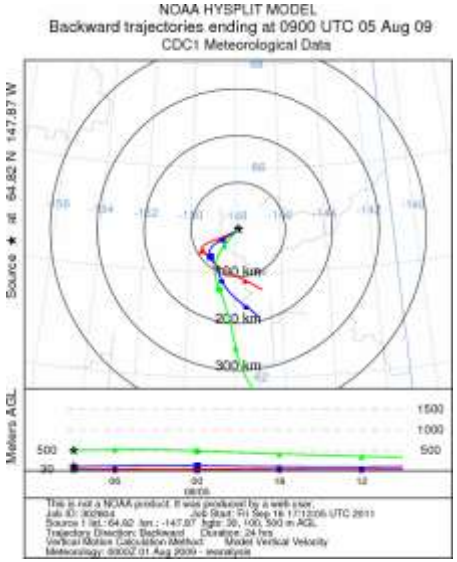
August 4, 2009

Figure 50, MODIS imagery shows clear skies over most of the interior and Canada. Fires and smoke are clearly visible.

The HYSPLIT backwards trajectory indicates the flow has returned to be from the west south west, bringing smoke from the Minto Flats fire into Fairbanks. While the 30m trajectory winds became more southerly, the surface winds remained from an easterly direction through the period. See Figure 51. The 30m wind would bring smoke into Fairbanks from the Minto flats fires and the easterly downslope flow at the surface would bring smoke down from the Little Black One fire.

Observations at the Fairbanks airport show smoke was the most dense in the early morning hours with a slight improvement in the afternoon and evening with the increase in mixing height caused by daytime warming (Figure 51).

August 4 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 130.11µg/m^3. This is a slight improvement from the last couple of days.



A. HYSPLIT Backwards Trajectory Forecast from August 5, 2009, 00LST backward to August 4, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. August 4 2009, 12:14 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

04-Aug	HRLY PM2.5
0:00	297.2
1:00	380.7
2:00	362.9
3:00	331.7
4:00	317.8
5:00	300.9
6:00	276.5
7:00	255.7

04-Aug	HRLY PM2.5
8:00	145.9
9:00	109.3
10:00	77.0
11:00	72.4
12:00	47.5
13:00	
14:00	71.2
15:00	30.2

04-Aug	HRLY PM2.5
16:00	27.5
17:00	31.1
18:00	29.7
19:00	35.5
20:00	36.0
21:00	48.7
22:00	41.1
23:00	27.2

D. Hourly $PM_{2.5}$ for August 4, 2009,

Figure 50 August 4, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 38: Hourly Observations for Fairbanks International Airport, August 4, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200908032353	20	3	***	3	4 (Smoke)	**
702610	26411	200908040053	60	5	***	2.5	4 (Smoke)	**
702610	26411	200908040153	60	6	***	1.5	4 (Smoke)	**
702610	26411	200908040253	70	3	***	1.3	4 (Smoke)	**
702610	26411	200908040353	40	6	***	1.3	4 (Smoke)	**
702610	26411	200908040453	50	3	***	0.8	4 (Smoke)	**
702610	26411	200908040553	***	0	***	0.8	4 (Smoke)	**
702610	26411	200908040653	***	0	***	0.8	4 (Smoke)	**
702610	26411	200908040753	40	3	***	0.8	4 (Smoke)	**
702610	26411	200908040853	30	3	***	1	4 (Smoke)	**
702610	26411	200908040953	70	7	***	1.5	4 (Smoke)	**
702610	26411	200908041053	90	7	***	4	4 (Smoke)	**
702610	26411	200908041153	90	7	***	4	4 (Smoke)	**
702610	26411	200908041253	110	9	***	4	4 (Smoke)	**
702610	26411	200908041353	100	10	***	4	4 (Smoke)	**
702610	26411	200908041453	110	7	***	5	4 (Smoke)	**
702610	26411	200908041553	110	6	***	7	**	**
702610	26411	200908041653	90	3	***	7	**	**
702610	26411	200908041753	80	5	***	6	4 (Smoke)	**
702610	26411	200908041853	20	5	***	6	4 (Smoke)	**
702610	26411	200908041953	10	5	***	6	4 (Smoke)	**
702610	26411	200908042053	***	0	***	7	**	**
702610	26411	200908042153	***	0	***	10	**	**
702610	26411	200908042253	***	0	***	5	4 (Smoke)	**

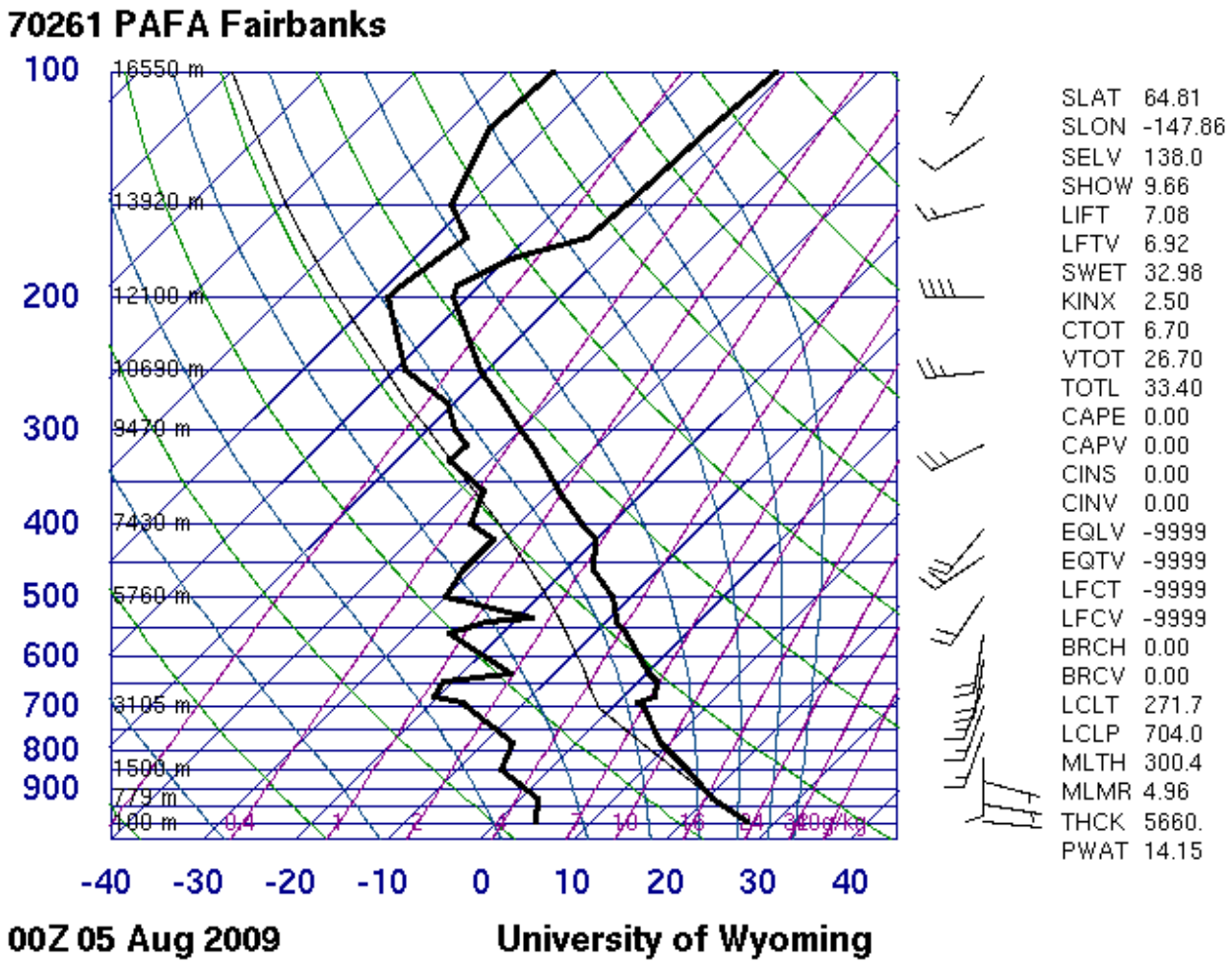


Figure 51: Upper Air Balloon Sounding from Fairbanks, August 4, 3PM AST

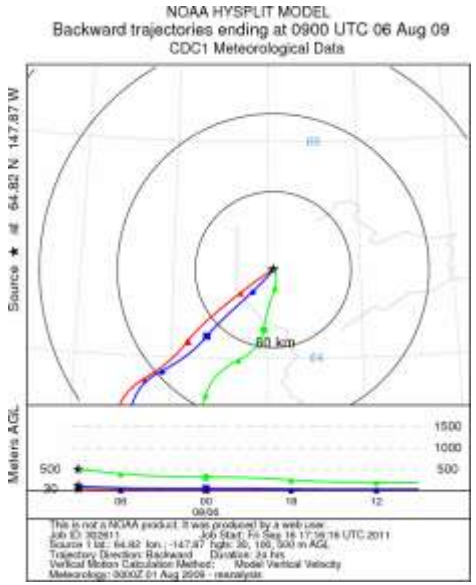
August 5, 2009

Figure 52, MODIS imagery shows that the smoke continues to increase in area and intensity across all of Central and Northern Alaska and into Canada. Very dense smoke is visible on the MODIS imagery to the southwest and to the northeast of Fairbanks.

The HYSPLIT backwards trajectory indicates airflow from the southwest, across the Minto Flats fire, transporting dense smoke into the city of Fairbanks.

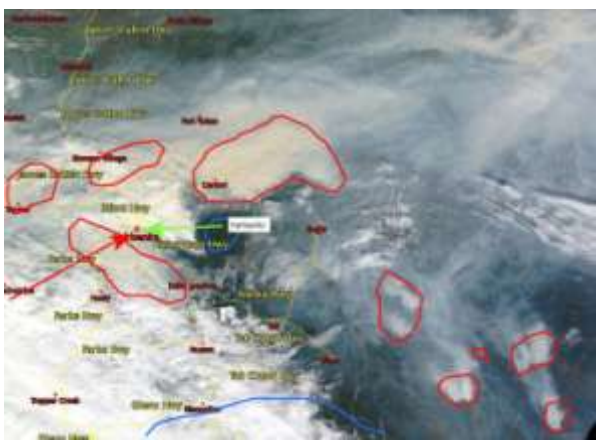
Observations at the Fairbanks airport show decreases in visibility throughout the period. This is indicative of the increase in smoke concentration at the Fairbanks Airport.

FRM 24 hour $PM_{2.5}$ concentration was 127.7µg/m^3 for this date. As occurred on July 30 when the smoke was very dense, the FRM filter were overloaded so the average is not a complete 24 hour period. Only 19 hours of FRM data was available on this date. Secondary $PM_{2.5}$ 24 HR average was 155.56µg/m^3.when averaged for the same 19 hours as the FRM data. However, if all concentrations of the secondary measurement for the 24 hour period are used, the average is 258.53µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from August 6, 2009, 00LST backward to August 5, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. August 5 2009, 12:54 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

05-Aug	HRLY PM2.5
0:00	30.4
1:00	35.5
2:00	30.2
3:00	33.1
4:00	36.5
5:00	36.3
6:00	36.0
7:00	42.6

05-Aug	HRLY PM2.5
8:00	40.9
9:00	69.7
10:00	52.1
11:00	36.0
12:00	31.1
13:00	81.7
14:00	243.3
15:00	319.2

05-Aug	HRLY PM2.5
16:00	409.6
17:00	475.2
18:00	456.9
19:00	994.8
20:00	994.8
21:00	667.1
22:00	570.0
23:00	481.6

D. Hourly $PM_{2.5}$ for August 5, 2009,

Figure 52 August 5, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 39: Hourly Observations for Fairbanks International Airport, August 5, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200908042353	***	0	***	6	4 (Smoke)	**
702610	26411	200908050053	40	3	***	6	4 (Smoke)	**
702610	26411	200908050153	***	0	***	6	4 (Smoke)	**
702610	26411	200908050253	30	3	***	6	4 (Smoke)	**
702610	26411	200908050353	40	3	***	5	4 (Smoke)	**
702610	26411	200908050453	50	3	***	5	4 (Smoke)	**
702610	26411	200908050553	***	0	***	5	4 (Smoke)	**
702610	26411	200908050653	***	0	***	6	4 (Smoke)	**
702610	26411	200908050753	990	5	***	6	4 (Smoke)	**
702610	26411	200908050853	50	3	***	7	**	**
702610	26411	200908050953	60	3	***	3	4 (Smoke)	**
702610	26411	200908051053	***	0	***	2	4 (Smoke)	**
702610	26411	200908051153	***	0	***	2.5	4 (Smoke)	**
702610	26411	200908051253	***	0	***	2.5	4 (Smoke)	**
702610	26411	200908051353	***	0	***	3	4 (Smoke)	**
702610	26411	200908051453	***	0	***	1.8	4 (Smoke)	**
702610	26411	200908051553	***	0	***	0.8	4 (Smoke)	**
702610	26411	200908051653	***	0	***	0.5	4 (Smoke)	**
702610	26411	200908051753	230	3	***	0.5	4 (Smoke)	**
702610	26411	200908051853	***	0	***	0.5	4 (Smoke)	**
702610	26411	200908051953	250	5	***	0.5	4 (Smoke)	**
702610	26411	200908052053	***	0	***	0.5	4 (Smoke)	**
702610	26411	200908052153	***	0	***	0.5	4 (Smoke)	**
702610	26411	200908052253	210	5	***	0.8	4 (Smoke)	**

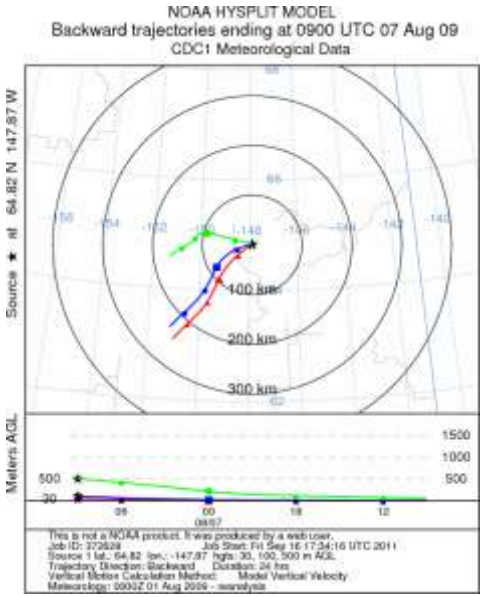
August 6, 2009

Figure 53, on this MODIS imagery the solid blue lines that are used on other days to indicate areas of smoke cannot be used since the entire image is smoke saturated. There is significant cloud cover with an approaching weather front.

The HYSPLIT backwards trajectory continues to show southwest trajectory and this trajectory continues bring smoke from the Minto Flats fire into Fairbanks.

Observations at the Fairbanks airport show that precipitation begins at midnight and that visibility begins a very, very gradual improvement. The precipitation was mostly light and that along with the increased mixing with the frontal system did lead to a decrease in the smoke concentration and thus the PM concentrations but overall the air quality remained Unhealthy.

August 6 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 130.34µg/m^3. A slow improvement occurs between the beginning and the end of the 24 hour period. At the beginning of the period the $PM_{2.5}$ 24 hour concentration was 520.4µg/m^3. By the end of the 24 hour period the value was 56.5µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from August 7, 2009, 00LST backward to August 6, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. August 6 2009, 11:59 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is smoke). Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

06-Aug	HRLY PM2.5
0:00	520.4
1:00	483.5
2:00	320.9
3:00	215.9
4:00	180.3
5:00	141.2
6:00	113.2
7:00	520.4

06-Aug	HRLY PM2.5
8:00	117.8
9:00	122.4
10:00	141.7
11:00	137.3
12:00	124.2
13:00	114.6
14:00	116.1
15:00	107.3

06-Aug	HRLY PM2.5
16:00	76.1
17:00	70.0
18:00	61.2
19:00	51.9
20:00	50.4
21:00	54.3
22:00	54.6
23:00	56.5

D. Hourly $PM_{2.5}$ for August 6, 2009,

Figure 53 August 6, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 40: Hourly Observations for Fairbanks International Airport, August 6, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW	WW
702610	26411	200908052353	230	6	***	0.8	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908060053	210	5	***	0.8	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908060153	990	3	***	0.5	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908060253	190	3	***	0.8	4 (Smoke)	**	**
702610	26411	200908060353	210	3	***	0.8	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908060453	220	3	***	0.8	63 (Mod Rain)	4 (Smoke)	**
702610	26411	200908060553	200	3	***	0.8	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908060653	***	0	***	0.5	63 (Mod Rain)	4 (Smoke)	**
702610	26411	200908060753	***	0	***	0.5	61 (Lgt Rain)	44 (Fog)	4 (Smoke)
702610	26411	200908060853	***	0	***	0.5	61 (Lgt Rain)	44 (Fog)	4 (Smoke)
702610	26411	200908060953	***	0	***	0.5	61 (Lgt Rain)	44 (Fog)	4 (Smoke)
702610	26411	200908061053	***	0	***	0.8	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908061153	***	0	***	0.8	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908061253	200	3	***	0.8	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908061353	***	0	***	0.8	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908061453	***	0	***	0.8	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908061553	200	3	***	1.5	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908061653	210	3	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908061753	200	3	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908061853	***	0	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908061953	210	5	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908062053	200	3	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908062153	***	0	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908062253	***	0	***	2	4 (Smoke)	10 (Mist)	**

August 7, 2009

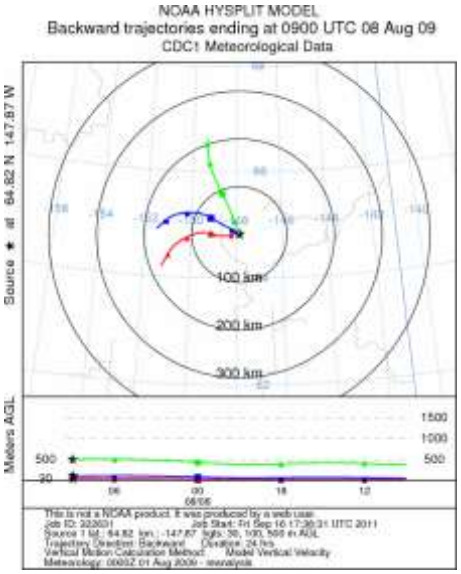
Figure 54, on the MODIS imagery smoke can be seen over most of Interior Alaska. However, increasing clouds indicate the approach of wetter weather.

The HYSPLIT backwards trajectory brings flow from the west and continues to bring smoke into Fairbanks. However, as previously noted, smoke has saturated the entire area.

Observations at the Fairbanks airport show an increase in humidity and light rain. This signals the beginning of the end of the fire season in Interior Alaska for 2009. The code “10” in the weather column indicates “Mist”. This code is used by the automated system when the temperature and dew point are within 5^0F. Otherwise the restriction to visibility would have been reported as smoke. While the use of this code indicates an increase in humidity, smoke is still a restriction to visibility.

Surface weather analysis: Figure 57, for August 7 shows a cold front at the extreme northern portion of the analysis. This front will continue south bringing much needed relief from the fire smoke.

August 7 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 60.26µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from August 8, 2009, 00LST backward to August 7, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. August 7 2009, 11:04 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

07-Aug	HRLY PM2.5
0:00	55.8
1:00	64.3
2:00	65.1
3:00	56.8
4:00	60.2
5:00	66.8
6:00	60.2
7:00	72.6

07-Aug	HRLY PM2.5
8:00	78.5
9:00	74.8
10:00	70.4
11:00	94.6
12:00	105.4
13:00	62.9
14:00	61.7
15:00	71.2

07-Aug	HRLY PM2.5
16:00	58.0
17:00	58.2
18:00	57.7
19:00	55.3
20:00	58.2
21:00	74.8
22:00	66.8
23:00	56.0

D. Hourly $PM_{2.5}$ for August 7, 2009,

Figure 54 August 7, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 41: Hourly Observations for Fairbanks International Airport, August 7, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW	WW
702610	26411	200908062353	200	3	***	2	4 (Smoke)	10 (Mist)	**
702610	26411	200908070053	***	0	***	3	4 (Smoke)	10 (Mist)	**
702610	26411	200908070153	***	0	***	2	4 (Smoke)	10 (Mist)	**
702610	26411	200908070253	***	0	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908070353	***	0	***	2	4 (Smoke)	10 (Mist)	**
702610	26411	200908070453	***	0	***	1.5	4 (Smoke)	10 (Mist)	**
702610	26411	200908070553	200	3	***	1	4 (Smoke)	10 (Mist)	**
702610	26411	200908070653	***	0	***	0.8	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908070753	***	0	***	0.8	51 (Drizzle)	4 (Smoke)	10 (Mist)
702610	26411	200908070853	***	0	***	0.5	51 (Drizzle)	44 (Fog)	4 (Smoke)
702610	26411	200908070953	***	0	***	0.8	51 (Drizzle)	4 (Smoke)	10 (Mist)
702610	26411	200908071053	***	0	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908071153	***	0	***	1.3	4 (Smoke)	10 (Mist)	**
702610	26411	200908071253	***	0	***	1.8	4 (Smoke)	10 (Mist)	**
702610	26411	200908071353	***	0	***	2.5	4 (Smoke)	10 (Mist)	**
702610	26411	200908071453	***	0	***	3	4 (Smoke)	10 (Mist)	**
702610	26411	200908071553	290	5	***	4	4 (Smoke)	10 (Mist)	**
702610	26411	200908071653	50	6	***	4	4 (Smoke)	10 (Mist)	**
702610	26411	200908071753	30	5	***	4	4 (Smoke)	10 (Mist)	**
702610	26411	200908071853	***	0	***	4	4 (Smoke)	10 (Mist)	**
702610	26411	200908071953	50	3	***	5	4 (Smoke)	10 (Mist)	**
702610	26411	200908072053	***	0	***	4	4 (Smoke)	10 (Mist)	**
702610	26411	200908072153	***	0	***	4	4 (Smoke)	10 (Mist)	**
702610	26411	200908072253	***	0	***	4	4 (Smoke)	10 (Mist)	**

August 8, 2009

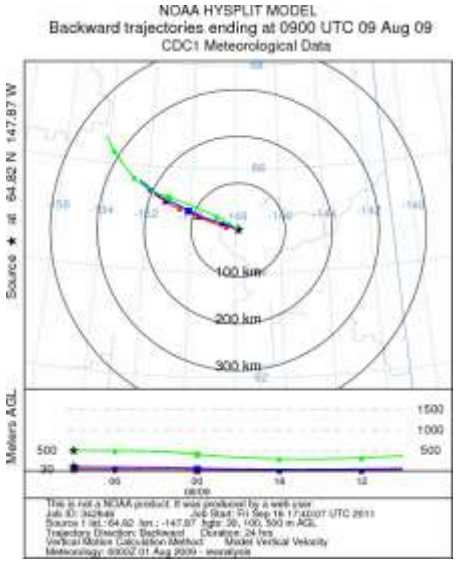
Figure 55, MODIS imagery shows that mostly cloudy conditions exist making it difficult to determine which areas remain smoke covered. While the clouds may obscure the smoke, the smoke remains at the surface.

The HYSPLIT backwards trajectory indicates flow is turning to come from the northwest with the changing of the weather pattern. However, this trajectory passes through areas of smoke from active fires and residual smoke in the area.

Observations at the Fairbanks airport indicate fog and smoke at the airport. The addition of fog in the observations indicates an increasing wetter lower atmosphere.

Surface weather analysis depicts a cold front across the northern part of Alaska, (Figure 57). On this day the front is approximately parallel to the Brooks Range. This front will bring cooler temperatures and an end to the dense fire smoke

FRM 24 hour $PM_{2.5}$ concentration was 61.0µg/m^3 for this date. Secondary $PM_{2.5}$ 24 hour concentration was 61.95µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from August 9, 2009, 00LST backward to August 8, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m

C. August 8 2009, 11:47 AM LST MODIS imagery with 30m trajectory (red outline is fire, blue is s Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

08-Aug	HRLY PM2.5
0:00	60.2
1:00	66.3
2:00	64.6
3:00	71.7
4:00	68.7
5:00	59.9
6:00	63.6
7:00	74.1

08-Aug	HRLY PM2.5
8:00	70.4
9:00	69.0
10:00	69.5
11:00	78.0
12:00	72.6
13:00	75.8
14:00	73.4
15:00	69.2

08-Aug	HRLY PM2.5
16:00	51.9
17:00	61.2
18:00	57.0
19:00	61.4
20:00	69.7
21:00	77.3
22:00	82.9
23:00	83.6

D. Hourly $PM_{2.5}$ for August 8, 2009,

Figure 55 August 8, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 42: Hourly Observations for Fairbanks International Airport, August 8, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW
702610	26411	200908072353	***	0	***	2.5	4 (Smoke)	10 (Mist)
702610	26411	200908080053	***	0	***	2.5	4 (Smoke)	10 (Mist)
702610	26411	200908080153	***	0	***	3	4 (Smoke)	10 (Mist)
702610	26411	200908080253	***	0	***	3	4 (Smoke)	**
702610	26411	200908080353	***	0	***	2	4 (Smoke)	**
702610	26411	200908080453	80	5	***	0.1	45 (Fog)	4 (Smoke)
702610	26411	200908080553	130	3	***	0	45 (Fog)	4 (Smoke)
702610	26411	200908080653	***	0	***	0	45 (Fog)	**
702610	26411	200908080753	120	3	***	0	45 (Fog)	**
702610	26411	200908080853	***	0	***	0.1	45 (Fog)	**
702610	26411	200908080953	180	3	***	0.1	45 (Fog)	**
702610	26411	200908081053	***	0	***	0.1	45 (Fog)	**
702610	26411	200908081153	130	3	***	0.5	45 (Fog)	**
702610	26411	200908081253	***	0	***	2	4 (Smoke)	**
702610	26411	200908081353	***	0	***	3	4 (Smoke)	**
702610	26411	200908081453	***	0	***	3	4 (Smoke)	**
702610	26411	200908081553	280	6	***	3	4 (Smoke)	**
702610	26411	200908081653	300	5	***	5	4 (Smoke)	**
702610	26411	200908081753	300	7	***	6	4 (Smoke)	**
702610	26411	200908081853	280	5	***	6	4 (Smoke)	**
702610	26411	200908081953	300	5	***	5	4 (Smoke)	**
702610	26411	200908082053	***	0	***	4	4 (Smoke)	**
702610	26411	200908082153	250	5	***	3	4 (Smoke)	**
702610	26411	200908082253	***	0	***	2.5	4 (Smoke)	**

August 9, 2009

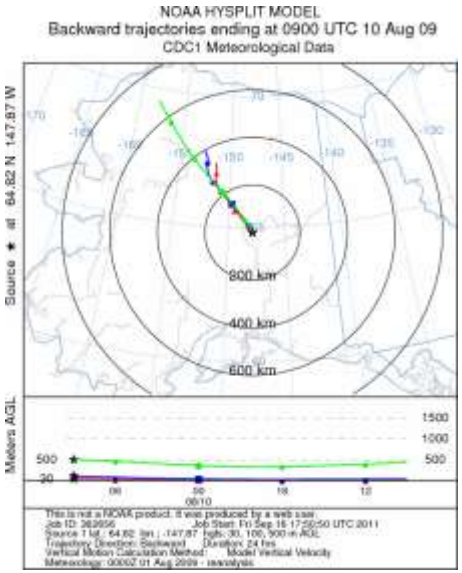
Figure 56, on the MODIS imagery I highlighted the cold front and the secondary trof with a purple line on the MODIS imagery. The MODIS clearly shows clear air behind the cold front. The clearing air, enhanced mixing with the cold front finally lifts the smoke out of the Fairbanks area.

The HYSPLIT backwards trajectory indicates the trajectory has now shifted so wind is from the northwest. After the passage of the cold front, this wind flow brings colder, cleaner, smoke free air into Fairbanks.

Observations at the Fairbanks airport: Visibility increased to 10 miles after 10:00 AST. The combination of rain and overall humidity increases has finally overcome the persistent smoke.

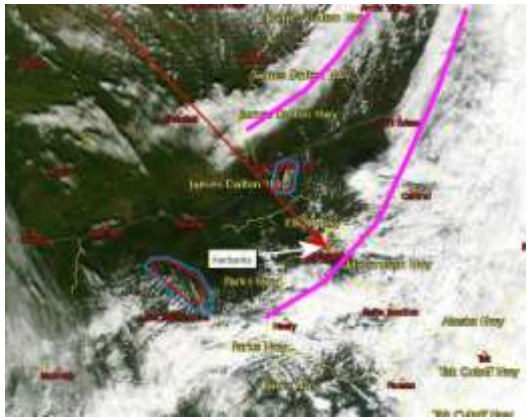
Surface weather analysis: The cold front has now moved south of Fairbanks. Note the much cooler temperatures (Table 44).

August 7 was not a scheduled sampling day, so FRM data are not available for this day. Secondary $PM_{2.5}$ 24 hour concentration was 22.97µg/m^3.



A. HYSPLIT Backwards Trajectory Forecast from August 10, 2009, 00LST backward to August 9, 2009, 00LST.

B. HYSPLIT Trajectory forecast on Google Earth map. Red = 30m, Blue = 100m, Green=500m



C. August 9 2009, 12:29 PM LST MODIS imagery with 30m trajectory (red outline is fire, blue is Trajectories are directly from the HYSPLIT model except the 30m trajectory on MODIS imagery is hand drawn.

09-Aug	HRLY PM2.5
0:00	92.9
1:00	78.5
2:00	71.7
3:00	76.1
4:00	68.2
5:00	52.1
6:00	53.6
7:00	39.9

09-Aug	HRLY PM2.5
8:00	12.8
9:00	6.2
10:00	3.8
11:00	0.4
12:00	-0.9
13:00	0.6
14:00	3.3
15:00	2.1

09-Aug	HRLY PM2.5
16:00	1.8
17:00	0.6
18:00	1.1
19:00	2.3
20:00	1.6
21:00	2.3
22:00	11.6
23:00	12.8

D. Hourly $PM_{2.5}$ for August 9, 2009,

Figure 56 August 9, 2009 All end points/arrow heads terminate at Fairbanks, Alaska

Table 43: Hourly Observations for Fairbanks International Airport, August 9, 2009

USAF	WBAN	YR--MODAHRMN (LST)	DIR (From)	SPD (MPH)	GUS (MPH)	VSB (SM)	WW	WW	WW
702610	26411	200908082353	240	3	***	2.5	4 (Smoke)	**	**
702610	26411	200908090053	200	5	***	2.5	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908090153	190	5	***	2.5	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908090253	200	5	***	2.5	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908090353	210	3	***	1.8	61 (Lgt Rain)	4 (Smoke)	**
702610	26411	200908090453	990	3	***	2	61 (Lgt Rain)	4 (Smoke)	10 (Mist)
702610	26411	200908090553	990	3	***	4	4 (Smoke)	10 (Mist)	**
702610	26411	200908090653	250	8	***	3	10 (Mist)	**	**
702610	26411	200908090753	260	9	***	4	10 (Mist)	**	**
702610	26411	200908090853	270	10	***	4	61 (Lgt Rain)	10 (Mist)	**
702610	26411	200908090953	300	6	***	10	**	**	**
702610	26411	200908091053	340	10	***	10	**	**	**
702610	26411	200908091153	320	16	24	10	**	**	**
702610	26411	200908091253	310	14	23	10	**	**	**
702610	26411	200908091353	320	15	24	10	**	**	**
702610	26411	200908091453	990	9	***	10	**	**	**
702610	26411	200908091553	330	10	***	10	**	**	**
702610	26411	200908091653	990	9	***	10	**	**	**
702610	26411	200908091753	***	0	***	10	**	**	**
702610	26411	200908091853	310	5	***	10	**	**	**
702610	26411	200908091953	260	5	***	10	**	**	**
702610	26411	200908092053	250	5	***	10	**	**	**
702610	26411	200908092153	300	3	***	10	**	**	**
702610	26411	200908092253	***	0	***	10	**	**	**

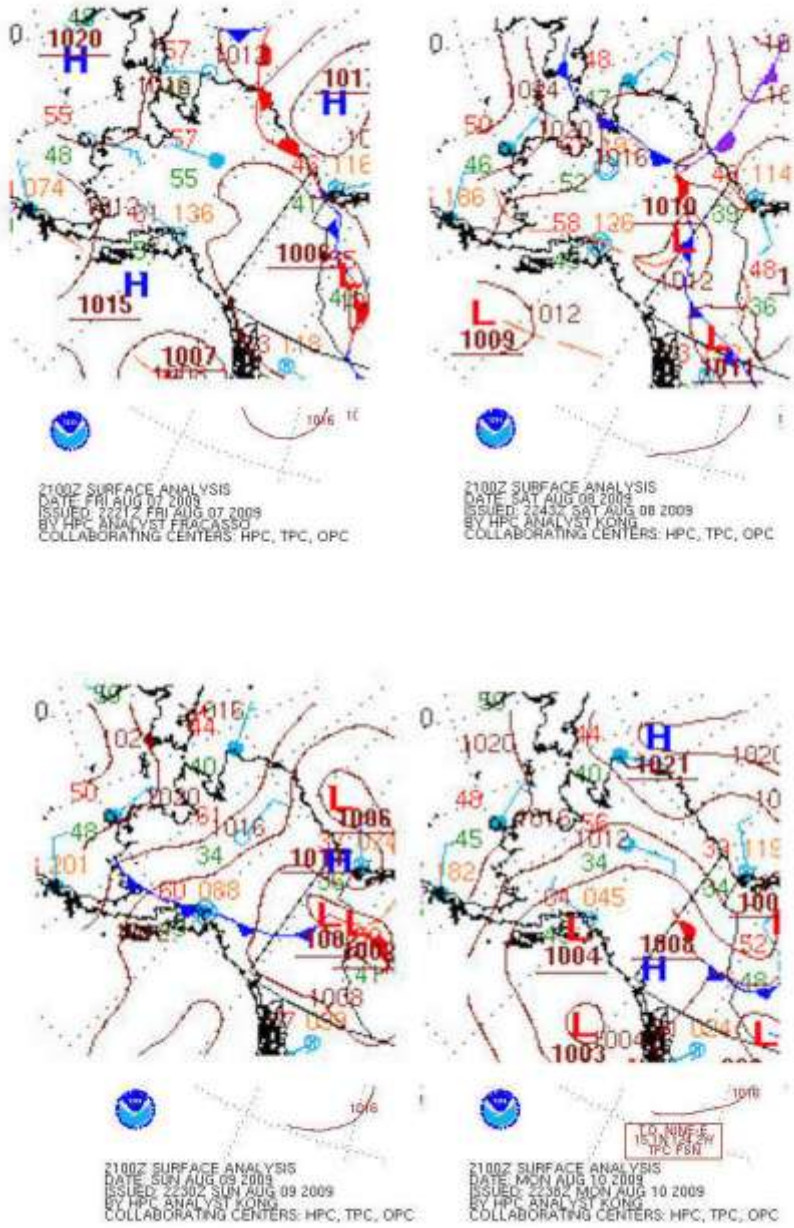


Figure 57 August 7 -10 Surface Analyses

August 10 2009. The event is over. Secondary $PM_{2.5}$ 24 HR average was 5.83µg/m^3.The next FRM filter, 24 HR $PM_{2.5}$ date is August 11, 2009. The value on that date was 3.2µg/m^3.

Table 44: August 9, 2009, Temperatures and Dew points

USAF	WBAN	YR--MODAHRMN (LST)	TEMP	DEWP
702610	26411	200908092353	49	43
702610	26411	200908100053	46	40
702610	26411	200908100153	46	41
702610	26411	200908100253	45	40
702610	26411	200908100353	44	40
702610	26411	200908100453	44	40
702610	26411	200908100553	43	39
702610	26411	200908100653	44	40
702610	26411	200908100753	44	40
702610	26411	200908100853	47	40
702610	26411	200908100953	48	41
702610	26411	200908101053	51	40
702610	26411	200908101153	52	41
702610	26411	200908101253	54	42
702610	26411	200908101353	58	42
702610	26411	200908101453	58	41
702610	26411	200908101553	58	39
702610	26411	200908101653	57	39
702610	26411	200908101753	56	34
702610	26411	200908101853	53	33
702610	26411	200908101953	53	36
702610	26411	200908102053	54	32
702610	26411	200908102153	50	31
702610	26411	200908102253	47	32

The daily analysis above shows the onset, concentration and duration of the 2009 smoke event in the Fairbanks area. Figure 58 below highlights the major shifts in $PM_{2.5}$ concentrations through the Interior Alaska 2009 fire season suppression.

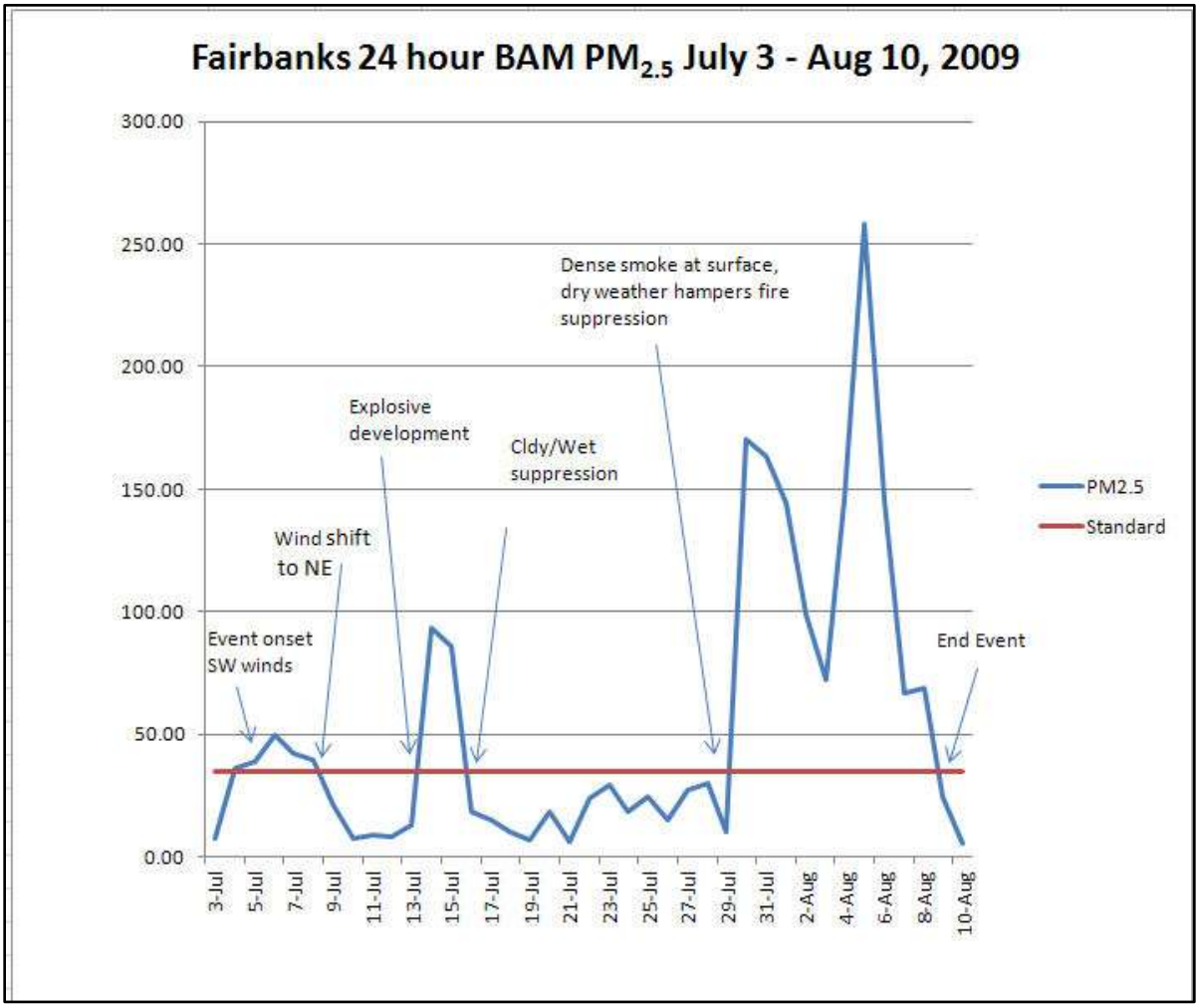


Figure 58 Graph of $PM_{2.5}$ concentrations Fairbanks, July 3 through August 10, 2009

There would have been no exceedance except for the event

While the cause of the wildfires was drought and lightning, an evaluation was performed look at other meteorological factors.

We analyzed the surface wind speed to see if 2009 and other fire years were less windy, and therefore had less smoke dispersion, than low-fire years. We defined the fire season as the period from June 1st through August 31st for each year since these dates included all days with elevated $PM_{2.5}$ concentrations and all the major fire periods. We requested a wind analysis from the National Climate Data Center for the years 2001 through 2011 for winds at Fairbanks International Airport. This data period of record was matched to the same months are the fire season, June 1 through August 31. Data were analyzed for each year, 2001 through 2011. We selected the fire acreage as a proxy for smoke since a 3 month average of $PM_{2.5}$ data would not be representative. A correlation analysis was then performed between fire acreage and surface winds less than 6 knots (Figure 59).

In the summer of 2009, a strong high pressure cell remained over Interior Alaska, including Fairbanks, most of the summer. This high pressure cell blocked most weather systems from impacting the Fairbanks area. During the fire season of 2009 there were few frontal passages at Fairbanks that were strong enough to increase the mixing, bring some precipitation, or help disperse the wildfire smoke. During this time period, the winds were light or calm 66.3% of the hourly observations. This analysis for the year 2009 showed a positive correlation between the occurrence of light and calm winds and the occurrence of smoke in Fairbanks. Without frontal passages, stronger winds that could mix the atmosphere and disperse the smoke were absent. To see if this held true for other fire seasons, the wind and acres burned data for fire season years 2001 through 2011 were examined. This analysis showed proved that there was no significant correlation between light winds and fire area for this time period.

The fire season in 2009 had the second highest percent occurrence of light and calm winds of any years from 2001 through 2011 (Table 45) However, note the fire season in 2007 which had the highest percent of observed light and calm winds at 69.4% of the observations did not have a significant number of fires or any days with elevated $PM_{2.5}$ concentrations. Regression and correlation analysis of the hypothesis that there is a relationship between the light and calm winds and acres burned during a fire season proved the hypothesis false. The statistics r^2 = 0.0207, t-test = 0.0074 and Pearson's = 0.1439 all demonstrate a lack of any correlation between the light winds and fire size.

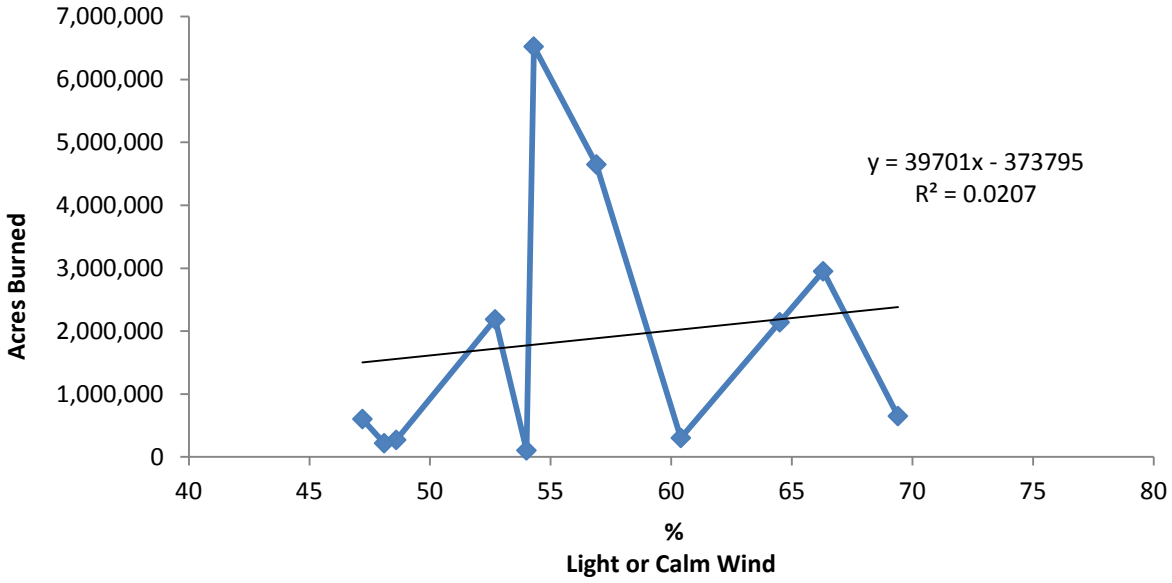


Figure 59 Acres burned compared to percent light and calm winds

Table 45: Percentage of light winds compared to burned acres for years 2001-2011

YR	% lgt wnd	Acres burned
2007	69.4	649,411
2009	66.3	2,951,592
2010	64.5	2,140,984
2011	60.4	302,079
2005	56.9	4,649,597
2004	54.3	6,523,816
2008	54	103,299
2002	52.7	2,186,682
2006	48.6	270,539
2001	48.1	218,113
2003	47.2	602,146
Average	56.6	1,872,569
Max	69.4	6,523,816
Min	47.2	103,299
Median	54.3	649,411
ttest	0.0074	
Pearsons	0.1439	

The HYSPLIT backwards trajectory model as used in Section F provides a path that the air traveled to arrive at Fairbanks. However, it does not have any fire source information or chemical processes built into the model.

In order to model fire data, define atmospheric and chemical processes, ADEC issued a contract to the University of Alaska Fairbanks (UAF), Geophysical Institute. Martin Stuefer[†††], the lead researcher, selected the WRF/Chem Model to complete this analysis. He states the he selected this model because it is "… recognized as an ideal tool to investigate dispersion of atmospheric pollutants such as wildfire smoke, since it predicts trace gas and particulate dynamics inline with meteorological fields of WRF and allows for full interaction of chemistry and weather" (Appendix F, WRF/Chem modeling for Exceptional Events (Wild Fire) Waiver Request).

A short description of the model is provided below. For an extensive review of the model and how this project was set up see Appendix F, Stuefer, Engle, and Waigl, "WRF/Chem Modeling for Exceptional Events (Wild Fire) Waiver Request".
For an extensive review of the model and how this project was set up see Appendix F, Stuefer, Engle, and Waigl, "WRF/Chem Modeling for Exceptional Events (Wild Fire) Waiver Request".

[†††] Martin Stuefer, the lead researcher of Atmospheric Science group, Geophysical Institute, UAF

WRF/Chem Model Summary

The WRF/Chem fire plume Model uses fuel type, loading and fire intensity to derive emission data. A fire plume model has been coupled inline with WRF/Chem, accounting for the feedback processes between the smoke plume with the environmental air.

Fire source data were created using AICC products and shapefiles. The shapefiles generated in this manner showed the entire area that each fire had burned but did not specifically delineate what areas within the shapefile were actively burning or smoldering at a specific day/time. To improve the analysis and the model input, further analysis was done within the fire shapes using MODIS satellite imagery. This allowed the input of actual areas that were either actively burning or smoldering.

The input meteorological data were from the NCEP North American Regional Reanalysis (NARR) data base. These data were used to derive the meteorological initial and boundary conditions for WRF for summer 2009. Information and details about the NARR data can be derived via the Project webpage at http://www.emc.ncep.noaa.gov/mmb/rreanl/

The remainder of this section, model results, were copied directly from Martin Stuefer's report. Since this section was copied, all nomenclature, such as Event 1Case 9, etc. were retained from the original. See appendix F for entire report.

Output and $PM_{2.5}$ comparison:

WRF modeled $PM_{2.5}$ concentrations have been derived for the WRF grid-cell closest to Fairbanks. The data show partly good coincidence with the measured $PM_{2.5}$ at the FNSB site in downtown Fairbanks. A daily mean $PM_{2.5}$ data comparison is shown in Figure 60. We performed control runs using the complete set of analyzed fire extents. In addition we have performed runs with partial fires in order to quantify the effects of certain fire emissions in terms of $PM_{2.5}$ for the location of Fairbanks. The comparison of the hourly $PM_{2.5}$ FNSB measurements and the modeled values is shown in Figure 60.

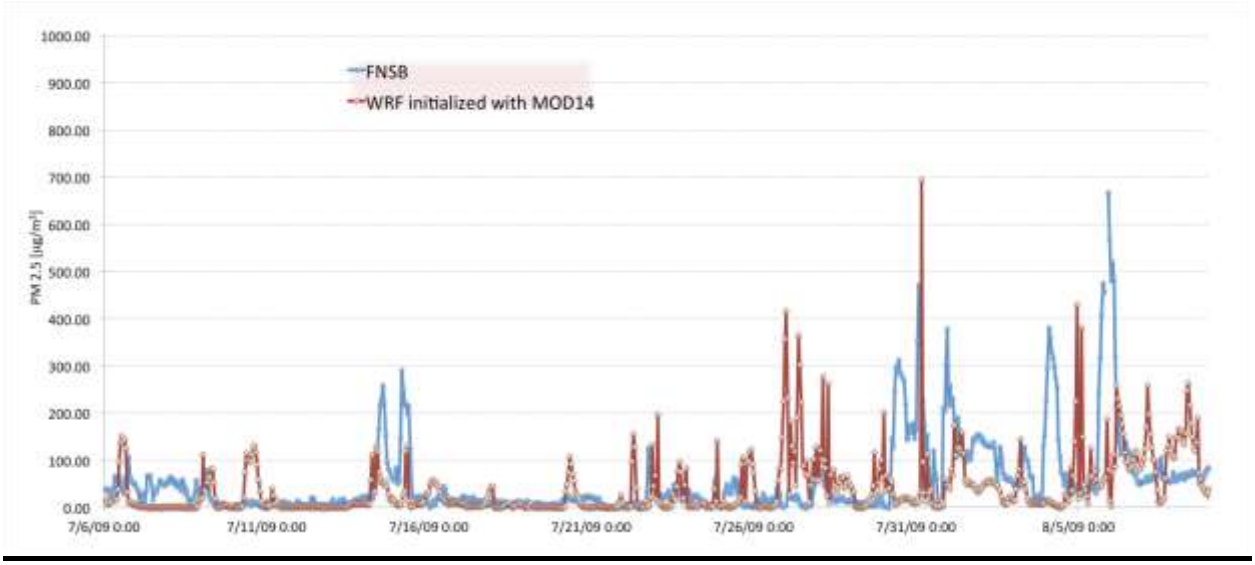


Figure 60: Hourly $PM_{2.5}$ concentration with data measured in Fairbanks (data from Jim Conner, FNSB) and derived from WRF/Chem.

The start date for WRF/Chem was the 3rd July 2009. We performed 24 hour model runs, and each run was re-initialized with new (NARR) meteorological initial and boundary fields, updated fire source data, and the $PM_{2.5}$ concentration and chemistry from the previous run. The $PM_{2.5}$ comparison shows partly good coincidence of the timing of events leading to exceedance (compare Figure 60). WRF/Chem $PM_{2.5}$ concentration based on AICC source input data was strongly exaggerated especially at the end of July/beginning of August 2009. The fires from the AICC database do remain constant in location during the course of the fire season, and the AICC data also do not give accurate information about the daily extent of active and smoldering fires. The data in figure 9 are derived from WRF/Chem runs initialized with MOD14 hotspots accumulated over 6 days proceeding to the start-date of each run. A typical area of 22 hectares of active burning was reported per hotspot. Assuming the same amount to account for smoldering fires resulted in an average of 44 hectares area per hotspot. We used only hotspots, which clearly could be associated with fires reported by the AICC in order to avoid MODIS false alarms. Overlapping hotspot areas were subtracted from corresponding hotspots. Figure 61 shows the daily mean average values of the modeled and measured $PM_{2.5}$

We attribute the main reason for discrepancies in the magnitude of modeled $PM_{2.5}$ concentration in comparison to the FNSB measurements to our lack of knowledge of fire characteristics such as extent, location during the modeled (daily) periods, and the relation between active and smoldering fires; smoldering contributes significantly to the high $PM_{2.5}$ concentrations. The MOD 14 algorithm may identify fires with a relatively small area on the order of tens of meters, thus a general assumption of a constant (44 ha) hotspot area may be considered as first order estimate. Also smoldering fires are normally not depicted by the MODIS data. However the model range of magnitudes coincide with the measurements, and there are no other homogeneous sources of daily fire information available.

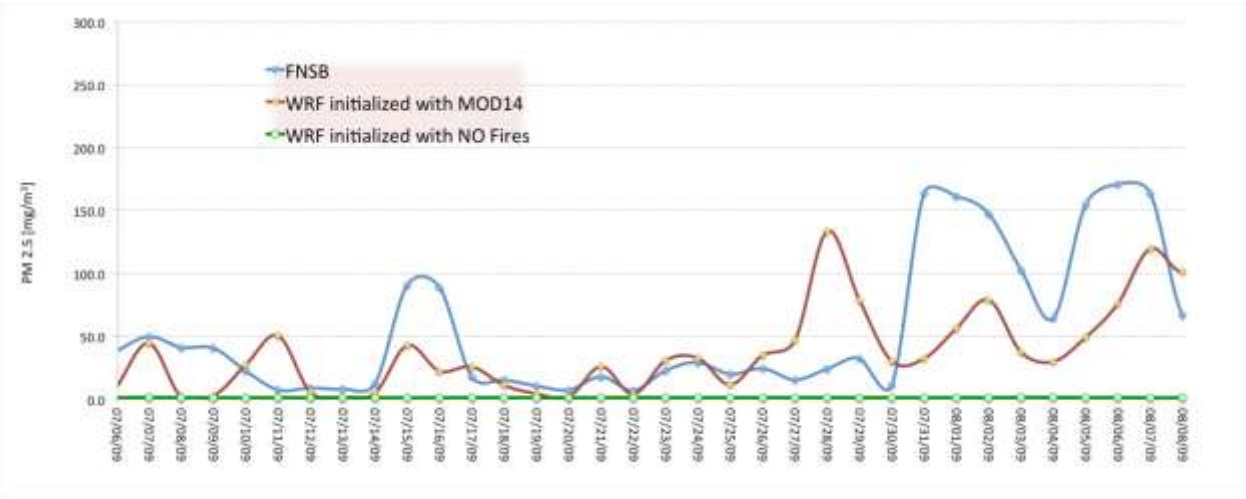


Figure 61: Daily mean data of $PM_{2.5}$ concentration measured in Fairbanks (data from Jim Conner, FNSB) and derived from WRF/Chem.

The daily mean $PM_{2.5}$ concentration for the exceedance events in the middle and the end of July, and the beginning of August were depicted well in time, however the modeled magnitudes were partly too low or too high (as in the event from 27 to 29 July). Figure 10 shows the daily mean values as well as the daily means for the WRF/Chem runs initialized without fires. The 'NO-Fire' chemical initialization includes the point sources of the National Emission Inventory (NEI) of 2008.

In the following we show model surface plots of $PM_{2.5}$ and the winds for the dates of: July 6, 15, 24, 27, 30, and August 2, 5, 8. The names and locations of fires larger than 100,000 acres (as stated in the AICC database) are included in the graphics for reference.

Event 1, 6 July: A modeled peak concentration of ~150µg/m^3 $PM_{2.5}$ occurred around noon of the 6 July 2009. The measured hourly maximum was 107µg/m^3 at 6:00 pm. The Figures 62 to 64 depict the fires around Minto Flats to the West of Fairbanks as the source of the pollution. Slight winds of typically 5 knots shifted from northwestern to western and southwestern directions. The large fires as included by the AICC database (total burned area greater than 100,000 acres) are marked in the figures.

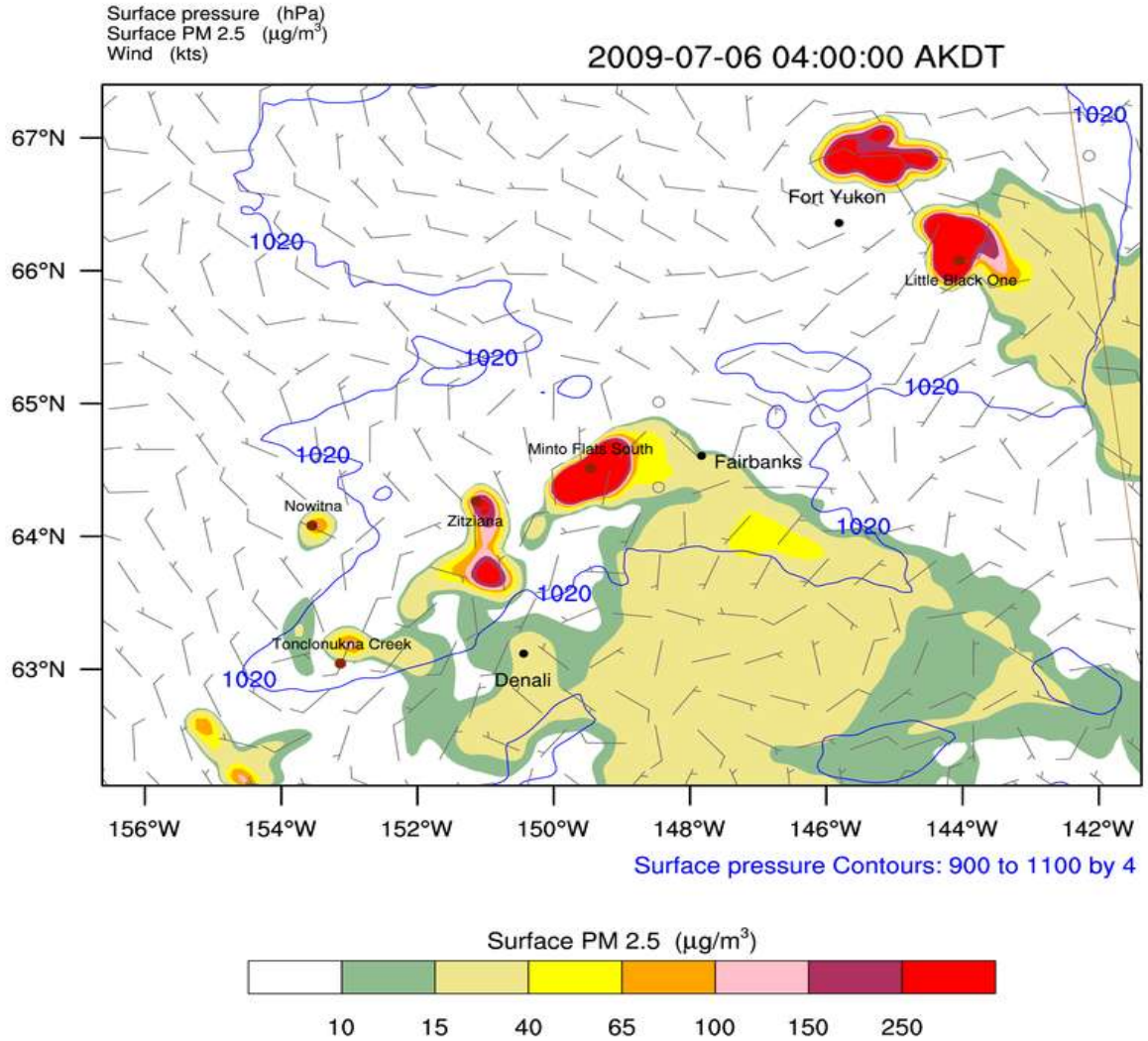


Figure 62: Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem

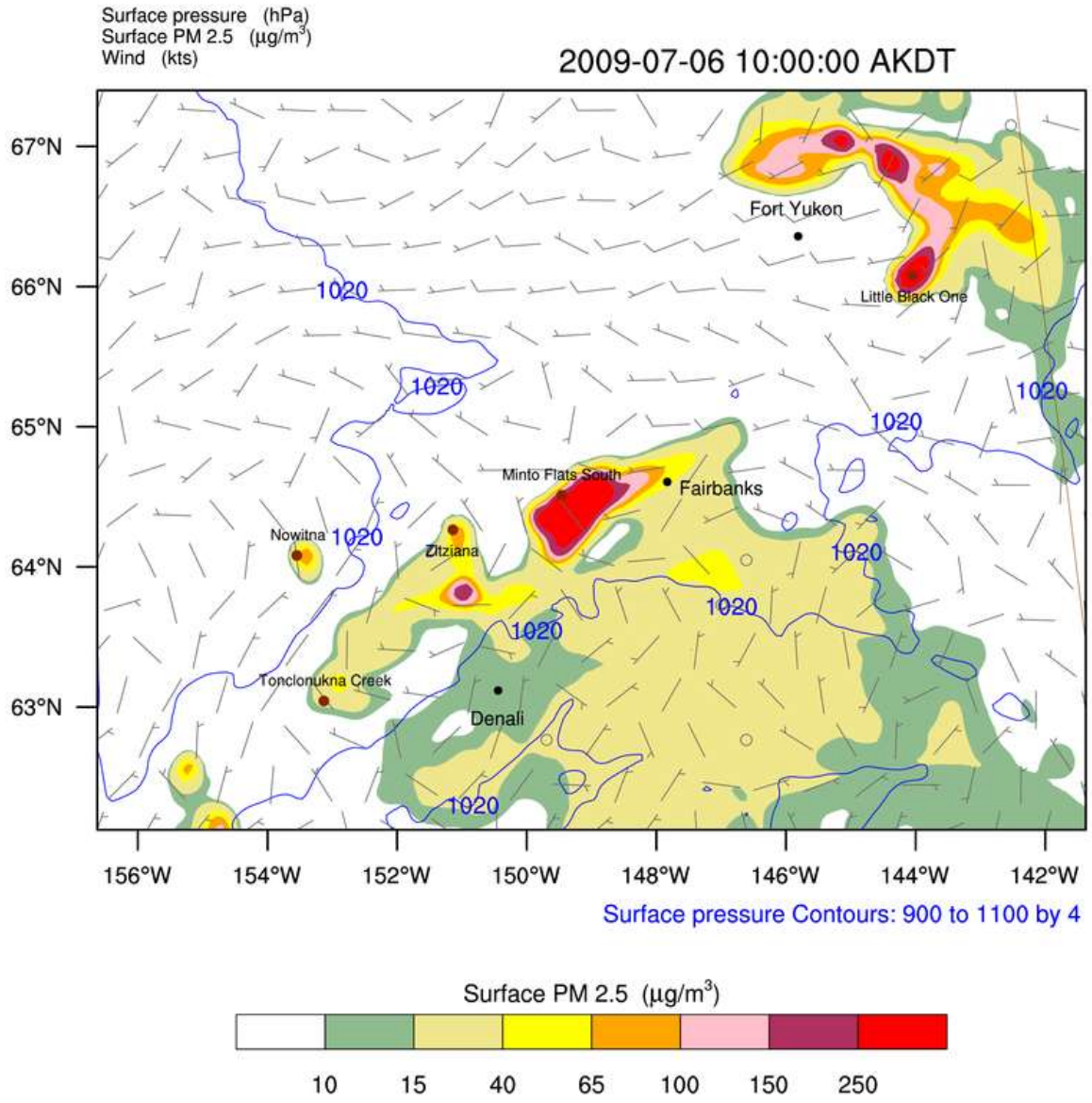


Figure 63: Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem

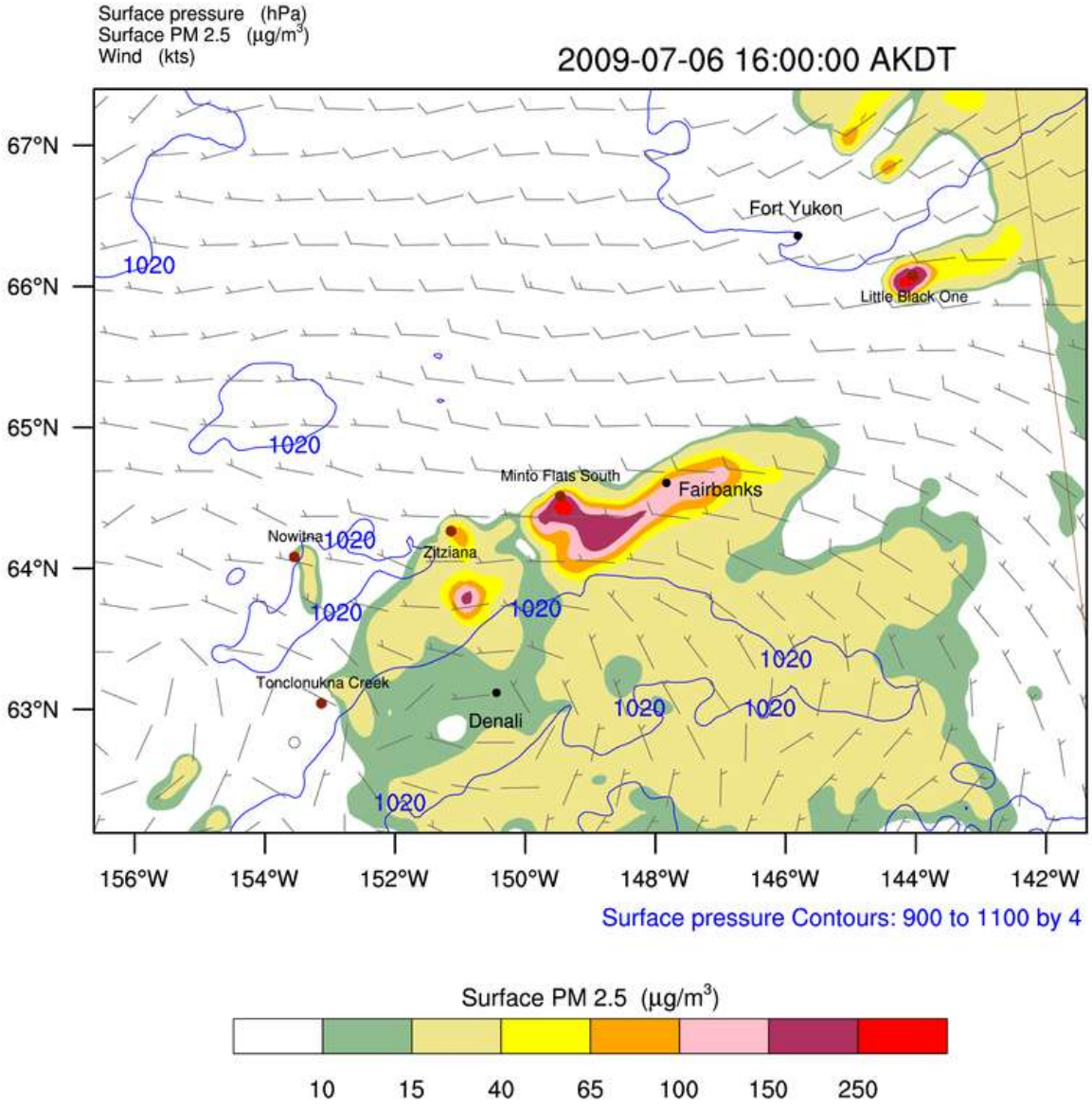


Figure 64: Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem

Case 9 July 2009: The derived $PM_{2.5}$ concentration from the FRM filter was 19.50µg/m^3. The FNSB hourly measurements reveal 6 hourly $PM_{2.5}$ peaks exceeding 40µg/m^3; three peak $PM_{2.5}$ events occurred between 77 and 79µg/m^3 from 3:00 to 5:00 AM AKDT (compare Figure 65). The fires increased in size due to the dry conditions and a record summer day with temperatures up to 91ºF in Fairbanks the 8 July. The Fairbanks surface winds shifted in the morning of the 9th with increasing intensity from slight northwest to west, and smoke from the Minto Flats South fire complex dispersed over the hills and along the Tanana River into the Fairbanks area, causing increased $PM_{2.5}$ pollution levels. The Minto Flats fires decreased slightly during the day due to decreasing westerly wind, cloudiness and cooler temperatures; active fires changed significantly to a smoldering stage.

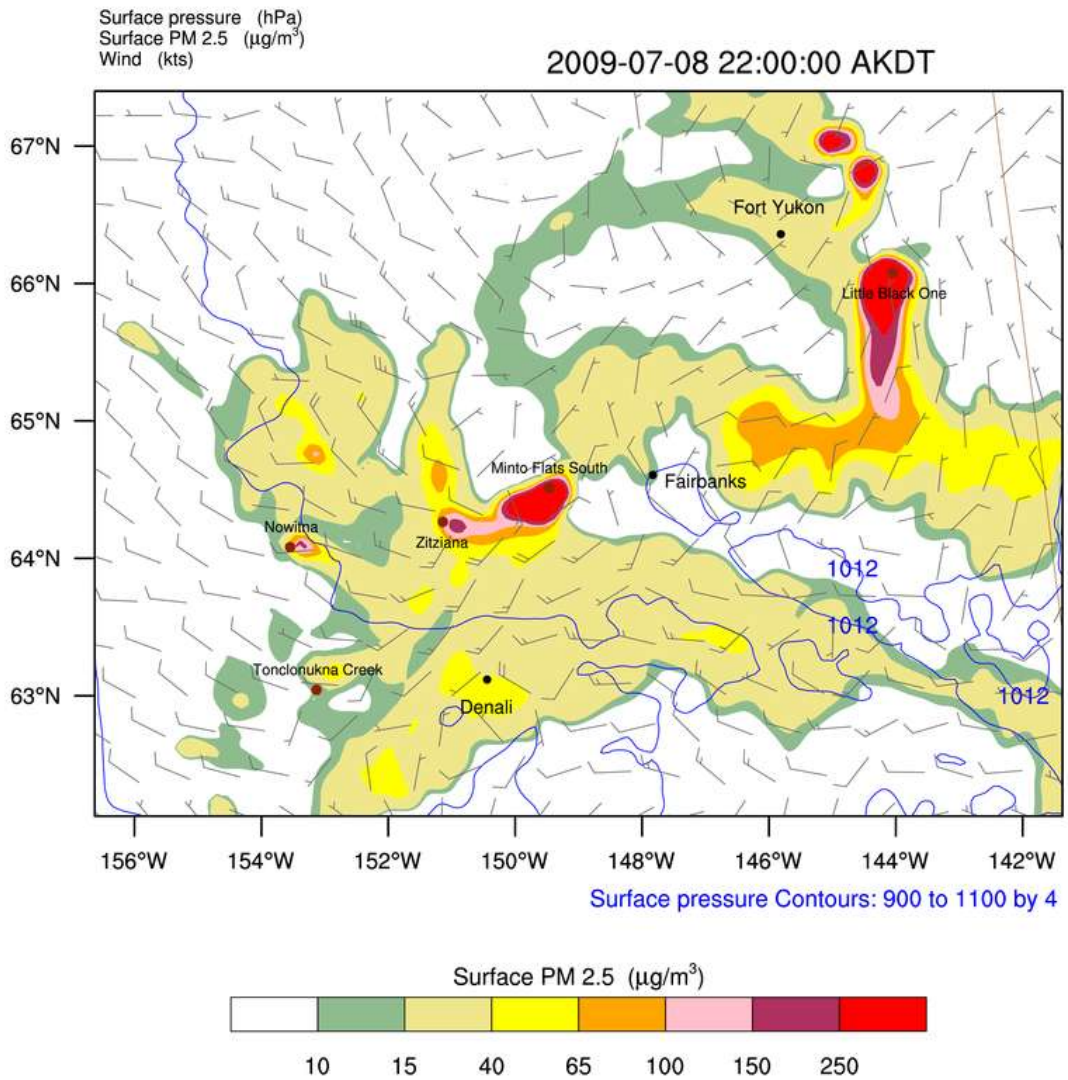


Figure 65 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

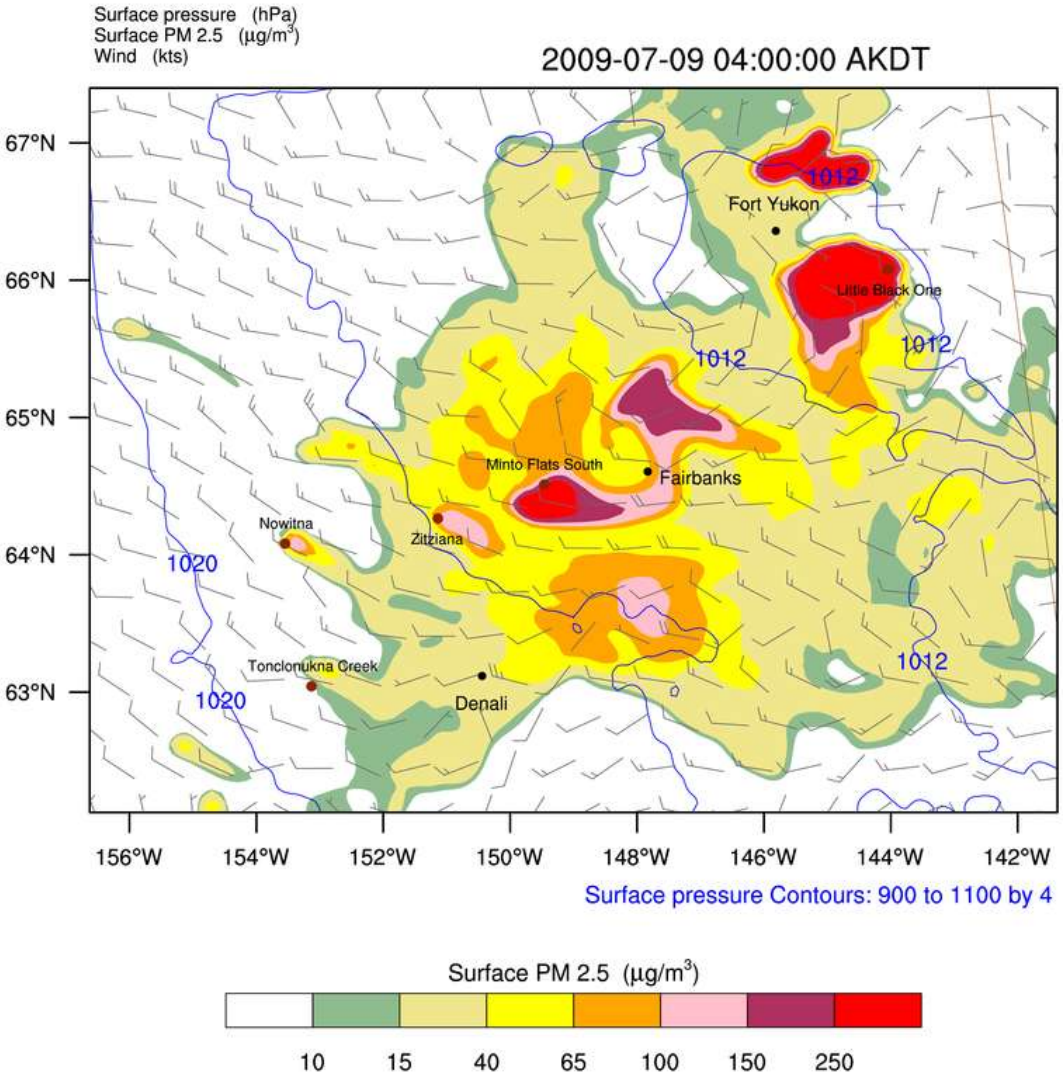


Figure 66 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

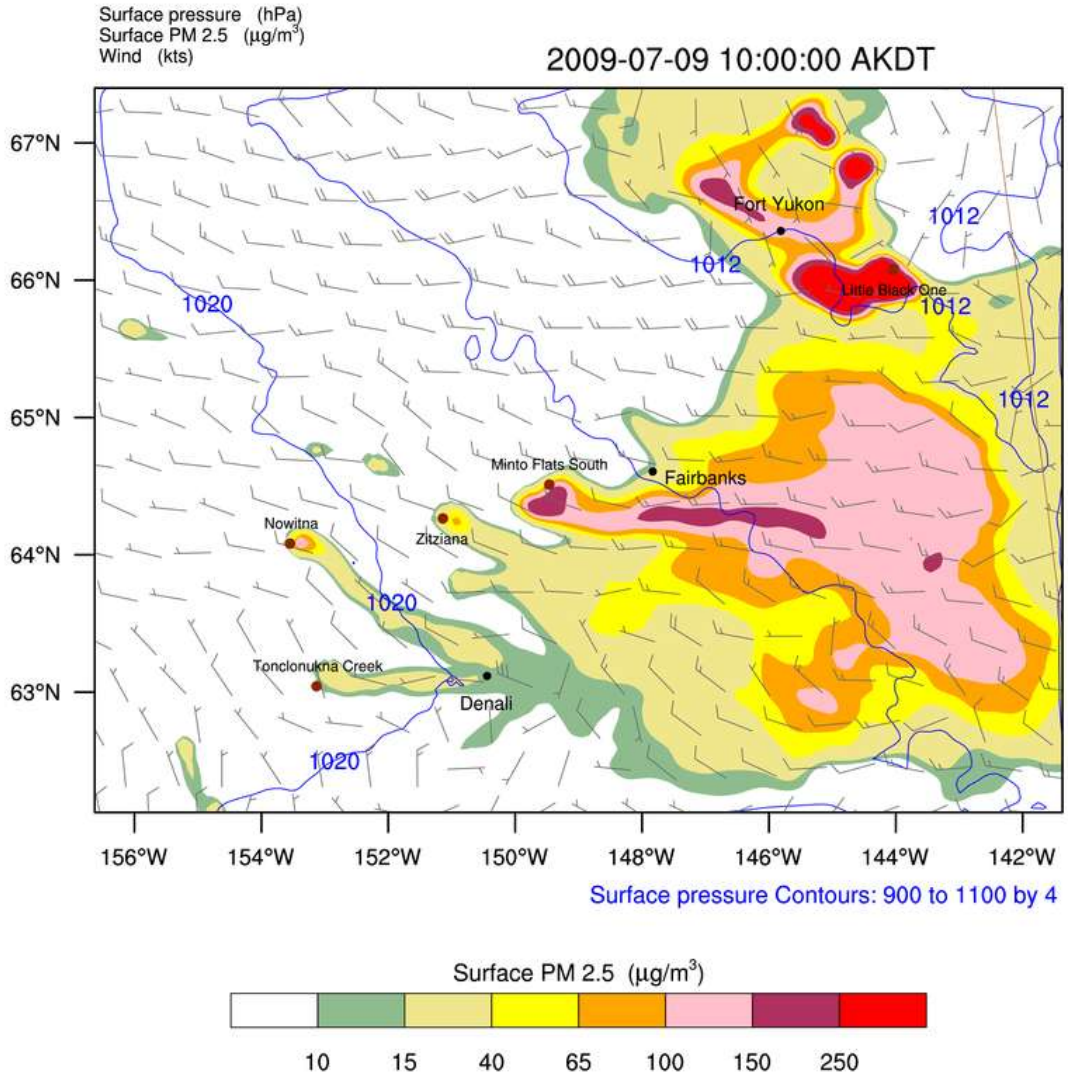


Figure 67 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

Event 2, 15 July: The FNSB hourly measurements reveal two peak $PM_{2.5}$ events the 14th at 14:00 and the 15th at 4:00 AKDT (Figure 68). A number of 10 hourly measurements exceed the 200 μg/m^3 $PM_{2.5}$ threshold during the period from 14th to 15th July 2009. Figure 14 shows the main $PM_{2.5}$ dispersion to Fairbanks originating from hotspots associated with the large fires in the West. $PM_{2.5}$ is also originating from fires in the Northwest of Fairbanks named according to the AICC database 'Logging Slash' and 'Slate Creek' fires. These (Northwest of Fairbanks) fires do not show up in the MOD 14 hotspots for the model runs for the 15th of July causing an underestimation of the total $PM_{2.5}$ concentration in Fairbanks (compare Figure 69 and Figure 70).

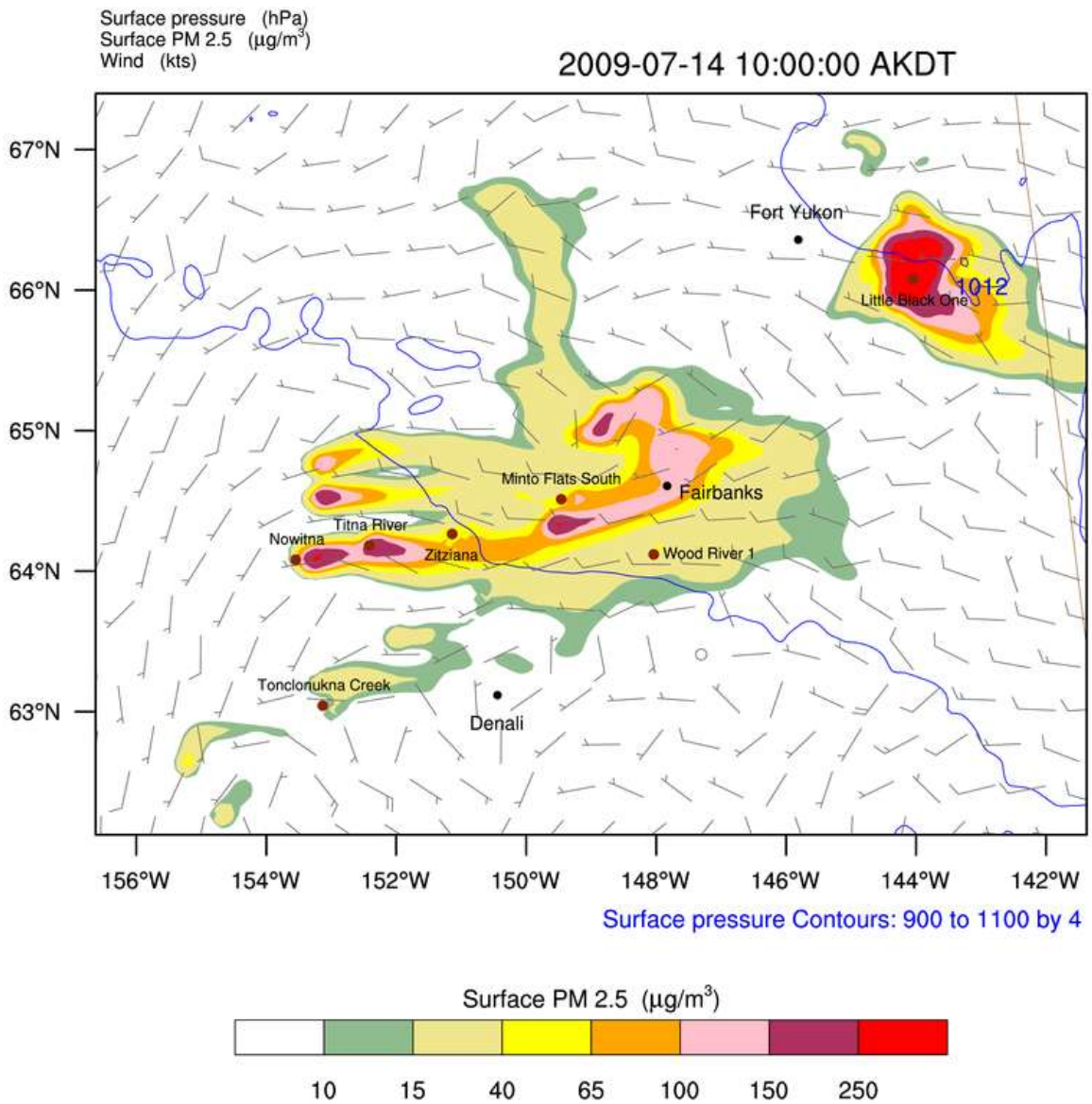


Figure 68 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

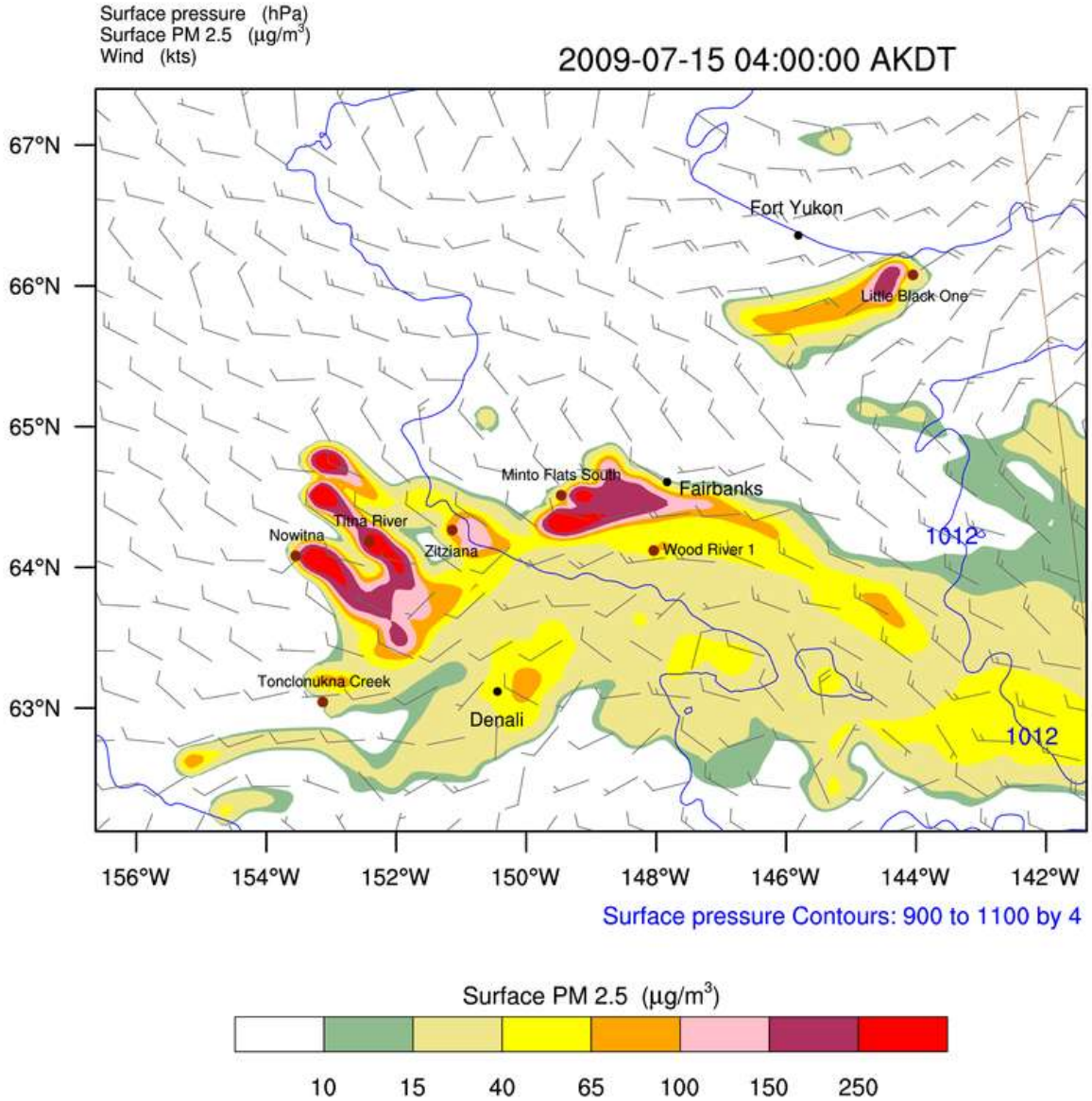


Figure 69 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

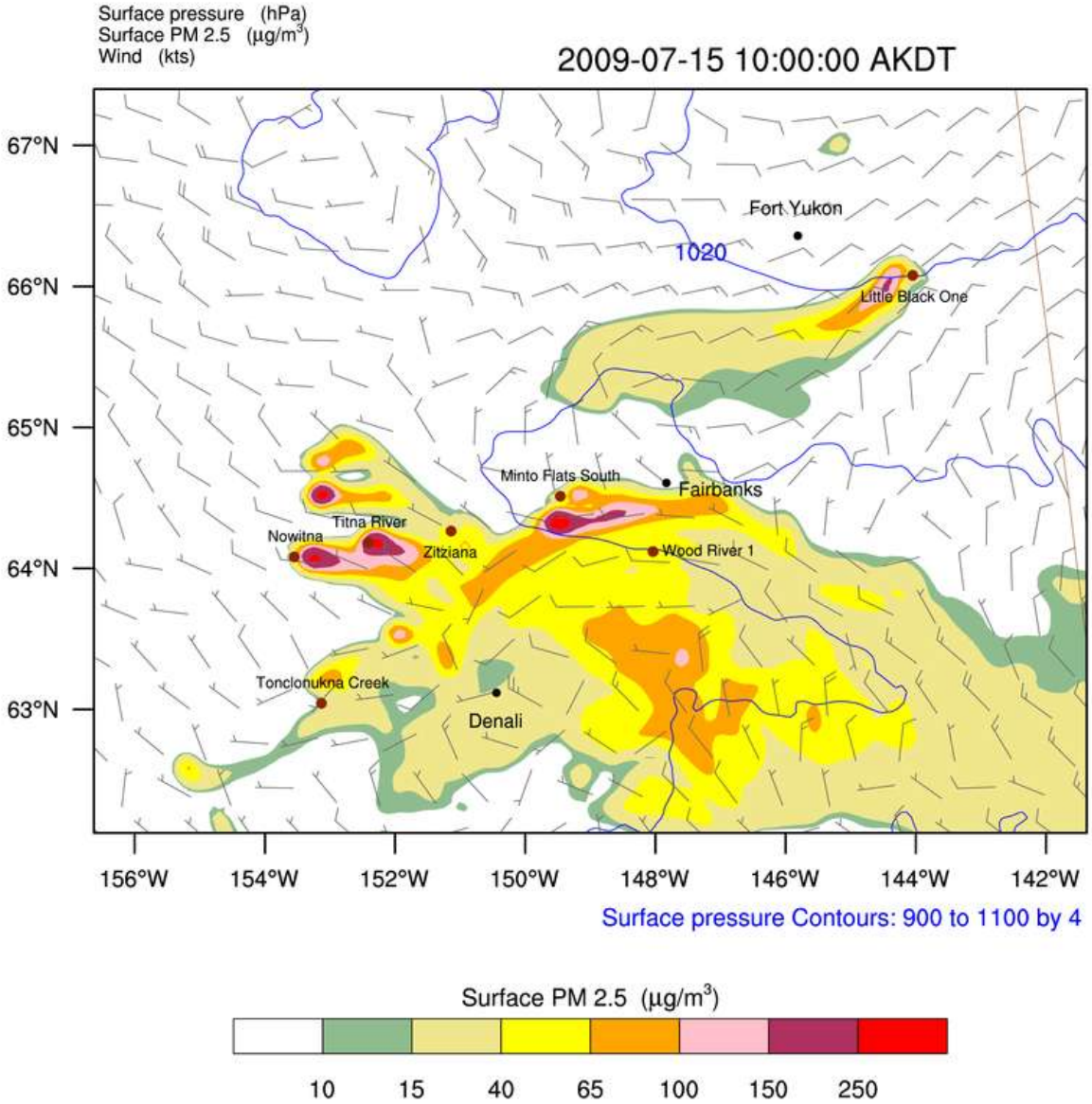


Figure 70 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

Event 3, 24 July: Moderate winds from the South to Southwest transported smoke from the 'Wood River 1' fire to Fairbanks (Figure 71).

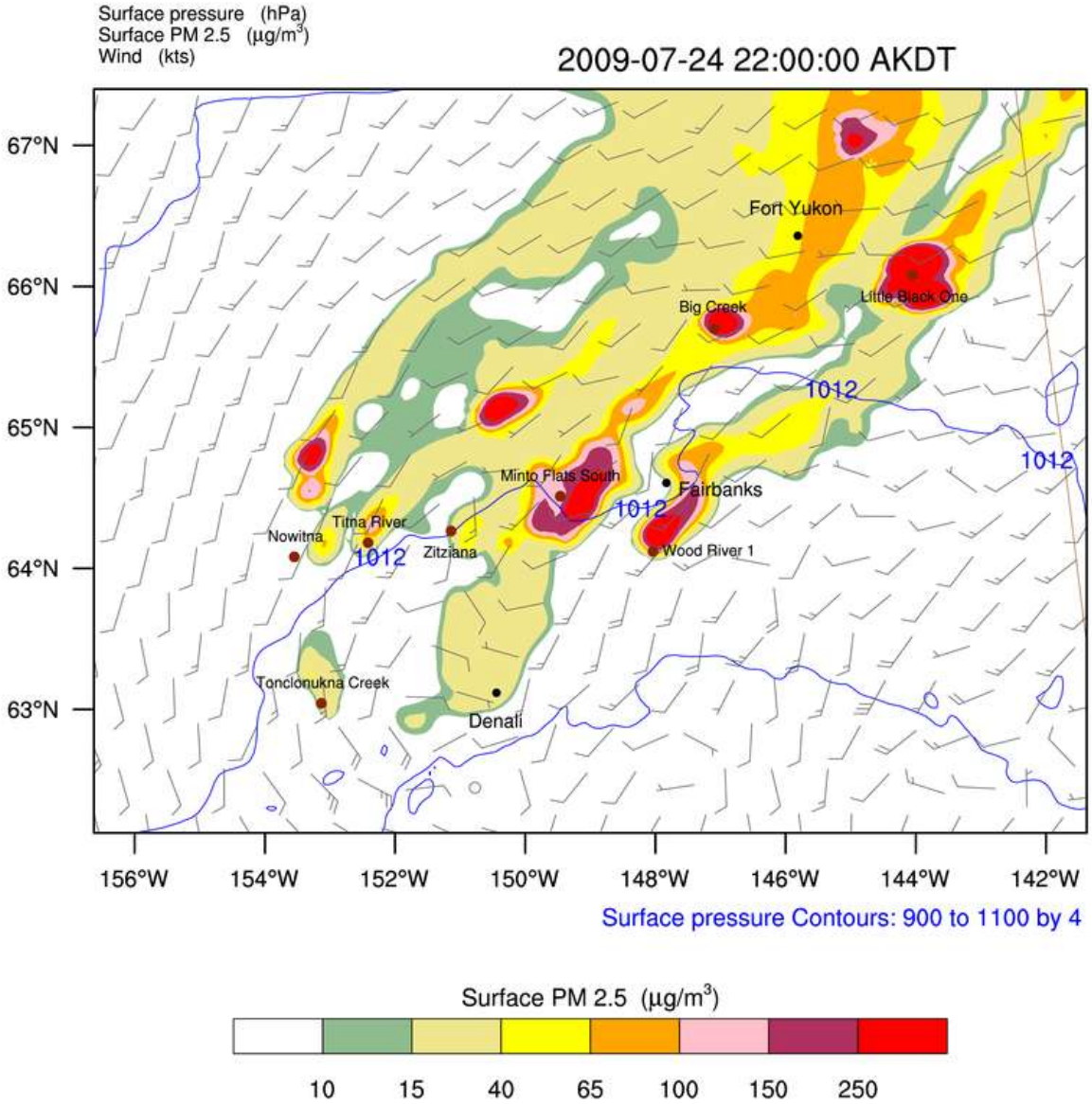


Figure 71 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

Event 4, 27 July: The maximum hourly concentration exceeding 100μg/m^3 $PM_{2.5}$ was measured the end of the 27th day of July. The WRF model clearly shows winds from the South and the Wood River 1 fire as the source for the air pollution in Fairbanks (Figure 72).

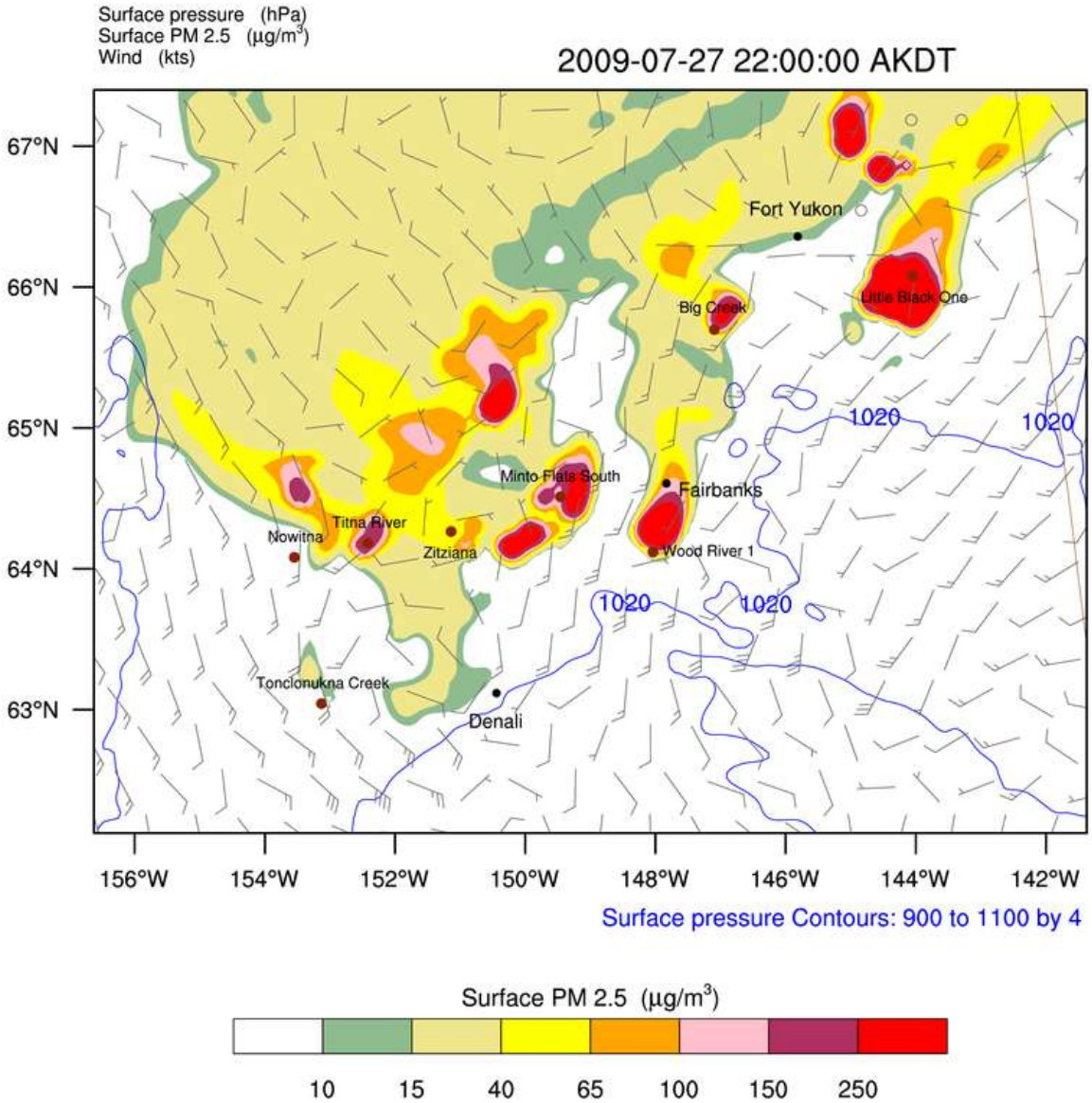


Figure 72 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

Event 5, 30 July: Significant smoke events occurred the end of July with hourly measurements exceeding 300µg/m^3 $PM_{2.5}$; the monthly maximum of 471µg/m^3 $PM_{2.5}$ was measured the 31st July (2:00 AKDST). Very light shifting winds occurred during this event. Smoke dispersed mainly from the West (Minto Flats) to Fairbanks (Figure 73).

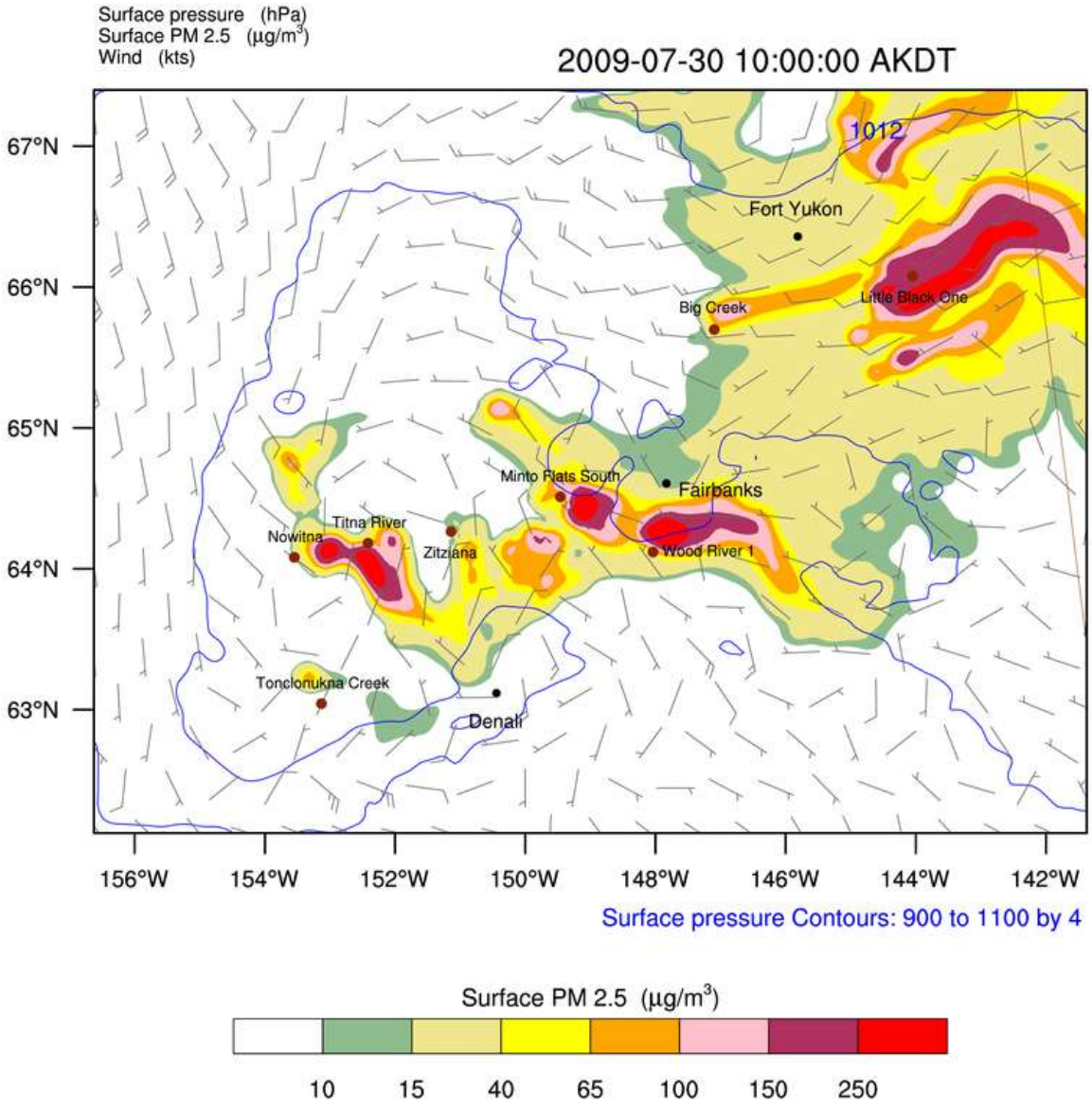


Figure 73 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

The winds increased in strength during this event with dominant southern flow from the Alaska Range, and the Wood River fires were clearly identified as the source of the main Fairbanks pollution (Figure 74).

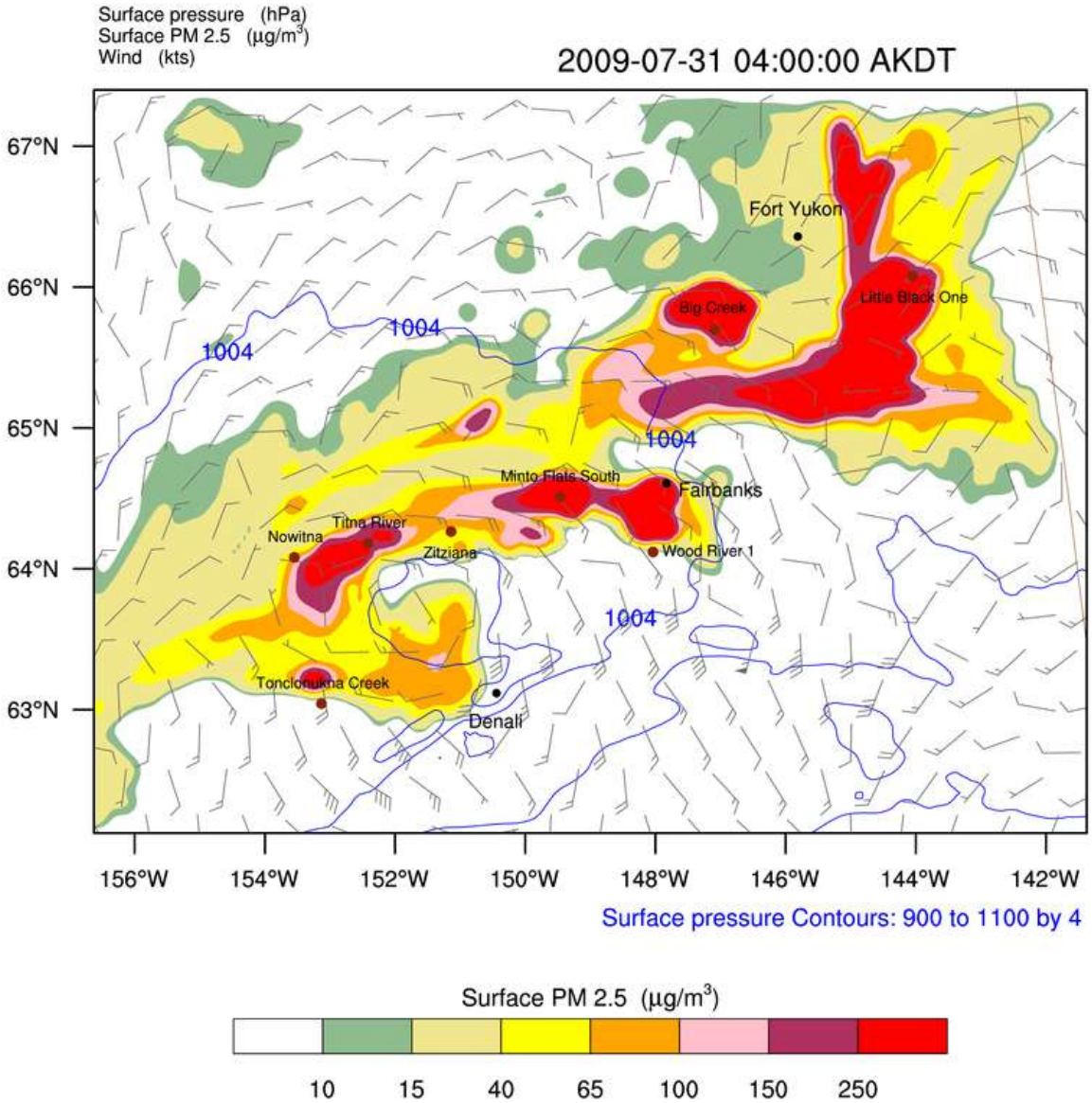


Figure 74 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

Event 6, 2 August: Continuous high $PM_{2.5}$ concentration typically on the order between 100 and 150µg/m^3 was measured by the FNSB the beginning of August. The dry weather caused a strong increase in fire activity (compare Figure 75 and Figure 76). The synoptic pressure gradients were too weak to cause a change in the highly polluted air in Fairbanks.

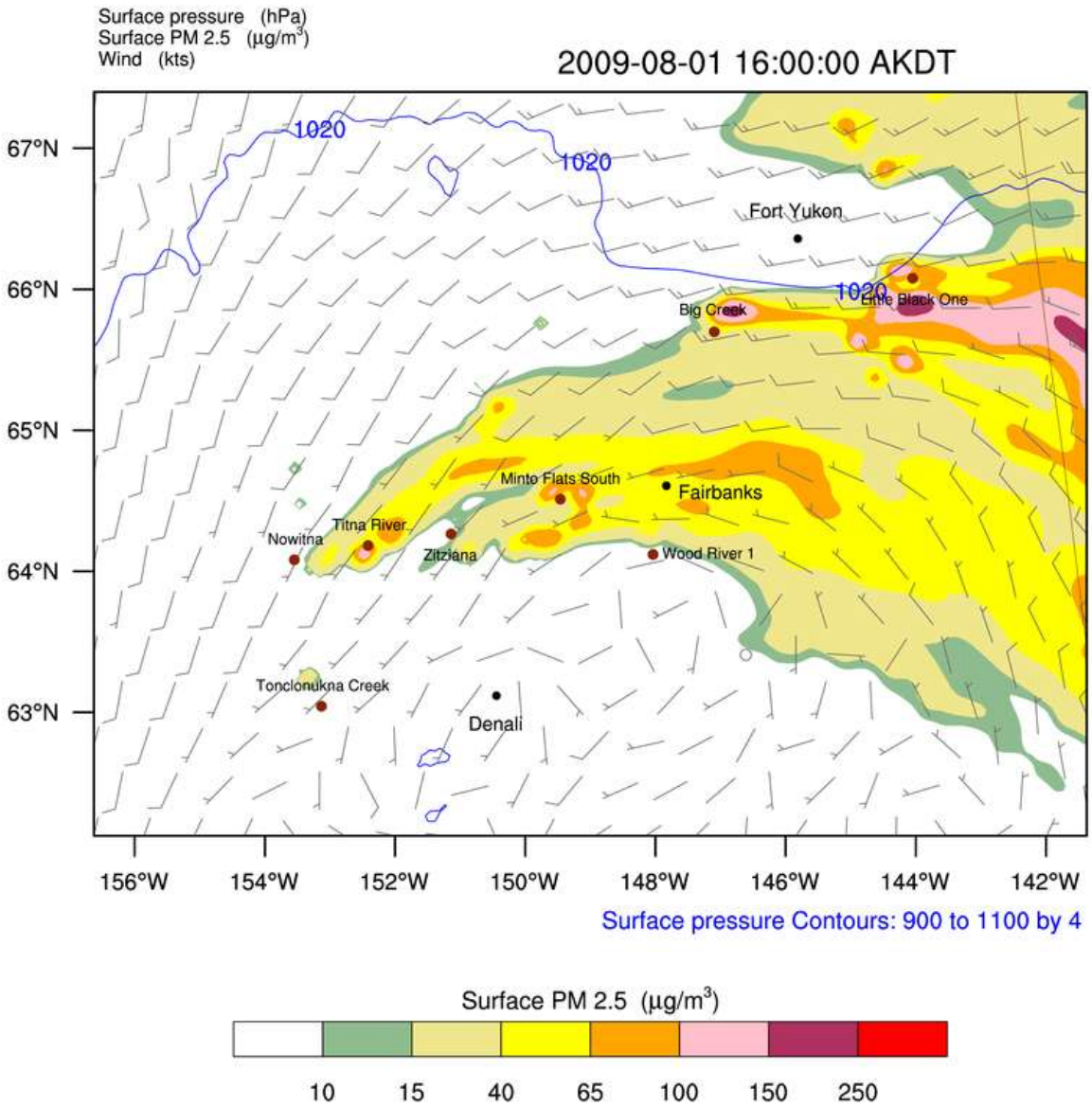


Figure 75 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

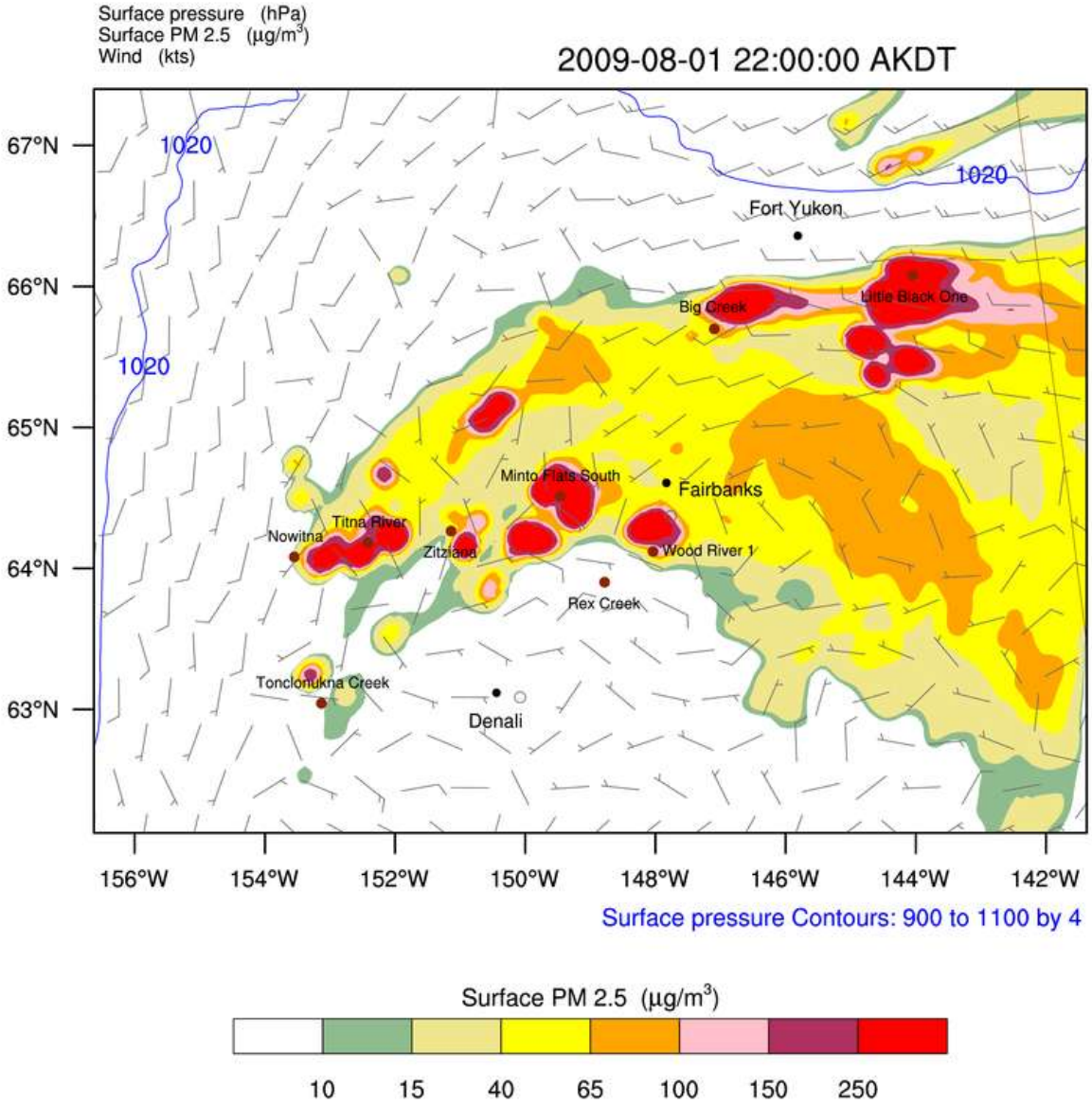


Figure 76 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

Event 7, 5 August: The $PM_{2.5}$ concentration increased to hourly values up to 66.7μg/m^3 the 5th August. A general increase of fire activity occurred. Although MOD14 hotspots were detected all around Fairbanks, the main pollution sources were identified to the West and Southwest of the city. The large Rex Creek fire was discovered the 1st of August to the South of the Wood River 1 fire; the fire burned in a relatively short period an estimated area greater than 100,000 acres.

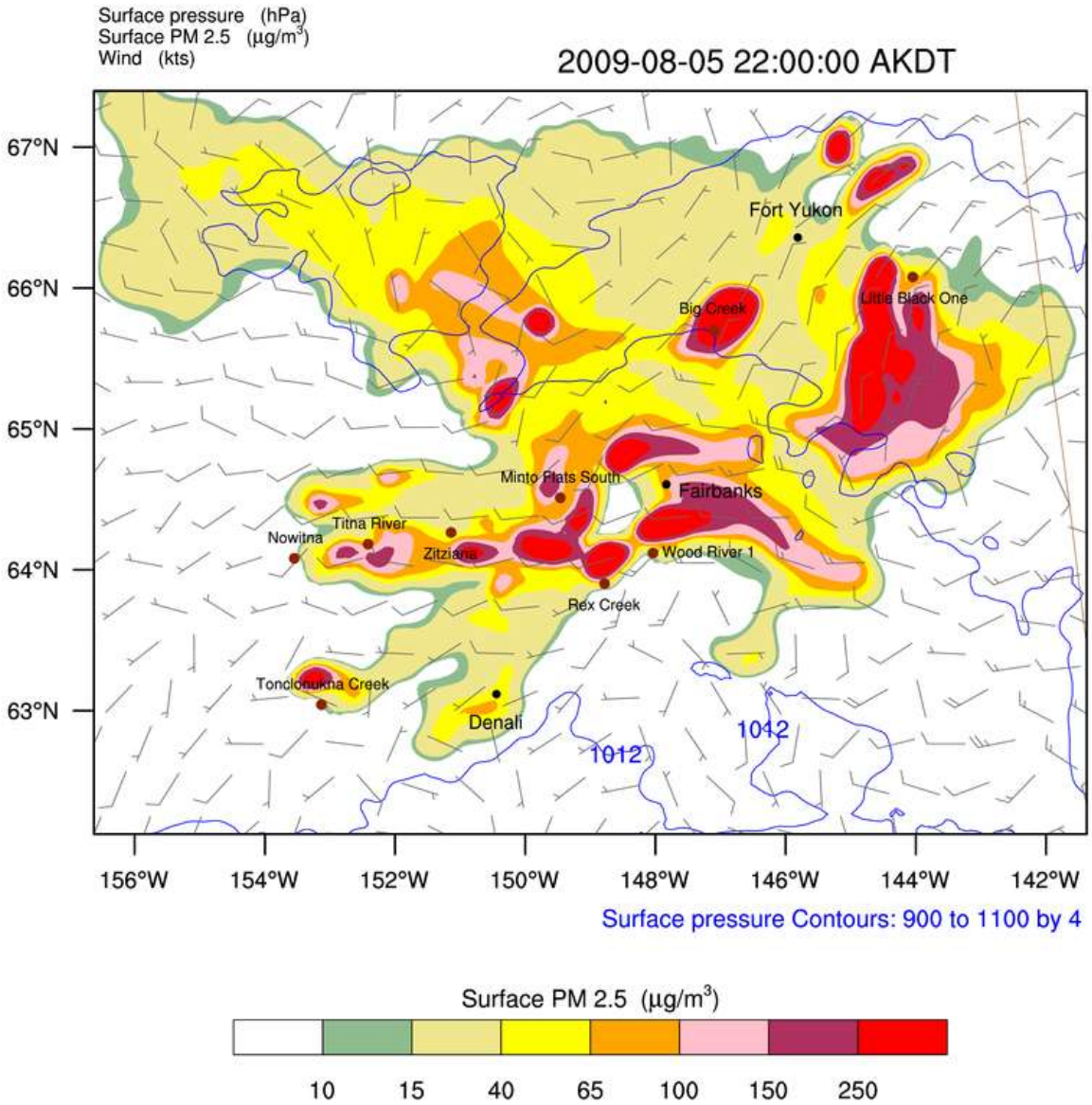


Figure 77 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

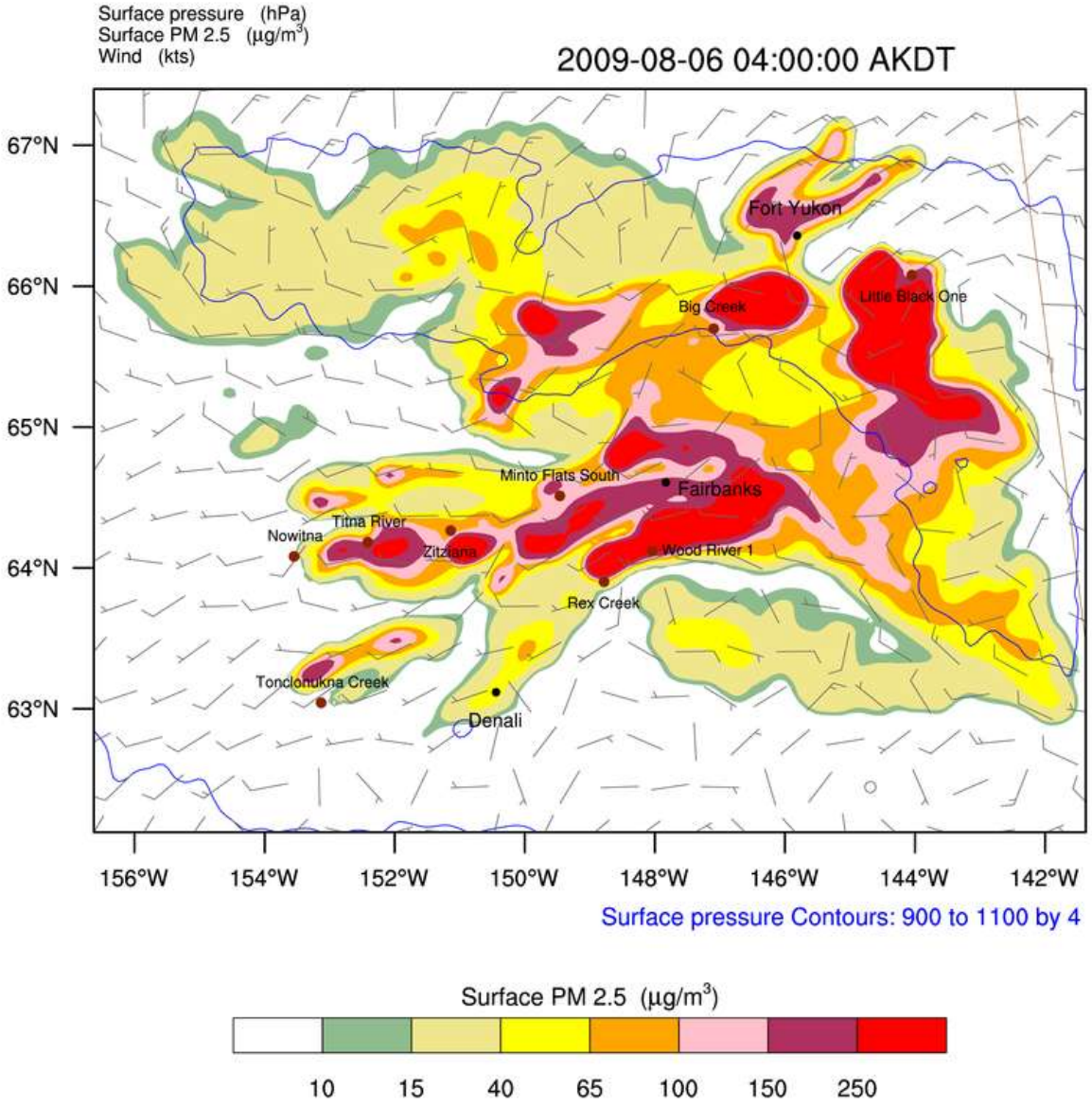


Figure 78 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

Event 8, 8 August: The $PM_{2.5}$ concentration decreased significantly during the 6th of August due to rain; 0.58 inches of rain were measured in Fairbanks the 6th of August, traces of rain continued during the following 2 days. However the rain amount and the relatively weak winds did not allow for further air quality improvements in Fairbanks. Continuous $PM_{2.5}$ levels of typically 70μg/m^3 were measured the 8th of August. The WRF/Chem. model over-estimated the $PM_{2.5}$ concentration in Fairbanks; we attribute this discrepancy mainly to a over-estimate of the hotspot areas in terms of active burning fires, and to a lack of precipitation in the NARR reanalysis meteorological fields. Figure 79 shows the extensive biomass burn $PM_{2.5}$ emissions and the relatively weak winds during this event.

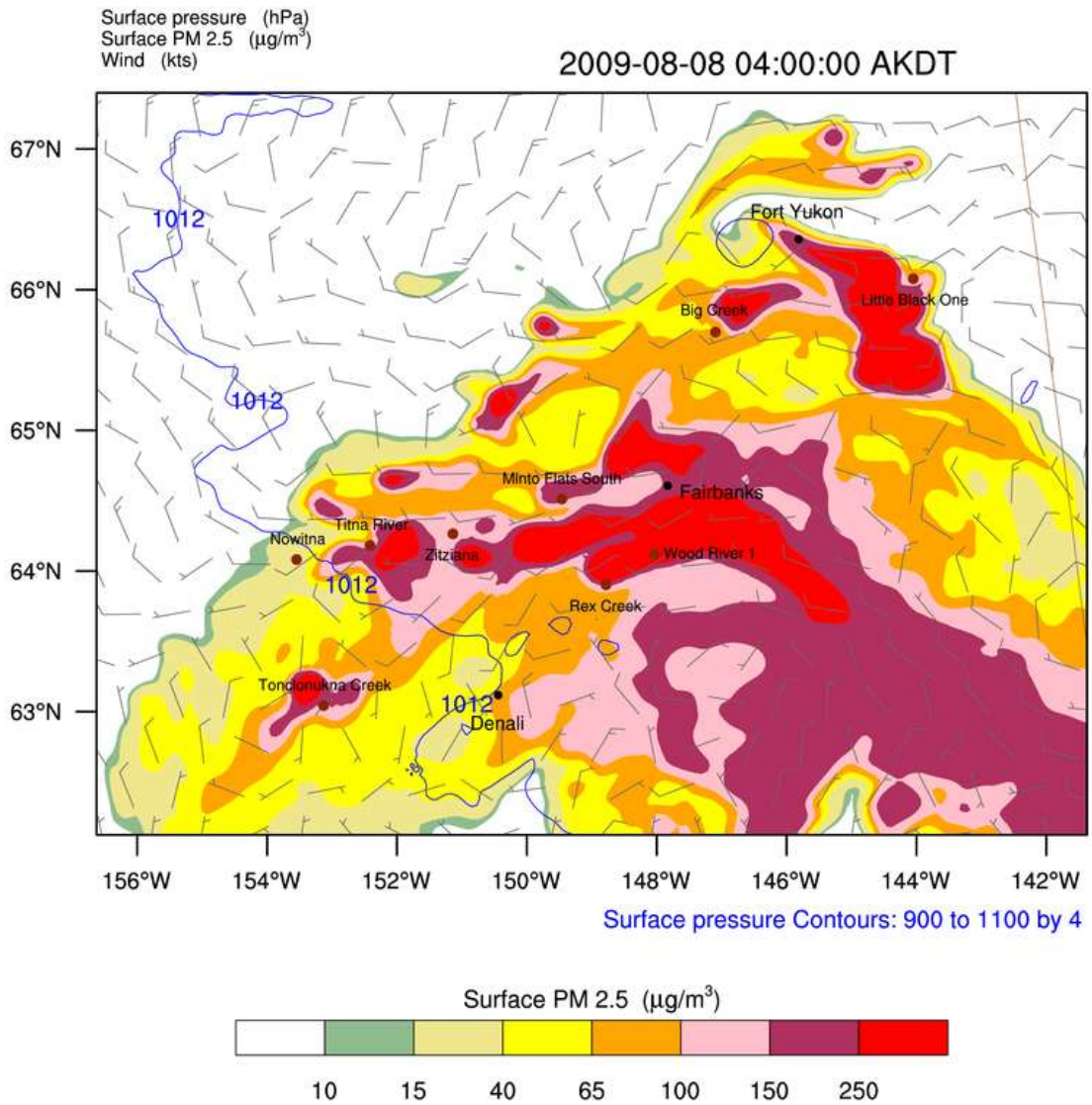


Figure 79 Surface $PM_{2.5}$ concentration, air pressure and winds as derived from WRF/Chem.

NOTE: This is the end of pages copied directly from Martin's report.

Mitigation

DEC continues to work closely with Alaska Fire Service, the AICC and the Fire Weather Forecasters to ensure Air Quality Advisory Notifications are sent to the public as rapidly as possible. New in place procedures allow ADEC to send Air Quality Advisories via Twitter and email greatly reducing the time required to contact government agencies and the general public.

ADEC, the federal land management agencies, and Alaskan tribes developed an interagency plan, the Alaska Interagency Wildland Fire Management Plan (AIWFMP), to address controlling wildland fires. The AIWFMP requires an annual, pre-season land manager(s)/owner(s) review of the fire protection needs on lands under their management authority. In addition, responsibilities and actions taken to mitigate impacts of wildfire smoke are outlined in the "Alaska's Enhanced Smoke Management Plan for Prescribed Fire, Procedures Manual April 10, 2006." The purpose of the Enhanced Smoke Management Plan (ESMP) is to provide a clear and equitable regulatory basis for smoke management in Alaska. The ESMP also outlines procedures for monitoring ambient air quality in the event of a wildfire.

Procedural Requirements

In accordance with the exceptional events rule 40 CFR §50.14(c)(2)(iii), nine data points (July 6, 9, 15, 24, 27, 30 and August 2, 5, and 8, 2009) were flagged in the State's AQS data submission. ADEC requests that EPA exclude these flagged data points when determining compliance with the $PM_{2.5}$ NAAQS for the Fairbanks State Office Building site.

Conclusions

This document describes the above normal number of wildfires and large acreage burned in Alaska in the summer of 2009. Further, the cause of all these major fires was lightening ignition of very dry fuels caused by drought conditions. Both these causes are natural occurring and uncontrollable phenomena.

The smoke from these fires impacted the Fairbanks area and caused nine days with elevated $PM_{2.5}$ concentrations, of which 6 exceeded the NAAQS between July 3 and Aug 9, 2009. These smoke impacted, natural event data should not be used in the determination of compliance with the NAAQS for Fairbanks and surrounding areas. It is clear that without the wildfires, $PM_{2.5}$ concentrations at the Fairbanks State Office Building site would have been much lower. Data

from low fire years provide an estimate of background summer time $PM_{2.5}$ concentrations in the range of 3-6 µg/m^3, less than 20% of the $PM_{2.5}$ NAAQS.

These wildfires will reoccur and are not controllable. State of Alaska ESMP and Air Quality Advisory procedures adequately cover actions to be taken when these events occur.

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Abbreviations

AICC Alaska Interagency Coordination Center
BL Boundary Layer
GDAS Global Data Assimilation System
GFS Global Forecast System
HYSPLIT HYbrid Single-Particle Lagrangian Integrated Trajectory
MODIS Moderate Resolution Imaging Spectroradiometer satellite imagery
NCEP National Centers for Environmental Prediction
AIWFMP Alaska Interagency Wildland Fire Management Plan
NAAQS National Ambient Air Quality Standard
FRM Federal Reference Method
FEM Federal Equivalent Method
UAF University of Fairbanks
WD Wind Direction
WS Wind Speed