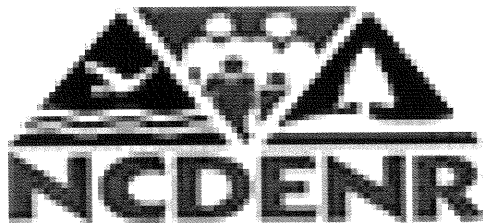


**AUGUST 7, 2007
EXCEPTIONAL EVENT
DEMONSTRATION PACKAGE**

FOR THE

**LINKHAW
(LUMBERTON, NORTH CAROLINA)
FINE PARTICLE
FEDERAL REFERENCE METHOD MONITOR
(371550005-88101-1)**

December 14, 2007



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A Division of the North Carolina Department
of Environment and Natural Resources
Mail Service Center 1641
Raleigh, North Carolina 27699-1641

TABLE OF CONTENTS

Discussion.....	1
Mapping Showing Location of the Monitor in Relationship to the Fires.....	2
PM 2.5 FRM Concentrations (micrograms per cubic meter) for the Fayetteville Region..	3
Evidence the Event Occurred	
News Article: More People Brought to Battle Robeson County Wildfires.....	4
News Article: Forestry Officials Keep Watch on Alamac Area.....	5
News Article: Wildfires Char Robeson County Landscape.....	6
Locations of Fires and Acreage Burned.....	7
Evidence the Event Impacted the Monitor	
Wind speed and direction data from Lumberton Municipal Airport.....	8
Time Conversion Table (Z Time to Eastern Standard Time).....	11
HYSPLIT back trajectories at 50m from Linkhaw pass through the fires on 8/7/07.....	12
HYSPLIT forward trajectories of fires 20, 21, and 22 at 100 m on 8/7/07.....	13
HYSPLIT forward trajectories of fires 23, 21, and 25 at 100 m on 8/6/07.....	14
NOAA Hysplit Model Forward trajectories starting at 06 UTC 06 Aug 07 (100 m) Fire 20.....	15
NOAA Hysplit Model Forward trajectories starting at 06 UTC 06 Aug 07 (100 m) Fire 21.....	16
NOAA Hysplit Model Forward trajectories starting at 06 UTC 06 Aug 07 (100 m) Fire 22.....	17
NOAA Hysplit Model Forward trajectories starting at 06 UTC 06 Aug 07 (100 m) Fire 23.....	18
NOAA Hysplit Model Forward trajectories starting at 06 UTC 06 Aug 07 (100 m) Fire 24	19

NOAA Hysplit Model Forward trajectories starting at 06 UTC 06 Aug 07 (100 m)
Fire 25.....20

Atypical Analysis

“Atypical” Analysis for 11 June 2007 Spruce Pine Exceedance.....21

“But For” Test

“But For” Test: There would have been no exceedance or violation “but for” the
event.....23

Linkhaw FRM-PM_{2.5} (No TEOM - PM_{2.5} collection at Linkhaw)
 1170 Linkhaw Road
 Lumberton, NC
 Robeson County, NC
 Site ID: 371550005 - 88101
 8/7/07
 FRM PM_{2.5} Concentration = 40.208 ug/m³
 Recommended Flag - E: Forest Fire

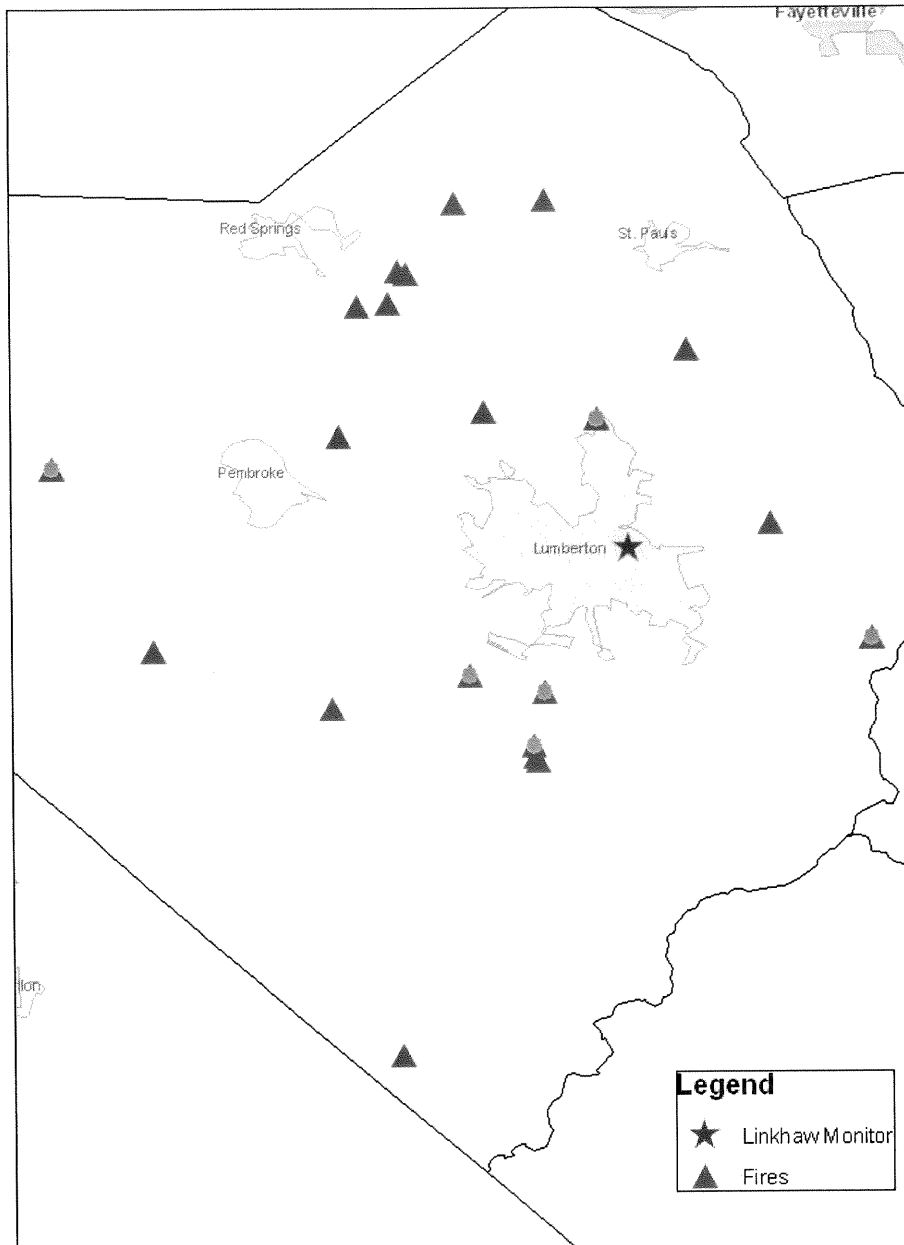
DISCUSSION:

 The North Carolina Division of Air Quality seeks EPA concurrence of the "E" flag (Forest Fire) for the Federal Reference Method (FRM) – PM_{2.5} monitor reading 40.21 micrograms per meter cubed (ug/m³) on 8/7/07 at the Linkhaw monitoring station.

The monitor sustained an impact from several wildfires that were burning the week before the measured exceedance of the daily fine particle standard (35 ug/m³). An investigation revealed firefighters responded to several wildfires in Robeson County between 8/2/07 and 8/10/07. Forward and backward HYSPLIT trajectories were overlaid on a map showing the fires and the monitor with GIS software. Trajectories indicate the smoke perhaps circulated near and around the monitor. The wildfires were within thirty miles or less of the Linkhaw PM_{2.5} FRM monitor. The exceedance FRM-PM_{2.5} value at Linkhaw on 8/7/07 was significantly higher than the readings prior to and after the event (Table 1).

Table 1 Comparative FRM-PM_{2.5} (ug m⁻³)

		Linkhaw FRM (ug m ⁻³)
Pre Event, 7/23 - 8/4	5-day Avg(FRM).	15.47
	Max	17.79
	Min	14.04
8/7/07 (Exceedance)	24 hr Avg (FRM).	40.21
Post Event, 8/10 - 8/22	5-day Avg(FRM).	23.83
	Max.	29.67
	Min.	16.79



All the fires that occurred in Robeson County between 8/2/07 and 8/7/07 plotted with GIS software. The Linkhaw monitor ran a sample on 8/7/07 and obtained an exceedance of the $PM_{2.5}$ daily standard at $40.208 \mu\text{g}/\text{m}^3$.

FIG 2.3 FPMV CONCENTRATIONS ug/m³

Site_ID1	371230001	371550005	370510009	370510009
Site_ID2	603	605	601	602
Region	PRO	PRO	PRO	PRO
Site	CN	LH	WO	WO
07/02/2007	14.38	14.63	10.92	7.33
07/05/2007	9.92	5.25	7.12	7.33
07/08/2007	20.54	21.08	19.17	7.33
07/11/2007	8.54	9.54	7.08	8.21
07/14/2007	18.17	22.04	19.25	8.21
07/17/2007	19.33	12.04	16.50	16.75
07/20/2007	22.71	28.67	17.04	16.75
07/23/2007	13.87	-14.04	10.67	12.13
07/26/2007	17.67	-12.00	20.08	12.13
07/29/2007	22.12	-17.79	29.87	19.67
08/01/2007	29.71	-17.13	19.71	18.96
08/04/2007	25.96	-16.37	32.62	18.96
08/07/2007	35.12	40.21	29.58	29.13
08/10/2007	18.04	29.25	20.00	23.88
08/13/2007	24.83	-16.79	23.37	23.88
08/16/2007	21.29	-21.46	28.04	17.08
08/19/2007	17.46	-29.67	16.92	17.08
08/22/2007	15.50	-21.96	14.46	16.25
08/25/2007	19.79	13.58	16.42	16.25
08/28/2007	22.00	14.96	19.88	12.96
08/31/2007	14.25	18.29	15.29	12.96
09/03/2007	18.21	12.75	16.92	8.42
09/06/2007	17.87	16.46	8.42	8.42
09/09/2007	9.75	10.33	20.17	10.75
09/12/2007	7.08	19.67	11.13	10.75
09/15/2007	9.21	12.33	5.21	7.25
09/18/2007	23.38	5.17	6.12	7.25
09/21/2007	9.46	5.67	20.08	11.79
09/24/2007	1.88	19.12	9.96	11.79
09/27/2007		9.21	5.54	
09/30/2007		5.96		
Average	17.34	16.56	16.58	14.70

LVA Khan
5/7/07

Handwritten annotations in the table including circled values and arrows pointing to specific rows.

More People Brought to Battle Robeson County Wildfires

State and local officials said they have brought in more than 90 firefighters from throughout the state in recent days to battle a series of wildfires in Robeson County.

Firefighters were working to control about 70 wildfires, some of which started four weeks ago and continue to burn or smolder, according to state officials.

The wildfires, which have ranged in size from a few acres to 200 acres, have not burned any homes or resulted in any serious injuries, authorities said. Most of the fires were smoldering in thick peat soil and were about 70 percent controlled.

Fire officials said they were working hard to keep some of the fires inside the lines of containment.



However, drought conditions have made it difficult for firefighters to contain all the fires.

During the past four weeks the multiple fires, known as the Longbranch/Robeson Complex, have threatened about 600 homes. In some cases, people have been temporarily evacuated from their homes, officials said.

The Division of Forest Resources also brought in single-engine air tankers from Kinston to assist firefighters. Each aircraft can carry up to 500 gallons of water or fire-retardant chemicals to dump onto fires.

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The Robesonian | The St. Pauls Review | The Red Springs

 <p>4311 Fayetteville Rd, Lumberton 759-3323 • Mon- Thurs. 8:00 - 5:00 Fri. 8:00 - 3:30 Saturday appointments available John I. Adams O.D. Charles L. Clark O.D. Katherine S. White O.D. Carolyn M. Marks Licensed Optician</p>	 <p>Back To School Special! CHILDREN'S EYE HEALTH & SAFETY MONTH Starting At \$79.95 Includes Quality Frame and Shatter Resistant Polycarbonate Lenses. Package has a one year warranty with NO additional cost. (No discounts where insurance applies)</p>	<p>Winner For Congratulations Geraldine Brev of Pembroke, N.C. The winner receives frame for the month. Register to win a free for the month of August. *Certain restrictions apply.</p>
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THE ROBESONIAN

Wednesday, August 15, 2007

Site updates 12 a.m.

Forestry officials keep watch on Alamac area

By Jonathan Yeomans - Staff writer

News

- Local News
- Obituaries
- Editorials
- Religion
- Pet of the Week
- Front Page

Sports

- Local Sports

Lifestyles

Health

Entertainment

Stocks / Finances

Classifieds

- Automotive
- Employment
- Legal Notices
- Real Estate

Guestbook

Info Desk

- About Us
- Place a Classified Ad
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Special Sections

Photo Reprints

Archives

Home

LUMBERTON - State forestry officials say it is still unclear what caused the wildfire that burned 200 acres and caused the evacuation of almost 40 homes on and around Alamac Road.

But they are offering tips to help prevent additional fires.

State officials say people are responsible for starting most forest fires. Almost one-third of the wildfires in the state are caused by people burning trash and then letting the fire get out of control. In an average year, wildfires damage about 50,000 acres of forests across the state.

Jim Schlenker, an assistant district forester with the N.C. Forest Service, said investigators don't know who or what started the Lumberton fire almost two weeks ago. It rekindled on Wednesday drawing fire crews from across the state and press coverage from USA Today and MSNBC. The wildfire also sent dozens of residents packing. No homes were destroyed, but a firefighter and a resident were treated for smoke and heat-related problems.

Schlenker said even though the fire has been contained, it continues to smolder.

"The fuels in there are still burning, because it's dry down to the bottom soil," he said. "In the 30 years I've worked, I haven't seen it this close. We monitor it all day. We have airplanes fly over, and we send in ground unit periodically throughout the day."

He said there is not much more crews can do. Residents, however, still have a role to play.

Wildfires Char Robeson County Landscape

The sweltering heat and dry conditions across North Carolina combined to fan 84 wildfires over the weekend, authorities said.

Robeson County has been among the more active locations for the fires, with 27 over the weekend burning 1,084 acres. Wildfires have burned more than 2,600 acres across the county since the beginning of the month, according to the state Division of Forestry, and some of the fires continue to burn.

"It's been a constant go, go, go, and it's been like that for the past month and a half now," Fairmont Rural Fire Department Chief Charlie Hunt said. "I think we had seven calls in a period of five hours' time (on Sunday)."

Outdoor burning is banned in Robeson County, but firefighting crews found a man burning trash behind his home within sight of a fire along Interstate 95.

"Yeah, I was burning trash," resident Jerry McCormick said. "I was fixing my back porch."

Firefighters ordered McCormick to douse his back-yard fire with a hose.

"Once I saw that fire, I figured I'd put mine out, too. So, that's what it was. They came and told me to put the fire out," he said.

Outdoor burning is to blame for many of the 125 wildfires that have turned Robeson County's forests into ashy, sooty moonscapes over the past month, authorities said.

"When the wind gets to these barrels and spreads the embers out all over, that's more or less what we're dealing with throughout the whole county," Hunt said.

The biggest fire has been around the town of Orrum, off U.S. Highway 74 and N.C. Highway 130. The fire had burned between 250 and 300 acres by Monday evening, and a few mobile homes near U.S. 74 had to be evacuated, authorities said.

Meanwhile, a wildfire broke out at about 1:15 p.m. in the Hasty community in Scotland County at Hasty and Peabridge roads. It was partially contained by 5 p.m., according to authorities. Several homes were evacuated.

More than 200 acres burned in Johnston County, and crews were working Monday to cool down hot spots. Authorities said lightning might have sparked the fire.

Reporter: Bryan Mims

Photographer: Michael Joyner

Web Editor: Matthew Burns

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Fire #	Date	Lat	Long	Acres
40	02-Aug-07	34-35.18	79-15.17	25
42	02-Aug-07	34-21.85	79-06.97	40
39	02-Aug-07	34-47.7	79-06.98	4
38	03-Aug-07	34-33.22	79-09.21	10
37	03-Aug-07	34-39.33	78-54.71	1
36	03-Aug-07	34-31.59	79-02.53	99
34	04-Aug-07	34-46.52	79-08.28	1
35	04-Aug-07	34-45.03	78-57.50	1
28	05-Aug-07	34-31.49	79-02.44	12
26	05-Aug-07	34-49.94	79-05.11	3
29	05-Aug-07	34-49.99	79-02.12	30
30	05-Aug-07	34-35.5	78-51.4	15
31	05-Aug-07	34-42.21	79-08.91	30
32	05-Aug-07	34-46.60	79-07.23	25
33	05-Aug-07	34-47.59	79-06.65	12
27	05-Aug-07	34-42.99	79-04.11	4
25	06-Aug-07	34-41.21	79-18.45	50
24	06-Aug-07	34-35.5	78-51.4	60
23	06-Aug-07	34-34.3	79-04.7	90
22	07-Aug-07	34-33.78	79-02.22	7
21	07-Aug-07	34-42.79	79-00.41	10
20	07-Aug-07	34-31.95	79-02.56	2

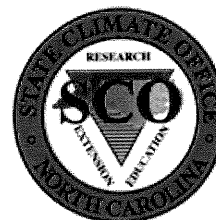
Distance from LH.
 13.87
 20.70

34.612
 -78.99028

Obtained from NC DFR
 office in Fayetteville Region -
 from Jim Schenker.

10

Station: KLBT - Lumberton Municipal Airport **Date of first observation:** March 1, 1999







STATION DETAILS

Station type: ASOS - Standard
City, State: Lumberton, NC **County:** Robeson County
Latitude: 34.6099167° **Longitude:** -79.0594444°
Elevation: 126 feet above sea level
Climate division: NC06 - Southern Coastal Plain
River basin: Pee Dee
Supported by: NOAA National Weather Service

This page is created dynamically and should not be bookmarked. Instead, bookmark the [page](#) preceding this.

Retrieving hourly data from Lumberton Municipal Airport for 2007-08-06 thru 2007-08-07 (2 days)

48 observations for this period of record (100% data available)

 Date/Time of ob (Eastern Standard Time)	 Wind Speed at 10m (mph)	 Wind Direction at 10m	 Wind Gusts at 10m (mph)
08/06/2007 00:54 ^H	4.6	South (170°)	*
08/06/2007 01:54 ^H	0	Calm or Variable	*
08/06/2007 02:54 ^H	3.5	South Southeast (150°)	*
08/06/2007 03:54 ^H	0	Calm or Variable	*
08/06/2007 04:54 ^H	0	Calm or Variable	*
08/06/2007 05:54 ^H	0	Calm or Variable	*
08/06/2007 06:54 ^H	0	Calm or Variable	*
08/06/2007 07:54 ^H	5.8	West Southwest (250°)	*
08/06/2007 08:54 ^H	0	Calm or Variable	*
08/06/2007 09:54 ^H	3.5	North Northeast (30°)	*
08/06/2007 10:54 ^H	6.9	North (360°)	*
08/06/2007 11:54 ^H	4.6	North (360°)	*
08/06/2007 12:54 ^H	5.8	Calm or Variable	*
08/06/2007 13:54 ^H	4.6	North Northeast (20°)	*
08/06/2007 14:54 ^H	5.8	East (80°)	*
08/06/2007 15:54 ^H	0	Calm or Variable	*
08/06/2007 16:54 ^H	3.5	Calm or Variable	*
08/06/2007 17:54 ^H	12.7	East (90°)	*
08/06/2007 18:54 ^H	5.8	Southeast (130°)	*
08/06/2007 19:54 ^H	0	Calm or Variable	*
08/06/2007 20:54 ^H	3.5	South (190°)	*
08/06/2007 21:54 ^H	4.6	South (190°)	*

08/06/2007 22:54 ^H	0	Calm or Variable	*
08/06/2007 23:54 ^H	0	Calm or Variable	*
08/07/2007 00:54 ^H	0	Calm or Variable	*
08/07/2007 01:54 ^H	0	Calm or Variable	*
08/07/2007 02:54 ^H	0	Calm or Variable	*
08/07/2007 03:54 ^H	0	Calm or Variable	*
08/07/2007 04:54 ^H	0	Calm or Variable	*
08/07/2007 05:54 ^H	0	Calm or Variable	*
08/07/2007 06:54 ^H	0	Calm or Variable	*
08/07/2007 07:54 ^H	0	Calm or Variable	*
08/07/2007 08:54 ^H	3.5	Northeast (40°)	*
08/07/2007 09:54 ^H	0	Calm or Variable	*
08/07/2007 10:54 ^H	4.6	Northeast (50°)	*
08/07/2007 11:54 ^H	4.6	Calm or Variable	*
08/07/2007 12:54 ^H	9.2	West Northwest (300°)	*
08/07/2007 13:54 ^H	4.6	Calm or Variable	*
08/07/2007 14:54 ^H	9.2	North Northwest (340°)	*
08/07/2007 15:54 ^H	6.9	Northeast (50°)	*
08/07/2007 16:54 ^H	9.2	Southeast (130°)	*
08/07/2007 17:54 ^H	9.2	Southeast (140°)	*
08/07/2007 18:54 ^H	5.8	South Southeast (160°)	*
08/07/2007 19:54 ^H	4.6	Southeast (140°)	*
08/07/2007 20:54 ^H	5.8	Southeast (140°)	*
08/07/2007 21:54 ^H	4.6	South Southeast (150°)	*
08/07/2007 22:54 ^H	4.6	South Southeast (160°)	*
08/07/2007 23:54 ^H	0	Calm or Variable	*
Sum	161.6		
Average $1/n \sum a_i$	5.8		
Mean $(max+min)/2$	8.1		
High	12.7		
Low	3.5		

Quality Control flags that may appear above

- * 48 Not yet quality checked
- U 0 Updated manually by a human
- T 0 Updated by algorithm
- R 0 Possible range failure
- B 0 Possible buddy check failure
- N 0 Data point differs from NCDC data set

E	0	Extracted/Augmented from NCDP Surface Airways Data
A	0	Augmented from old AgNet files
M	0	Recovered from the Bulletin Board System from 1978-1992
P	0	Precipitation Estimate from RADAR

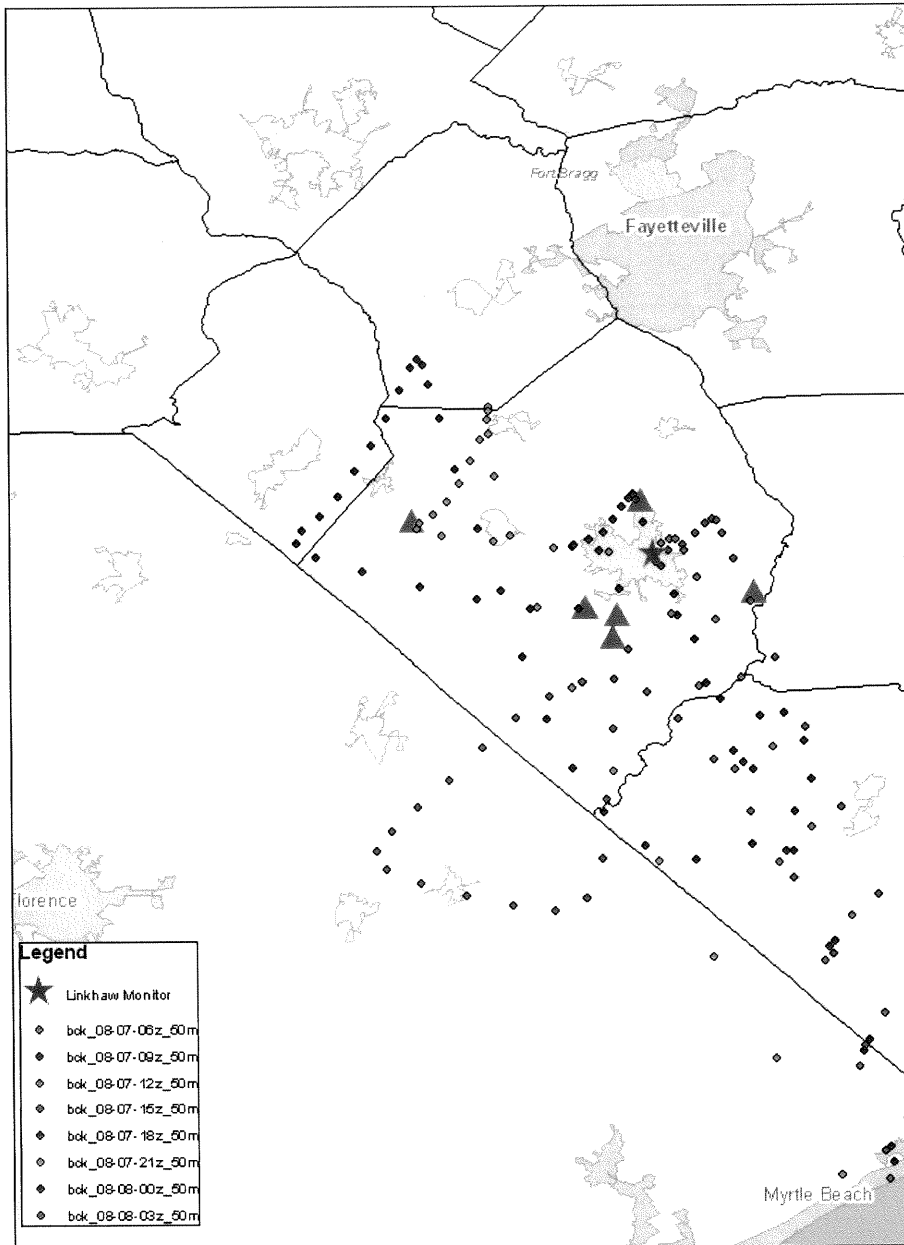
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Time Conversion Table

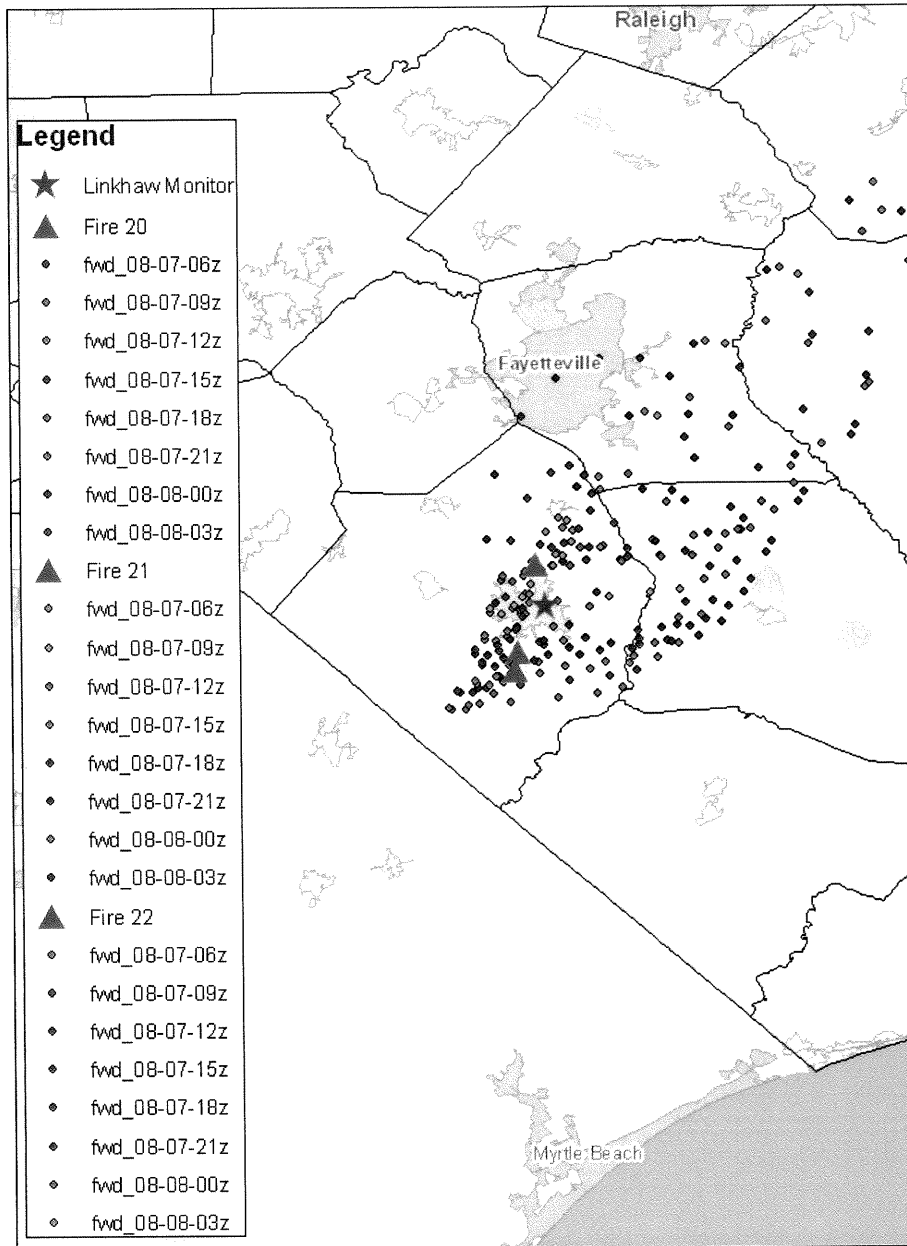
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06Z	10:00 PM	11:00 PM	12:00 AM	1:00 AM
09Z	1:00 AM	2:00 AM	3:00 AM	4:00 AM
12Z	4:00 AM	5:00 AM	6:00 AM	7:00 AM
15Z	7:00 AM	8:00 AM	9:00 AM	10:00 AM
18Z	10:00 AM	11:00 AM	12:00 PM	1:00 PM
21Z	1:00 PM	2:00 PM	3:00 PM	4:00 PM

Z Time (UTC)	Pacific Daylight Savings Time	Mountain Daylight Savings Time	Central Daylight Savings Time	Eastern Daylight Savings Time
00Z	5:00 PM	6:00 PM	7:00 PM	8:00 PM
03Z	8:00 PM	9:00 PM	10:00 PM	11:00 PM
06Z	11:00 PM	12:00 AM	1:00 AM	2:00 AM
09Z	2:00 AM	3:00 AM	4:00 AM	5:00 AM
12Z	5:00 AM	6:00 AM	7:00 AM	8:00 AM
15Z	8:00 AM	9:00 AM	10:00 AM	11:00 AM
18Z	11:00 AM	12:00 PM	1:00 PM	2:00 PM
21Z	2:00 PM	3:00 PM	4:00 PM	5:00 PM

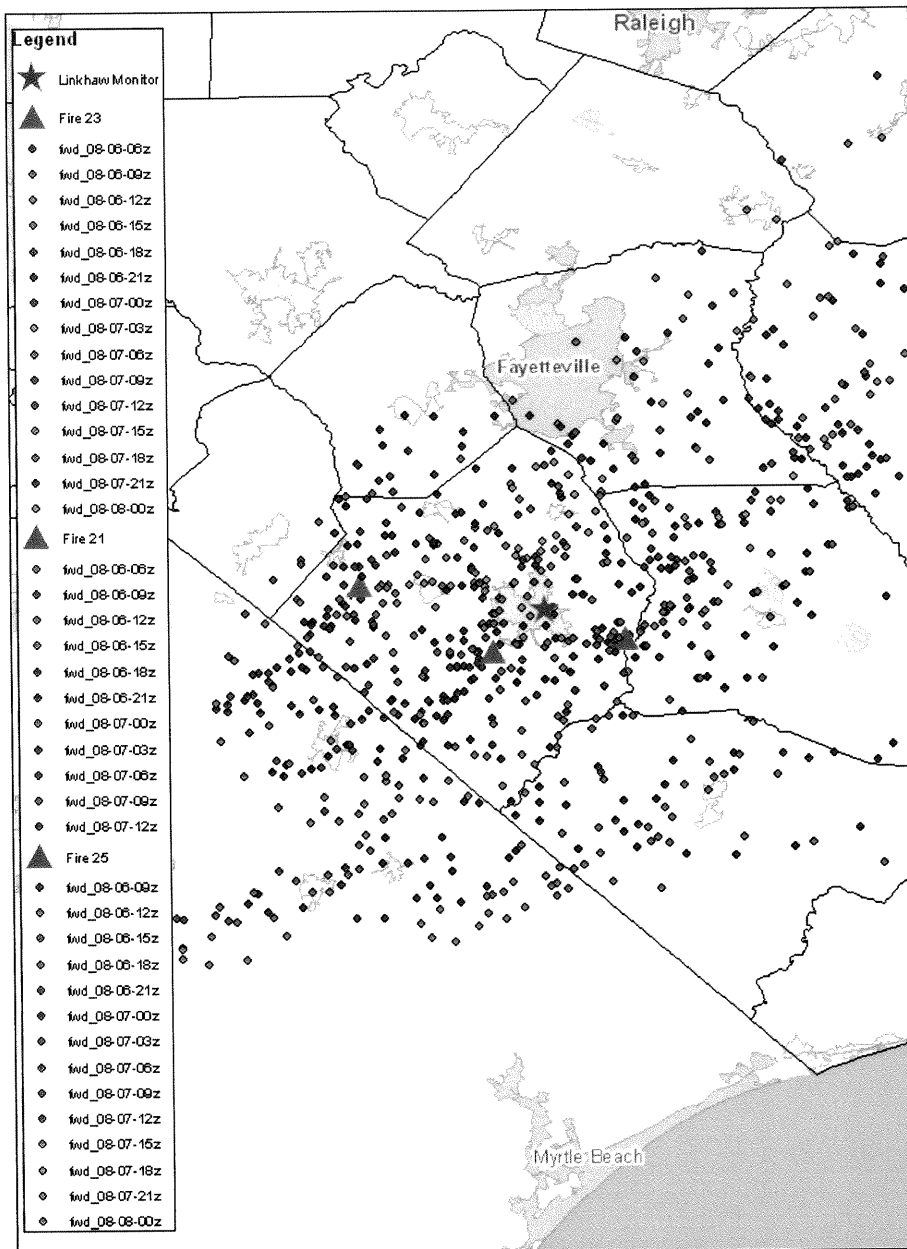
History of "Z-time" (UTC,GMT,etc) by Harold Maybeck



HYSPLIT back trajectories at 50m from Linkhaw pass through the fires on 8/7/07.



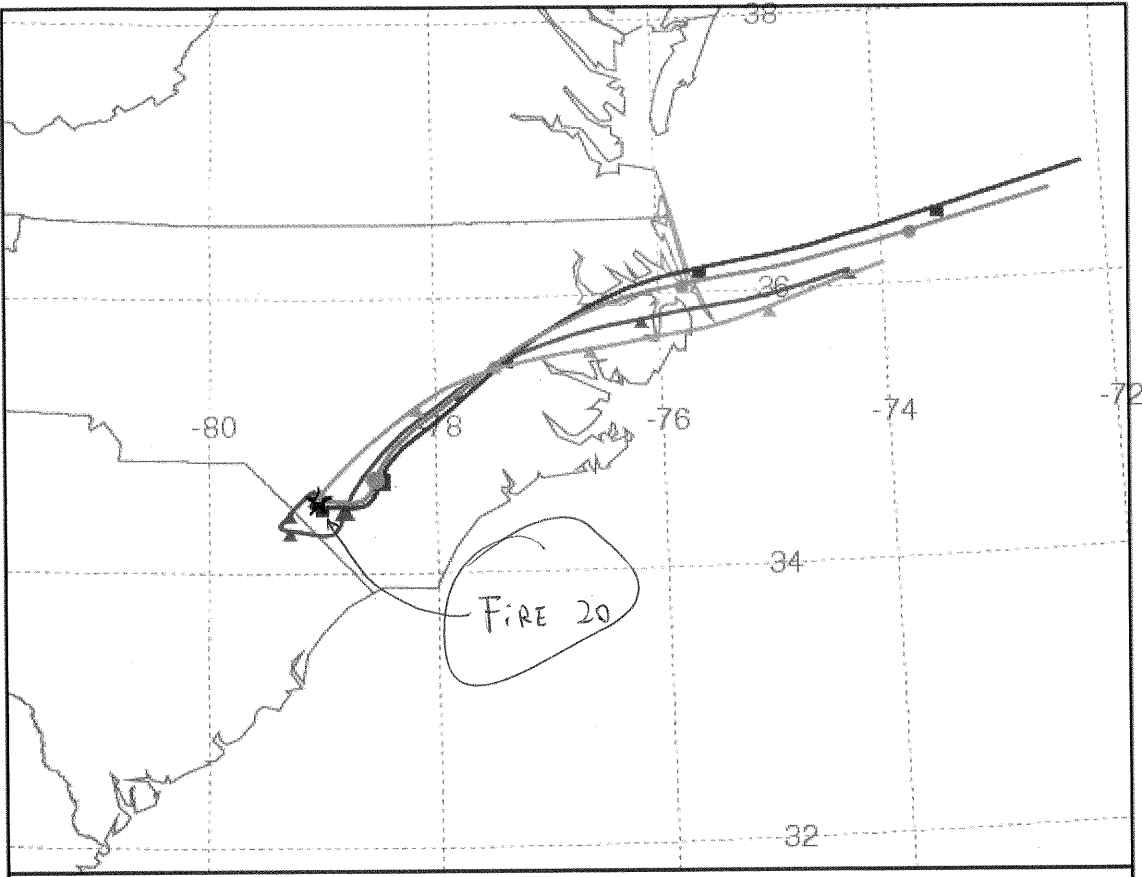
HYSPLIT forward trajectories of fires 20, 21, and 22 at 100m on 8/7/07.



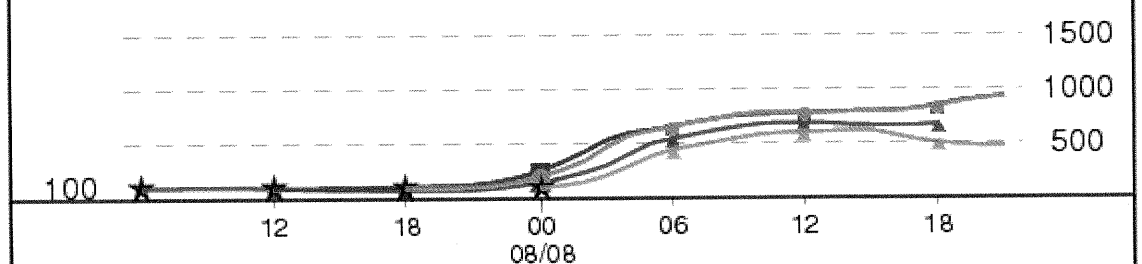
HYSPLIT forward trajectories of fires 23, 21, and 25 at 100m on 8/6/07.

NOAA HYSPLIT MODEL
 Forward trajectories starting at 06 UTC 07 Aug 07
 NAM Meteorological Data

Source ★ at 34.53 N 79.04 W



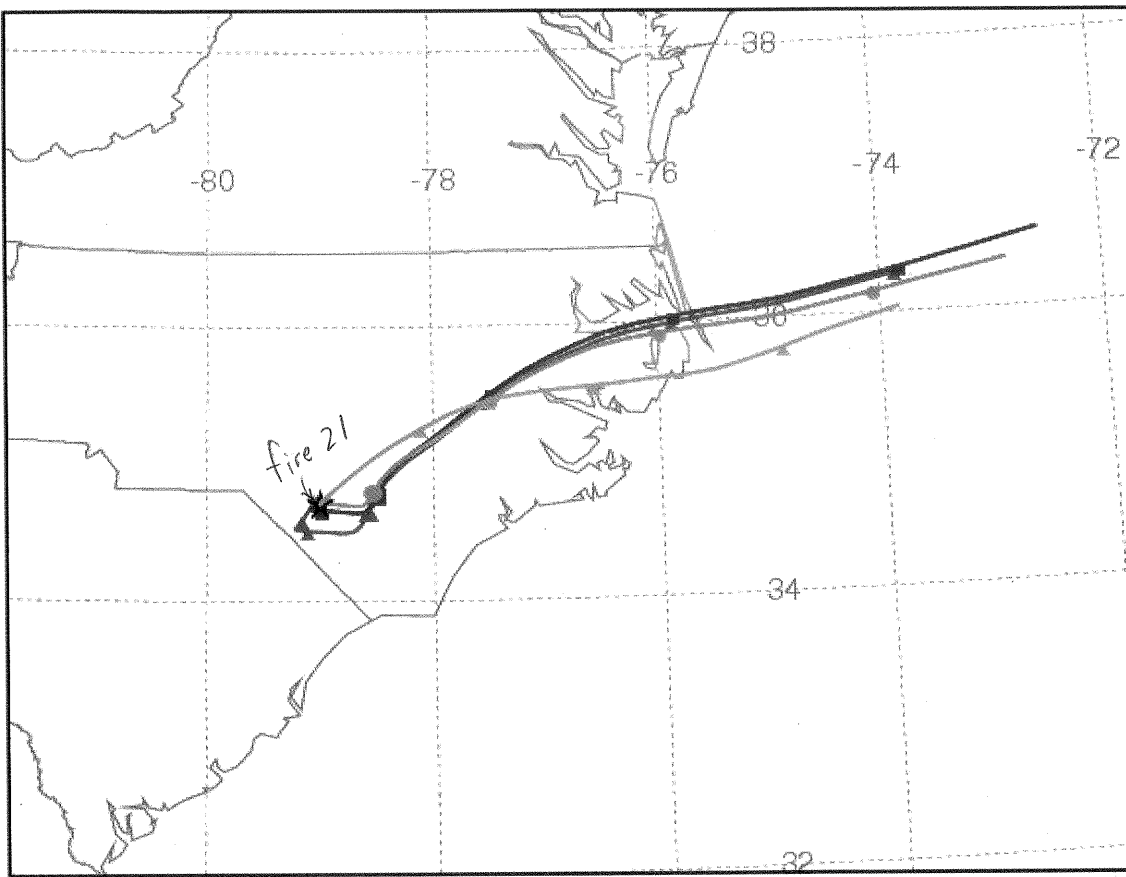
Meters AGL



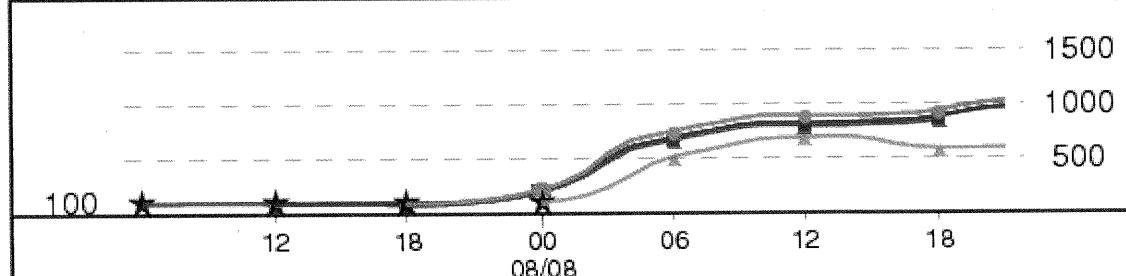
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 Trajectory Direction: Forward Duration: 36 hrs Meteo Data: NAM12 / GFS
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Forward trajectories starting at 06 UTC 07 Aug 07
 NAM Meteorological Data

Source ★ at 34.71 N 79.01 W



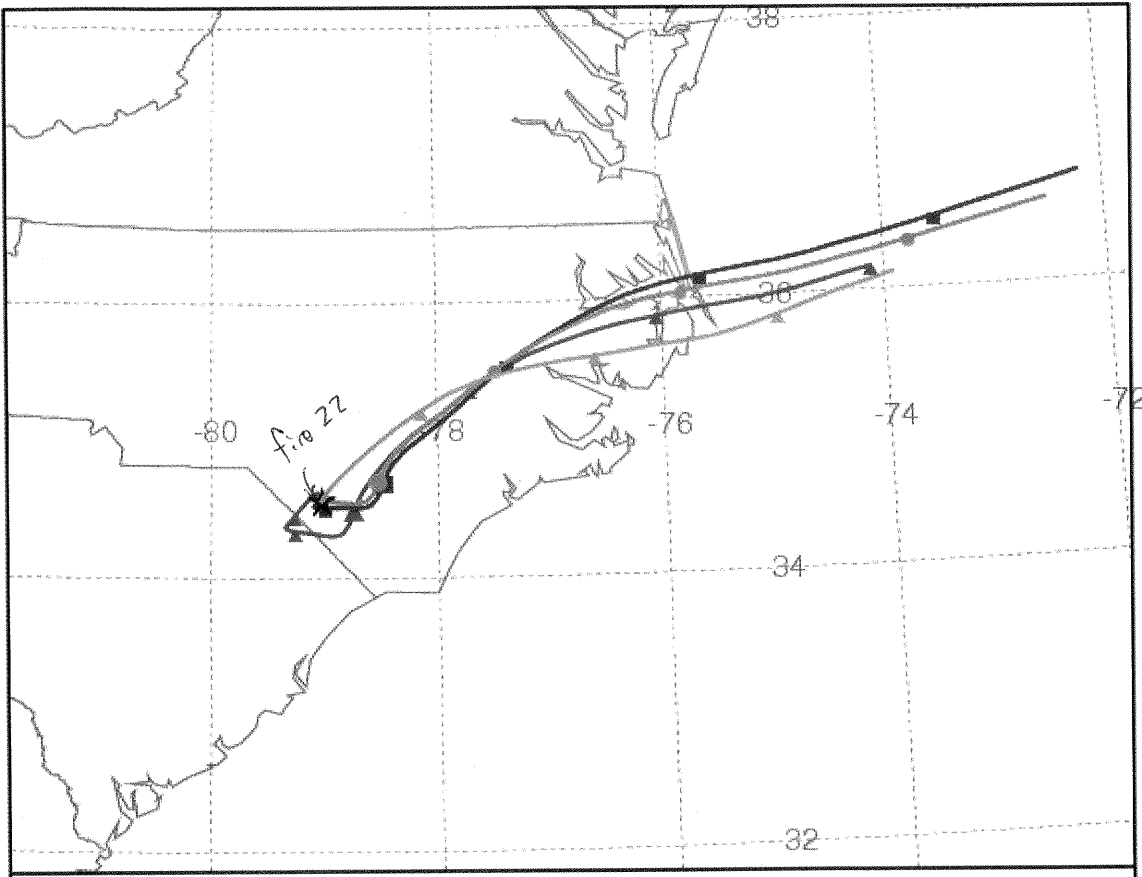
Meters AGL



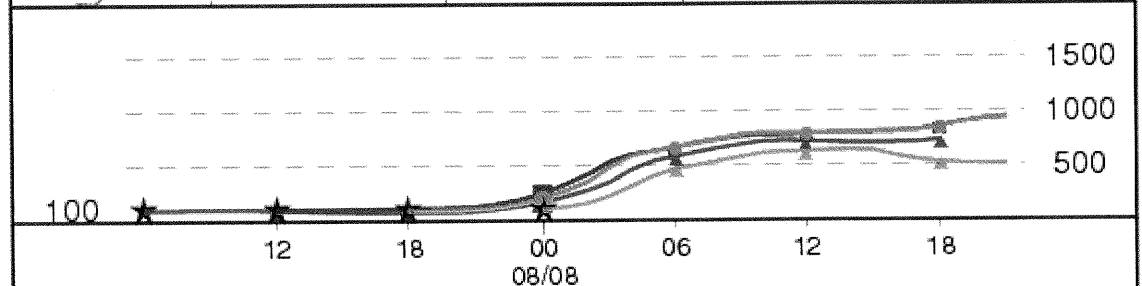
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 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Forward trajectories starting at 06 UTC 07 Aug 07
 NAM Meteorological Data

Source ★ at 34.56 N 79.04 W



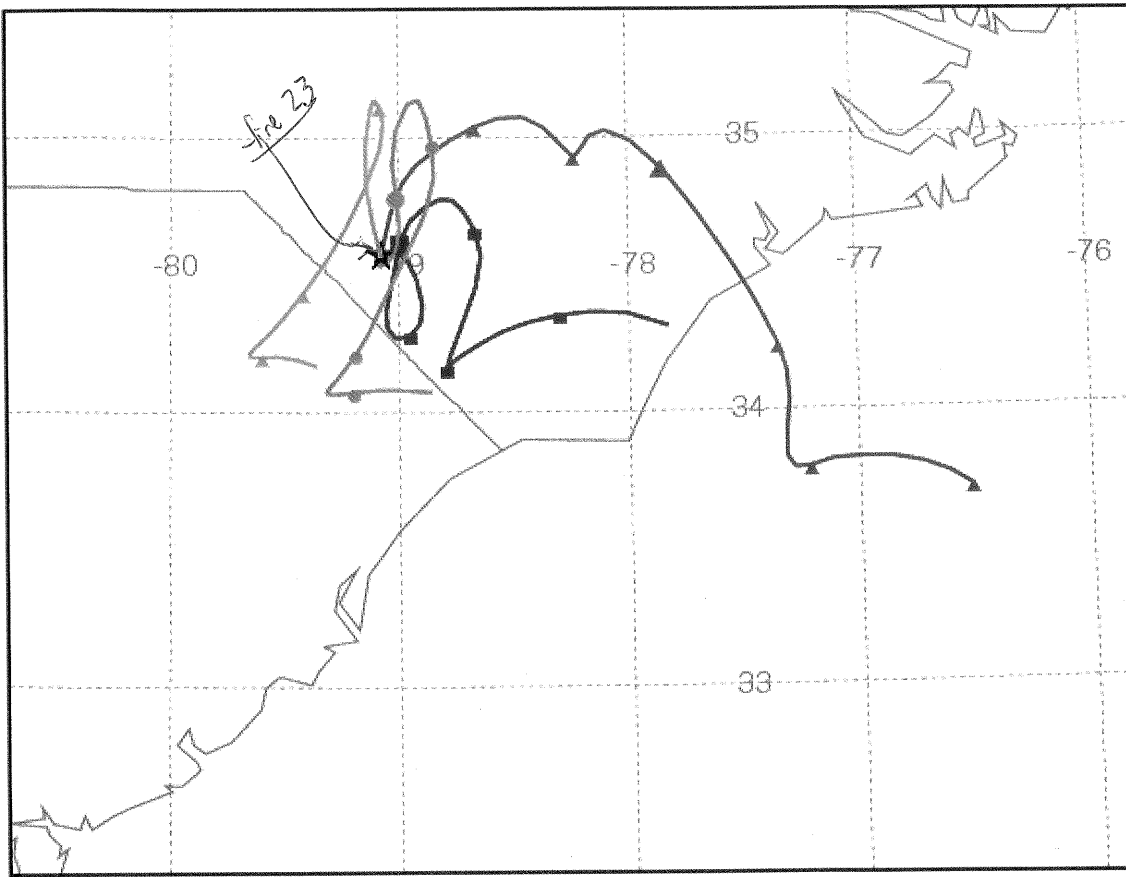
Meters AGL



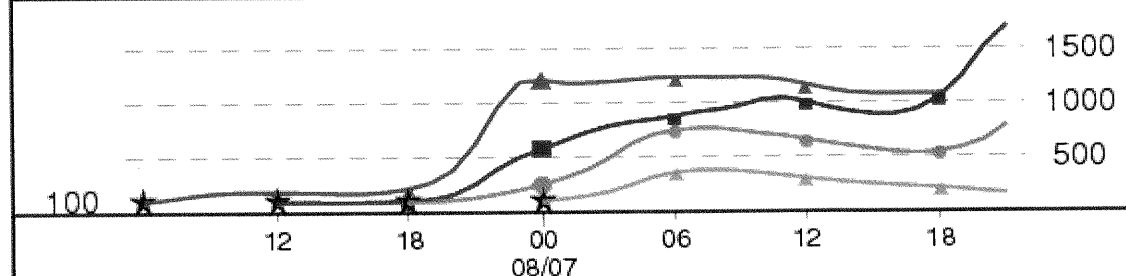
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 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Forward trajectories starting at 06 UTC 06 Aug 07
 NAM Meteorological Data

Source ★ at 34.57 N 79.08 W

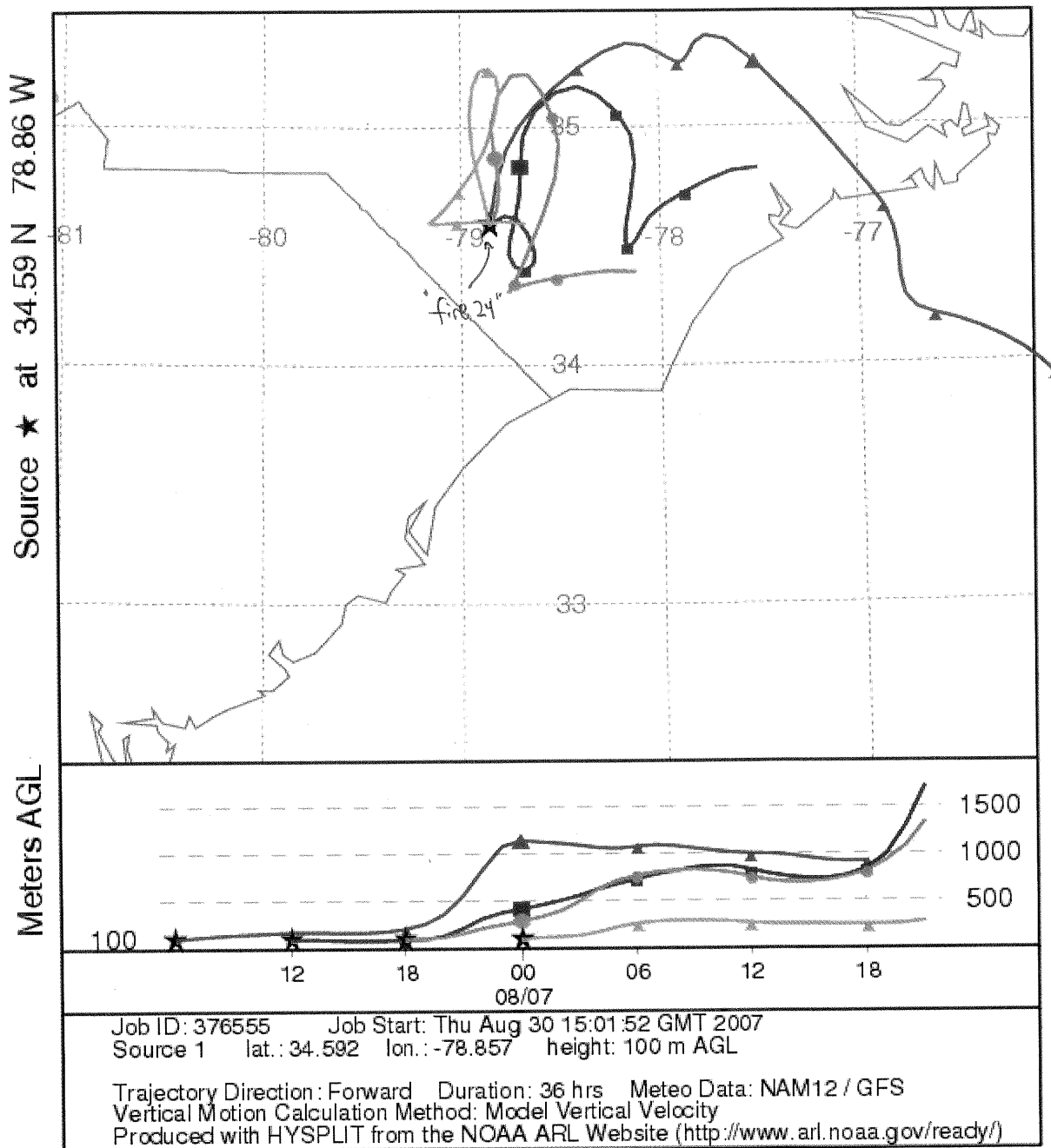


Meters AGL

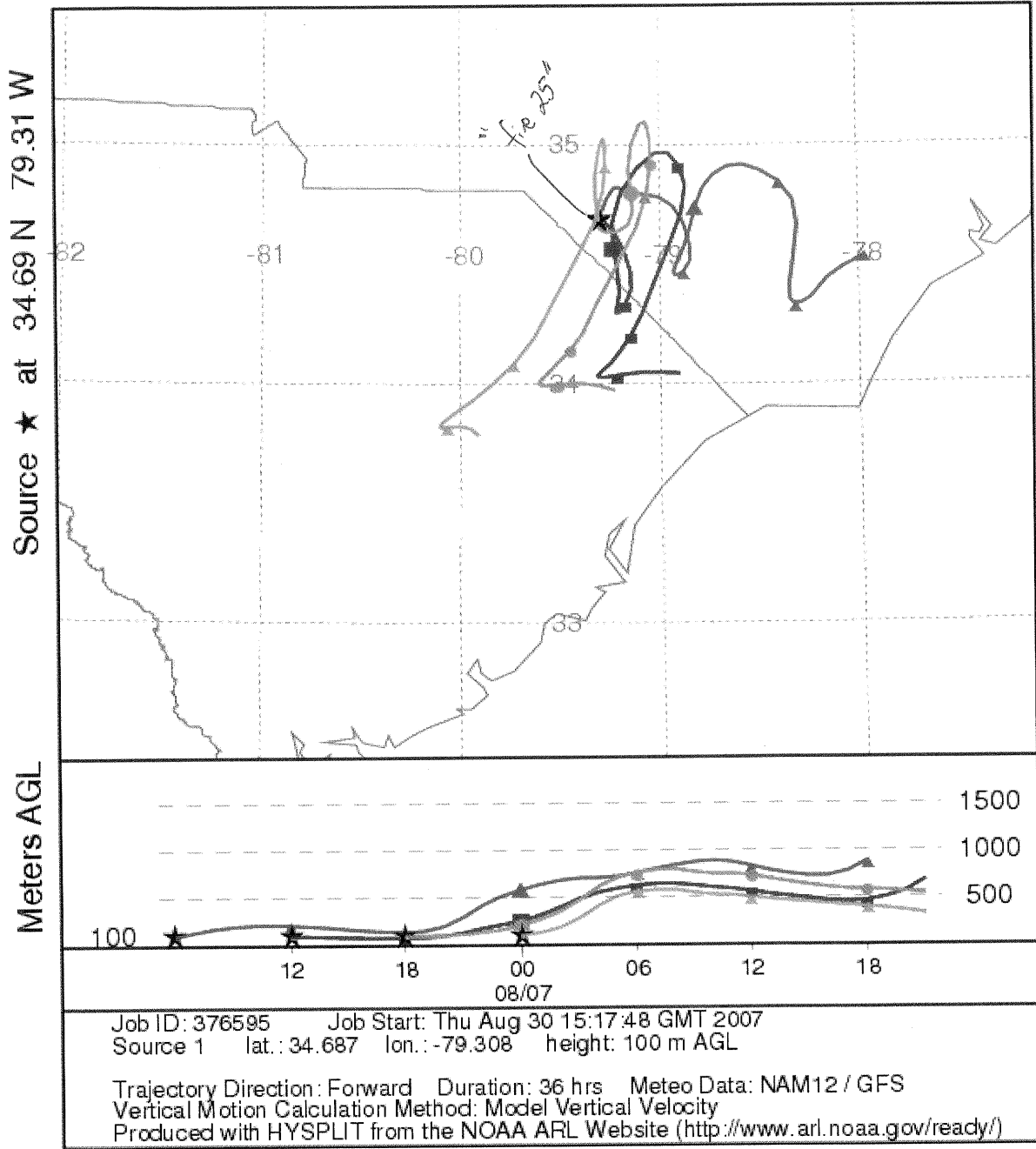


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 Source 1 lat.: 34.572 lon.: -79.078 height: 100 m AGL
 Trajectory Direction: Forward Duration: 36 hrs Meteo Data: NAM12 / GFS
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Forward trajectories starting at 06 UTC 06 Aug 07
 NAM Meteorological Data



NOAA HYSPLIT MODEL
 Forward trajectories starting at 06 UTC 06 Aug 07
 NAM Meteorological Data



"Atypical" Analysis for Linkhaw 7 August 2007 Exceedance

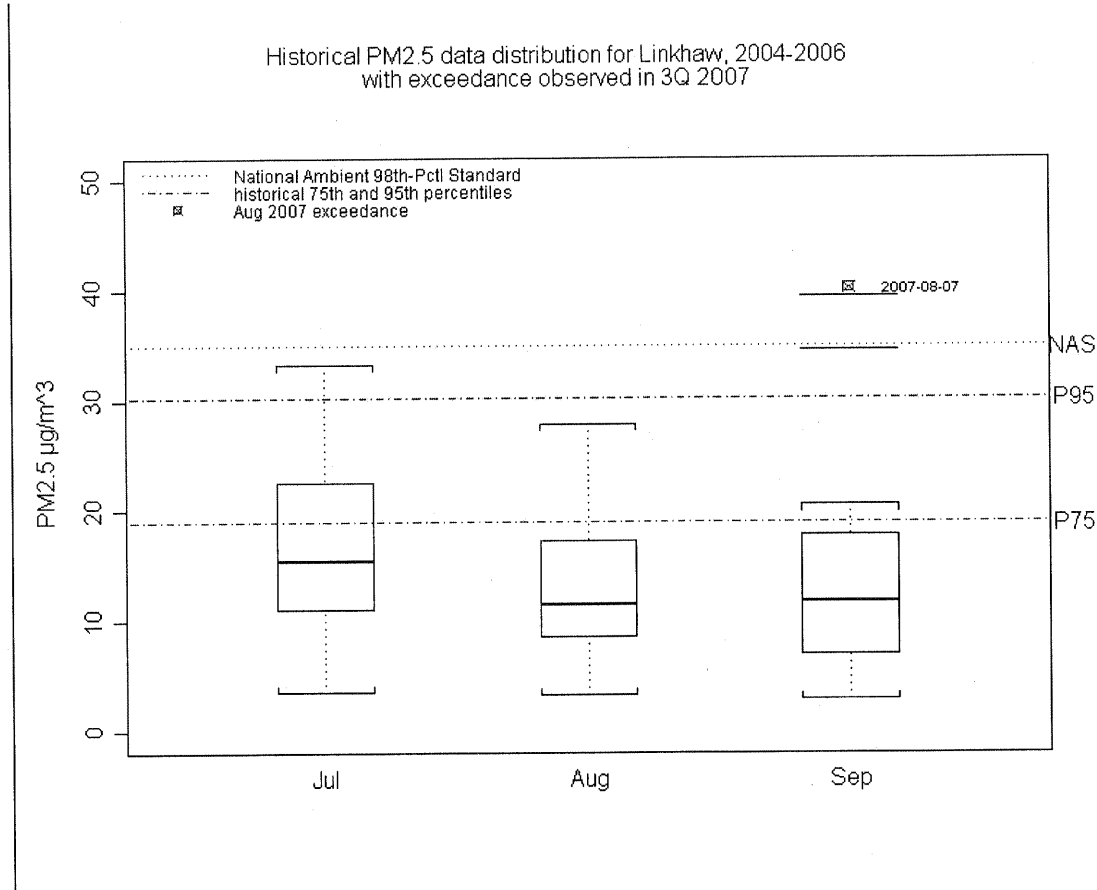


Figure 3.1 - shows "normal historical fluctuations" of PM2.5 data for the Linkhaw monitoring station during the first calendar quarter in the form of boxplots for the individual *monthly* distributions with reference lines showing the historical levels of the 75th and 95th percentile levels as well as the level of the National Ambient 98th-percentile Standard ($19.0 \mu\text{g}/\text{m}^3$, $30.3 \mu\text{g}/\text{m}^3$, and $35.0 \mu\text{g}/\text{m}^3$, respectively).

EPA has discussed the possible use of the historical 75th and 95th percentiles as objective thresholds for favorable concurrence decisions [Federal Register: March 10, 2006 (Volume 71, Number 47)] The Treatment of Data Influenced by Exceptional Events: Proposed Rules, p. 12592} The historical 95th percentile level for this event is $30.3 \mu\text{g}/\text{m}^3$. The 7 Aug 2007 exceedance exceeds the historical 95th percentile level by 33 percent.

"Atypical" Analysis for Linkhaw 7 August 2007 Exceedance (Cont'd)

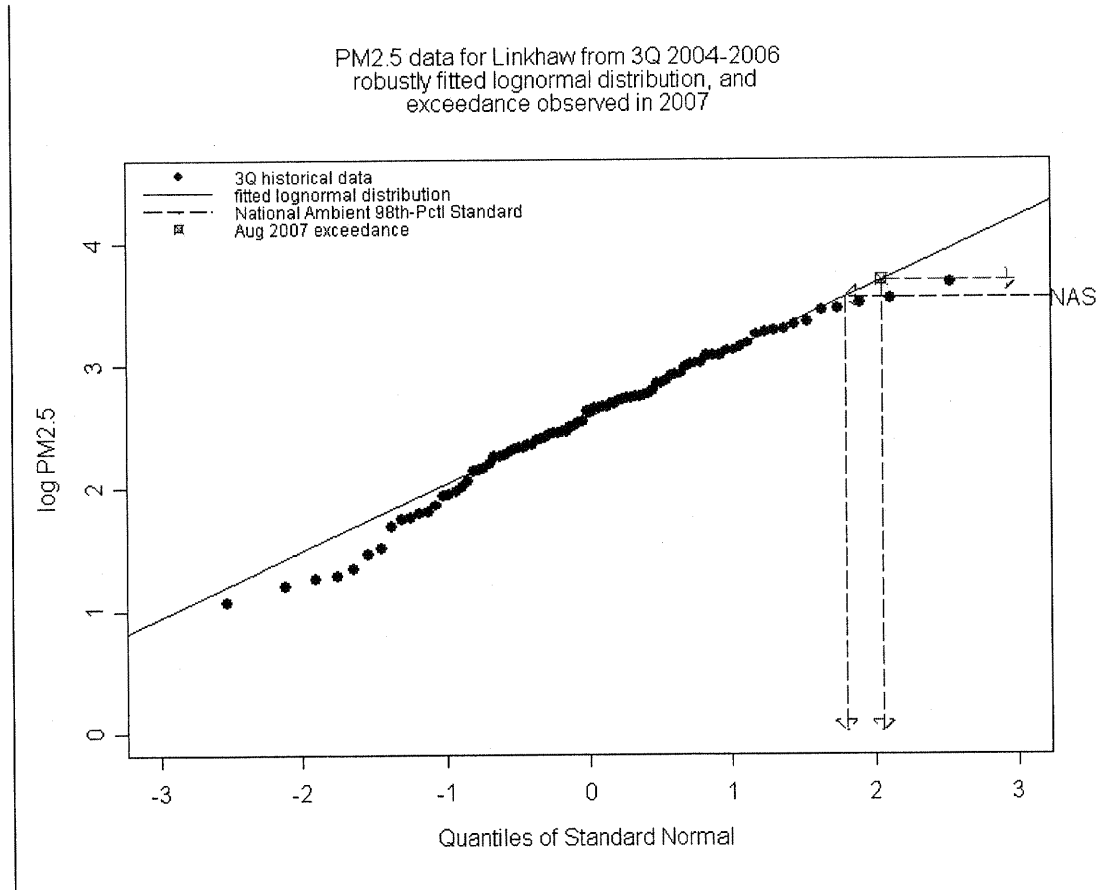


Figure 3.2 - shows "normal historical fluctuations" of PM2.5 data for the Linkhaw monitoring station during the first calendar quarter in the form of a lognormal distribution quantile plot.

Particulate pollution data are often well approximated by lognormal distributions. This graph shows the natural logarithms of the historical data (in $\log\text{-}\mu\text{g}/\text{m}^3$ units) sorted from smallest concentration to largest concentration, plotted against the corresponding quantiles of a standard normal distribution. An *exact* lognormal distribution closely matching these data is shown as a diagonal straight line in the graph. The level of the National Ambient 98th-percentile Standard ($y=3.56$) and the 07 Aug 2007 exceedance ($y=3.69$) are shown as points on the lognormal distribution line, illustrating that expected probability of exceeding the level of the National Ambient 98th-percentile Standard in the absence of exceptional events is about 3.6 percent (1.8 standard deviations greater than the lognormal mean value), and the expected probability of "unexceptional data" exceeding the level observed on 07 Aug 2007 is about 2.0 percent (2.06 standard deviations greater than the lognormal mean value).

“But For” Test: There would have been no exceedance or violation “but for” the event

Executive summary

To demonstrate that the wildfires in Robeson County caused an exceedance of the daily fine particle standard of 35 micrograms per cubic meter at the Linkhaw monitor on August 7, 2007, we need to find a way to either estimate (1) what the fine particle concentration value would have been on August 7, 2007, if the wildfire had not been present or (2) how many fine particles the wildfires contributed to the fine particle concentration measured at the Linkhaw monitor on August 7, 2007. Either approach should be sufficient to demonstrate that the wildfire caused this exceedance. There are several possible ways to approach either question. For the impact of this wildfire at Linkhaw on August 7, 2007, we opted to develop a model using meteorological measurements to estimate what the fine particle concentration value would have been on August 7, 2007 at Linkhaw if the wildfire had not occurred. A more detailed description of the model is provided below.

The model developed explains less than half of the observed variation in the fine particle concentrations in the dataset. As a result there is a large amount of uncertainty in the estimation of the fine particle concentration at Linkhaw on August 7, 2007. However, we can use the value calculated by the model and the uncertainty calculated by the model for that value to calculate the maximum value that we would expect to see at Linkhaw on August 7, 2007, with a certain probability. If we calculate the maximum expected value using a 95 percent probability and it is less than 35 micrograms per cubic meter, then there is at most a 5 percent probability that a value above the standard would have occurred at Linkhaw on August 7, 2007, if there had not been wildfires in the area.

Using the developed model and calculating the maximum expected value using a 95 percent probability indicates that there is a 5 percent probability that a value exceeding 35.27 micrograms per cubic meter would have occurred at Linkhaw on 8/7/2007. Thus, without the wildfire, there is a probability slightly greater than 5 percent that the National Ambient Air Quality Standard would have been exceeded on that day. As a result, we believe that the value of 40.2 micrograms per cubic meter, which exceeded the daily fine particle standard, would not have occurred at Linkhaw if there had not been wildfires in Robeson County around the day of August 7, 2007.

Data Description

For each day in the 3rd quarter of 2004, 2005, 2006 and 2007 on which there was a valid PM2.5 concentration the following met data was acquired to model the PM2.5 concentrations:

- AT daily mean ambient temperature at the PM2.5 monitoring station

- RH daily mean relative humidity at the PM2.5 monitoring station
- WS24 daily arith mean wind speed at KLBT, the NOAA automated met station at Lumberton , NC.
- VWD24 daily vector average wind direction at KLBT
- WG24 daily mean wind gust speeds at KLBT
- RN24 daily total precipitation at KLBT
- RN24.lag1 previous-day daily total precipitation at KLBT

Linear Models

I omitted from the model WG24, RN, and RN24.lag1 because they had missing values on the exceedance day, which prevents any model that uses these variables from making a prediction.

Method of analysis

1. Define a covariate for each exceptional event, setting its value at +1 on the the days of the event and 0 on all other dates. PM.e2 is the covariate for 08/07/2007 (actual concentration 40.2).
2. Define the response variable PM2.5 as follows:

Response Variable "PM2.5" = actual PM2.5 concentration, if there is not an exceptional event

= 0.0 on the day of this exceptional event

3. Fit linear model as defined below. The coefficient associated with PM.e2 provides an estimate of the expected concentrations that would have occurred if there had not been an exceptional event. (The coefficient value is to be subtracted from the surrogate 0.0 value, so it is actually the *negative* of the estimated concentration.)

Results

Call: aov(formula = PM2.5 ~ AT + RH + WS24 + VWD24 + PM.e2, data = LHtest008.df, na.action = na.exclude)

Residuals:				
Min	1Q	Median	3Q	Max
-16.16	-4.164	-1.417	4.43	24.24

Coefficients:				
	Value	Std. Error	t value	Pr(> t)
(Intercept)	107.1001	193.8953	0.5524	0.5818

AT	1.2254	0.2226	5.5048	0.0000
RH	-0.1571	0.2527	-0.6218	0.5354
WS24	-0.7579	0.2548	-2.9751	0.0036
VWD24	-0.0112	0.0068	-1.6399	0.1039
PM.e2	-24.3067	6.6066	-3.6792	0.0004
Residual standard error: 6.392 on 110 degrees of freedom				
Multiple R-Squared: 0.3109				
F-statistic: 9.924 on 5 and 110 degrees of freedom, the p-value is 7.456e-008				
2 observations deleted due to missing values				

Discussion

The linear model explains about one-third of the observed variation in PM2.5 concentrations in the dataset, and there is accordingly a large amount of uncertainty in the estimation of the two concentrations that were affected by exceptional events. Let's report the estimates using the assumptions that commonly justify regression analysis and analysis of variance. The expected values are as shown in the Coefficients tables, $2.361 \times \text{Std. Error}$ defines a 99-percent upper bound under the observed uncertainty. This means that "but for the exceptional event" we have concentrations as shown in Table 5. The column labeled "expectation" is the model's estimate of what concentration would have most likely been observed were the exceptional event not present. The column labeled "95% probability upper limit" takes the standard error into account and shows a threshold that there is less than 5 percent probability of exceeding. The column labeled "99% probability upper limit" takes the standard error into account and shows a threshold that there is less than 1 percent probability of exceeding. With this exceptional event, the expected concentration was $24.3 \mu\text{g}/\text{m}^3$ on 07 Aug 2007 and the 99-percent upper probability limit was approximately $40 \mu\text{g}/\text{m}^3$ -- within $0.3 \mu\text{g}/\text{m}^3$ of the observed concentration.

Table 5. Linkhaw Exceptional Event Concentration Statistics

Date	actual	expectation	95%-probability upper limit	99%-probability upper limit
07 Aug 2007	40.2	24.31	35.27	39.9