

**MAY 3, 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

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Atypical Analysis

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“But For” Test

“But For” Test: There would have been no exceedance or violation “but for” the event.....26

Linkhaw FRM-PM_{2.5} (No TEOM-PM_{2.5} at Linkhaw)
 1170 Linkhaw Road
 Lumberton, NC
 Robeson County, NC
 Site ID: 371550005-88101
 5/3/2007
 FRM PM_{2.5} concentration = 36.25 µg/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 36.25 micrograms per meter cubed (µg/m³) on 5/3/07 at the Linkhaw monitoring station.

Several HYSPLIT backward and forward trajectories of air indicate Linkhaw was directly impacted by the large “Roundabout” fire in Georgia which burned for weeks prior to the May 3, 2007 exceedance of the daily fine particle standard of 35 micrograms per meter cubed (µg/m³). Arson was suspected cause of this and several other fires that occurred in Georgia in May, 2007. Satellite imagery shows that the smoke plume of the “Roundabout” fire stretches from Georgia to southern portions of North Carolina. Robeson County, where the Linkhaw monitor is located, borders South Carolina. The trajectories were overlaid on a map of the areas of interest using GIS software. The raw trajectories are also attached. The exceedance value is three times higher than the maximum PM_{2.5} FRM values before and following the event (Table 1).

Table 1 Comparative PM_{2.5} Data (µg/m³)

		Linkhaw FRM
Pre Event	5-day avg.	11.86
4/18 – 4/30	Max	13.00
	Min	9.04
5/3/07 (Exceedance)	24 hr Avg	36.25
Post Event	5-day avg.	8.97
5/6 – 5/18	Max.	11.71
	Min.	5.92

TABLE 4.3 FKIWI CONCENTRATIONS ug/ml

Site_ID1 371230001 371550005 370510009 370510009

Site_ID2 603 605 601 602

Region FRO FRO LH FRO FRO FRO FRO

Site CN CN LH WO WO WO WO

04/03/2007	14.58	17.04	14.83				
04/06/2007	9.42	10.71	16.29	15.92			
04/09/2007	7.58	12.08	11.71				
04/12/2007	5.04	4.71	5.62	5.75			
04/15/2007	5.04	7.79	5.83				
04/18/2007	9.00	9.04	6.75	7.75			
04/21/2007	8.08	13.00	25.21				
04/24/2007	12.33	11.58	11.96	12.67			
04/27/2007	9.96	12.87	10.58				
04/30/2007	9.92	12.79	11.17	11.83			
05/03/2007	17.13	36.25	24.25				
05/06/2007	7.71	9.75	9.21	2.42			
05/09/2007		5.92	3.79				
05/12/2007	16.54	10.71	8.87	12.62			
05/15/2007	8.96	6.79	8.13				
05/18/2007	10.67	11.71	13.33	14.33			
05/21/2007	12.75	18.25	24.04				
05/24/2007	12.75	6.54	7.00	7.00			
05/27/2007	7.96	6.63	7.96				
05/30/2007	23.37	24.54	19.25	26.17			
Average	10.99	12.44	12.29	11.65			

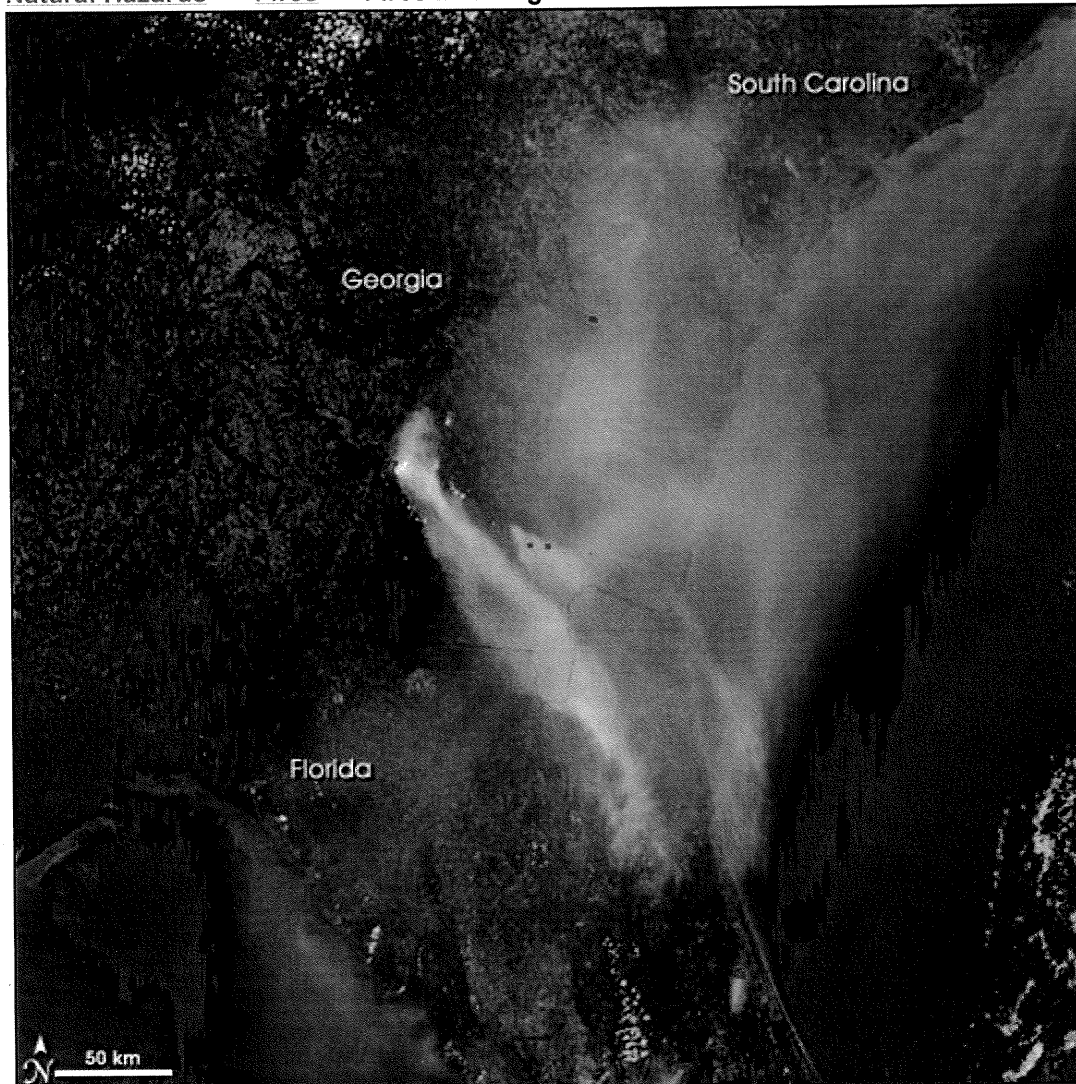
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NATURAL HAZARDS

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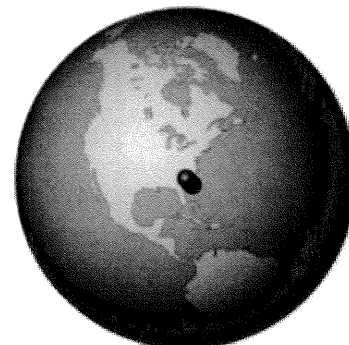
[Click here to view high-resolution version \(2.87MB\)](#)

Image Acquired: May 02, 2007

Fires in Georgia and Florida

Smoke hung over the coasts of Florida, Georgia, and South Carolina on May 2, 2007, when the Moderate Resolution Imaging Spectroradiometer ([MODIS](#)) on NASA's [Terra](#) satellite passed overhead and captured this image. Several large fires have been burning in Georgia for weeks, and because some parts of the fires are burning in inaccessible swamps, they will probably not be fully contained until significant rain falls on the area, according to reports from the

Where in the World



Southern Area Coordination Center.

MODIS detected actively burning fires in several locations, which are marked in red. The most prominent fire in the scene is the Roundabout Fire in Georgia. To its southeast, two “hotspot” locations surrounded by thick smoke may be active locations of either the Sweat Farm Road or Big Turnaround Complex Fires; these two fires are burning adjacent to each other in the northern parts of the Okefenokee Swamp.

The large image provided above has a spatial resolution (level of detail) of 250 meters per pixel. The MODIS Rapid Response Team provides twice-daily images of the United States in additional resolutions.

NASA image courtesy the MODIS Rapid Response Team, Goddard Space Flight Center

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Image Posted

May 03, 2007

Satellite & Sensor

Terra- MODIS

Other Images for this Event

Posted: [May 31, 2007](#)

Posted: [May 21, 2007](#)

Posted: [May 17, 2007](#)

Posted: [May 09, 2007](#)

Posted: [May 08, 2007](#)

Posted: [Apr 30, 2007](#)

Fires Latest Events

[Bushfires in Northern Australia](#)

[Fires in the Amazon](#)

[Fire on Alaska's North Slope](#)

[Fires in Southeast Africa](#)

[Fires on Sumatra](#)

[Bushfires in Northern Territory, Australia](#)

GFC Wildfires Occurring Over 100 Acres in Georgia

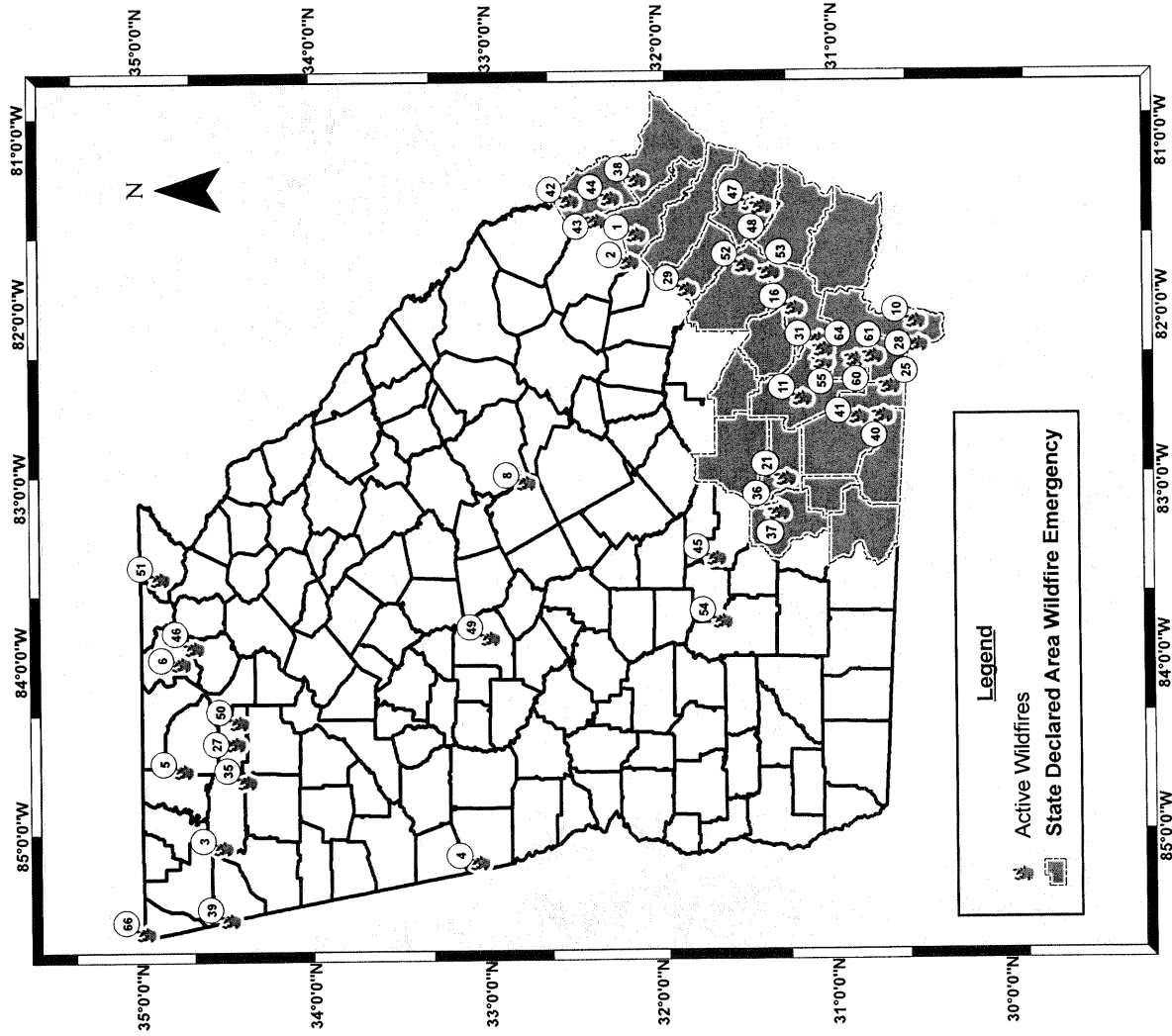
March 29 to June 6, 2007

Table 1. Active Wildfires in Georgia.

ID	COUNTY	INCIDENT NAME	SIZE
21	Atkinson	Roundabout Swamp Fire	5,956
35	Bartow	Bartow69	171
36	Berrien	Berrien 105	107
37	Berrien	Berrien124	108
16	Brantley	Kneeknocker Swamp Fire	1,778
31	Brantley	FORT MUDGE ROAD	925
1	Bryan	Harveytown Incident	663
2	Bulloch	Bulloch Bay Fire	713
10	Charlton	St. George Break Fire	800
28	Charlton	WHITE FLATS BAY	850
60	Charlton	Floyds Isalnd Prairie	2,020
38	Chatham	Savannah Quarters Fire	320
39	Chattooga	South Brow Fire	194
25	Clinch	Bugaboo Scrub 2	5,060
40	Clinch	North Fargo	2,485
41	Clinch	Clinch42	159
42	Effingham	Corinth Chnuch Rd Fire	109
43	Effingham	Riverside Drive Fire	116
44	Effingham	Courthouse Rd Fire	161
5	Glimmer	Pleasant Hill	965
3	Gordon	Pocket Gap	200
45	Inwin	Inwin48	222
29	Long	DREGGERS FIRE	1,573
46	Lumpkin	Lumpkin66	200
47	McIntosh	Duck Pond Fire	272
48	McIntosh	Franklin Street Fire	234
49	Monroe	Old Rumble Road Fire	156
27	Pickens	Short Mountain	125
50	Pickens	Harrinton Road Fire	160
51	Rabun	Chester York	109
4	Troup	Turkey Point Drive Fire	138
54	Turner	Worth40	183
6	Union	CHESTNUT MOUNTAIN	375
11	Ware	Sweat Farm Road	82,216
55	Ware	Big Turnaround Complex	405,638
61	Ware	Bugaboo Scrub Fire	0*
64	Ware	Cowhouse 07-1	787
52	Wayne	Easter Day	600
53	Wayne	Browntown Fire	410
8	Wilkinson	Triangle Fire	207
66	Dade	Vollshire	146

*Acreage is included in Big Turnaround Complex Fire

Estimated Acreage from Fires
Burning Over 100 Acres: 517,611



Legend

- Active Wildfires
- State Declared Area Wildfire Emergency

Coordinate System: GCS WGS 84



Produced by: Georgia Forestry Commission



Published on SavannahNow.com (<http://savannahnow.com>)

Georgia burning

By Savannah Morning News
Created 2007-05-02 23:30

THIS ISN'T the time to quibble over the cost of putting out fires that have scorched more than 135 square miles in Southeast Georgia and sent eye-watering smoke to Savannah, Jacksonville, Fla., and other Southeastern cities.

Let's get the fires out first.

And let's put the arsonists who have been setting some of the more recent fires behind bars, quickly. Then let's keep them there for a long, long time. According to the Georgia Forestry Commission, investigators are looking at six fires they consider suspicious - including one that broke out Saturday near the forestry commission's office in Ware County that firefighters have used as a command post.

Arson is a terrible crime on a normal day. But to think that arsonists are contributing to the worst wildfire in Georgia's history is despicable. Let's hope these firebugs are rounded up so that a Ware County jury can squish them.

Meanwhile, enough good things can't be said about the firefighters, foresters, emergency workers and others who have been trying to contain a fire of epic proportions, and one that has ravaged areas of Ware, Brantley and Atkinson counties, along with part of the Okefenokee Swamp.

These dedicated, brave and hard-working souls have been working 24/7 against some pretty tough odds - shifting winds, the ongoing lack of rain and

extremely dry conditions that have turned much of this corner of Georgia into a tinderbox. Yet amazingly, they have made some progress. And more remarkably, no deaths or serious injuries have occurred.

At least 87,000 acres of mostly forest and swamp land have been burned, along with 21 houses. Actually, it could have been worse. The limited property damage is a testament to the professionalism of foresters and firefighters who built fire breaks and tried to corral an untamable force.

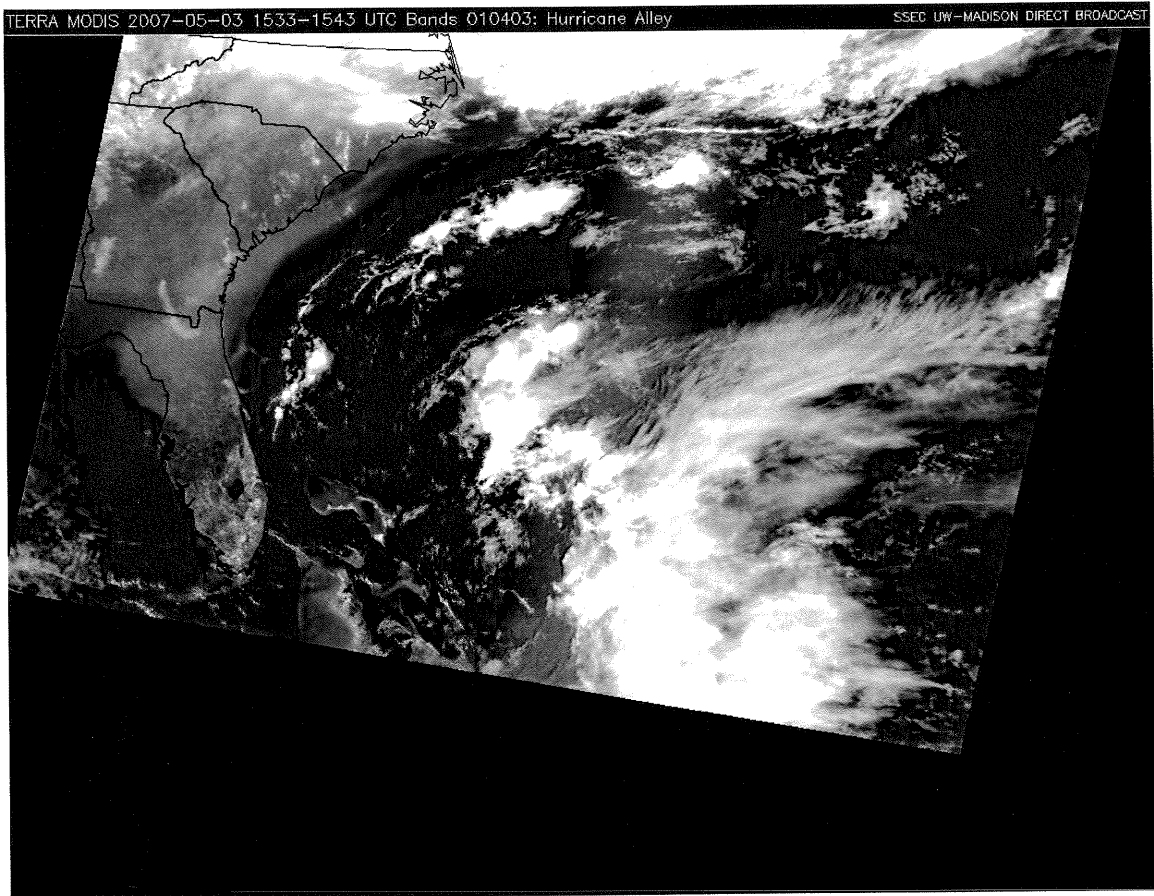
Georgia officials estimated Tuesday that it will cost \$18 million to fight the fires. That's a hefty sum, but the fight is worth every dime.

Georgia Gov. Sonny Perdue, who visited the flame-ravaged area, said he has already gotten some disaster relief funding from the feds. But now isn't the time to pinch pennies

It is, however, the perfect time to put the squeeze on criminals who are spreading destruction and misery. A team specializing in wildlife arson investigation is on the scene. Pray that they put a serious damper on anyone who lights extra fires.

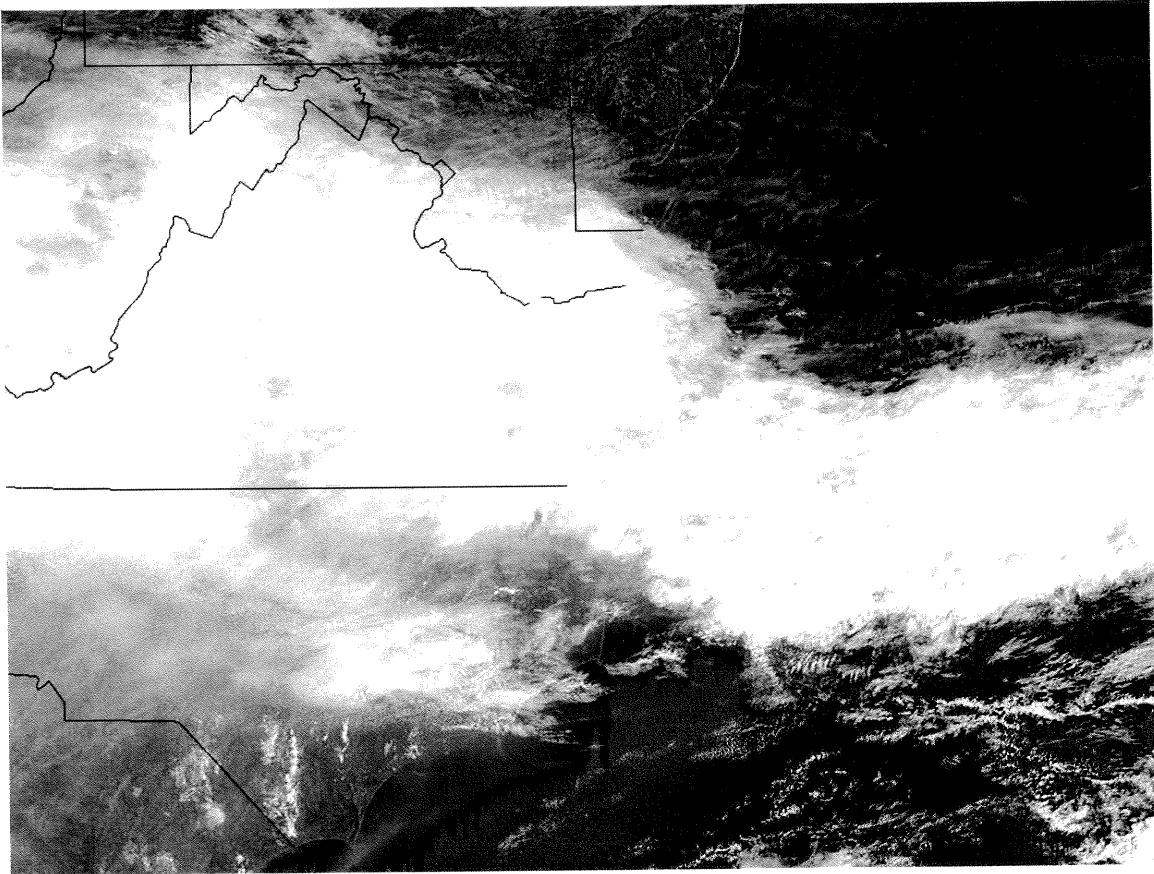
Source URL:

<http://savannahnow.com//node/277013>

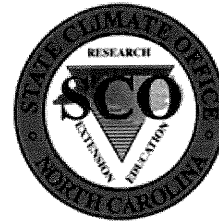


May 3, 2007 – The full smoke plume from the Ga. wildfire seen above stretched to North Carolina’s Robeson County where the Linkhaw monitor is located. All the PM2.5 FRM monitors in North Carolina ran on May 3, 2007.

May 3, 2007 – The smoke (from a Ga. Wildfire) is visible over the ocean, but remains somewhat obscured by clouds over LINKHAW.



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

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Retrieving hourly data from Lumberton Municipal Airport for 2007-05-02 thru 2007-05-03 (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)
05/02/2007 00:54 ^H	8.1	South Southwest (210°)	*
05/02/2007 01:54 ^H	6.9	South Southwest (210°)	*
05/02/2007 02:54 ^H	5.8	Southwest (230°)	*
05/02/2007 03:54 ^H	3.5	South Southwest (210°)	*
05/02/2007 04:54 ^H	5.8	South Southwest (210°)	*
05/02/2007 05:54 ^H	5.8	Southwest (220°)	*
05/02/2007 06:54 ^H	5.8	South Southwest (200°)	*
05/02/2007 07:54 ^H	11.5	South Southwest (210°)	19.6
05/02/2007 08:54 ^H	11.5	South Southwest (210°)	19.6
05/02/2007 09:54 ^H	9.2	West Southwest (240°)	*
05/02/2007 10:54 ^H	8.1	Southwest (230°)	*
05/02/2007 11:54 ^H	4.6	Southwest (230°)	*
05/02/2007 12:54 ^H	6.9	Calm or Variable	*
05/02/2007 13:54 ^H	6.9	West (280°)	*
05/02/2007 14:54 ^H	10.4	West (270°)	16.1
05/02/2007 15:54 ^H	6.9	Southwest (230°)	*
05/02/2007 16:54 ^H	6.9	Southwest (230°)	*
05/02/2007 17:54 ^H	4.6	South Southwest (200°)	*
05/02/2007 18:54 ^H	5.8	South Southeast (160°)	*
05/02/2007 19:54 ^H	5.8	South Southeast (160°)	*
05/02/2007 20:54 ^H	4.6	South (170°)	*
05/02/2007 21:54 ^H	3.5	South (180°)	*

↓ WEDNESDAY 5/2
 Mostly from South

10

05/02/2007 22:54 ^H	0	Calm or Variable	*
05/02/2007 23:54 ^H	4.6	South (180°)	*
05/03/2007 00:54 ^H	4.6	South (190°)	*
05/03/2007 01:54 ^H	9.2	North Northeast (30°)	*
05/03/2007 02:54 ^H	3.5	South Southeast (160°)	*
05/03/2007 03:54 ^H	4.6	South Southeast (160°)	*
05/03/2007 04:54 ^H	0	Calm or Variable	*
05/03/2007 05:54 ^H	0	Calm or Variable	*
05/03/2007 06:54 ^H	0	Calm or Variable	*
05/03/2007 07:54 ^H	0	Calm or Variable	*
05/03/2007 08:54 ^H	4.6	North Northeast (30°)	*
05/03/2007 09:54 ^H	8.1	East (90°)	*
05/03/2007 10:54 ^H	4.6	Calm or Variable	*
05/03/2007 11:54 ^H	10.4	East (80°)	*
05/03/2007 12:54 ^H	10.4	Northeast (50°)	16.1
05/03/2007 13:54 ^H	13.8	Northeast (40°)	*
05/03/2007 14:54 ^H	10.4	Northeast (50°)	20.7
05/03/2007 15:54 ^H	13.8	Northeast (50°)	*
05/03/2007 16:54 ^H	13.8	Northeast (40°)	23
05/03/2007 17:54 ^H	12.7	Northeast (40°)	*
05/03/2007 18:54 ^H	8.1	Northeast (50°)	*
05/03/2007 19:54 ^H	15	East Northeast (60°)	20.7
05/03/2007 20:54 ^H	10.4	Northeast (40°)	*
05/03/2007 21:54 ^H	8.1	North (10°)	*
05/03/2007 22:54 ^H	8.1	East Northeast (70°)	*
05/03/2007 23:54 ^H	3.5	North (10°)	*
Sum	331.2		135.8
Average $1/n \sum a_i$	7.7		19.4
Mean $(max+min)/2$	9.3		19.6
High	15		23
Low	3.5		16.1

Quality Control flags that may appear above

- * 41 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 NCDC 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

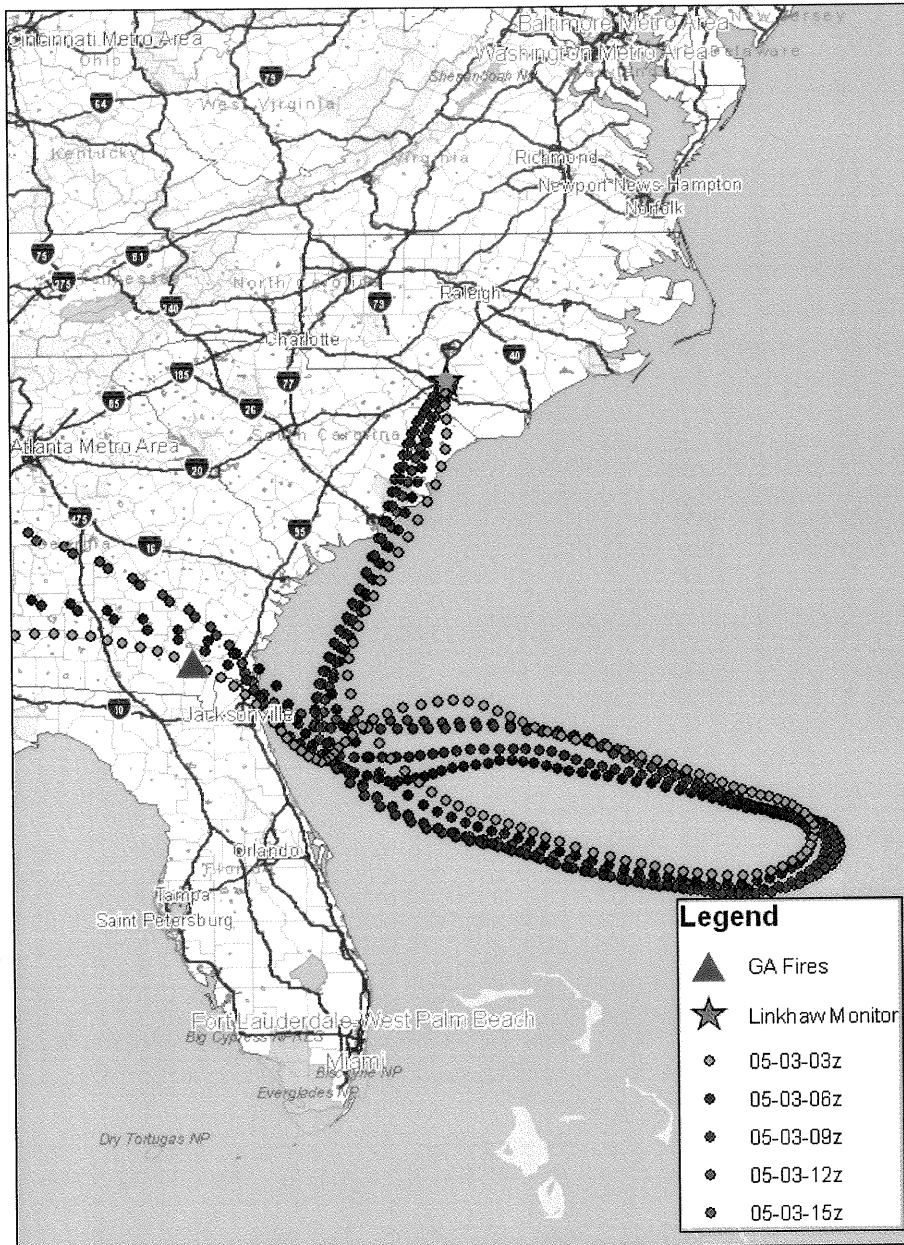
NC CRONOS Database version 2.6.0 beta
Query script last modified Sep 07, 2007 12:07:28

Time Conversion Table

Z Time (UTC)	Pacific Standard Time	Mountain Standard Time	Central Standard Time	Eastern Standard Time
00Z	4:00 PM	5:00 PM	6:00 PM	7:00 PM
03Z	7:00 PM	8:00 PM	9:00 PM	10:00 PM
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

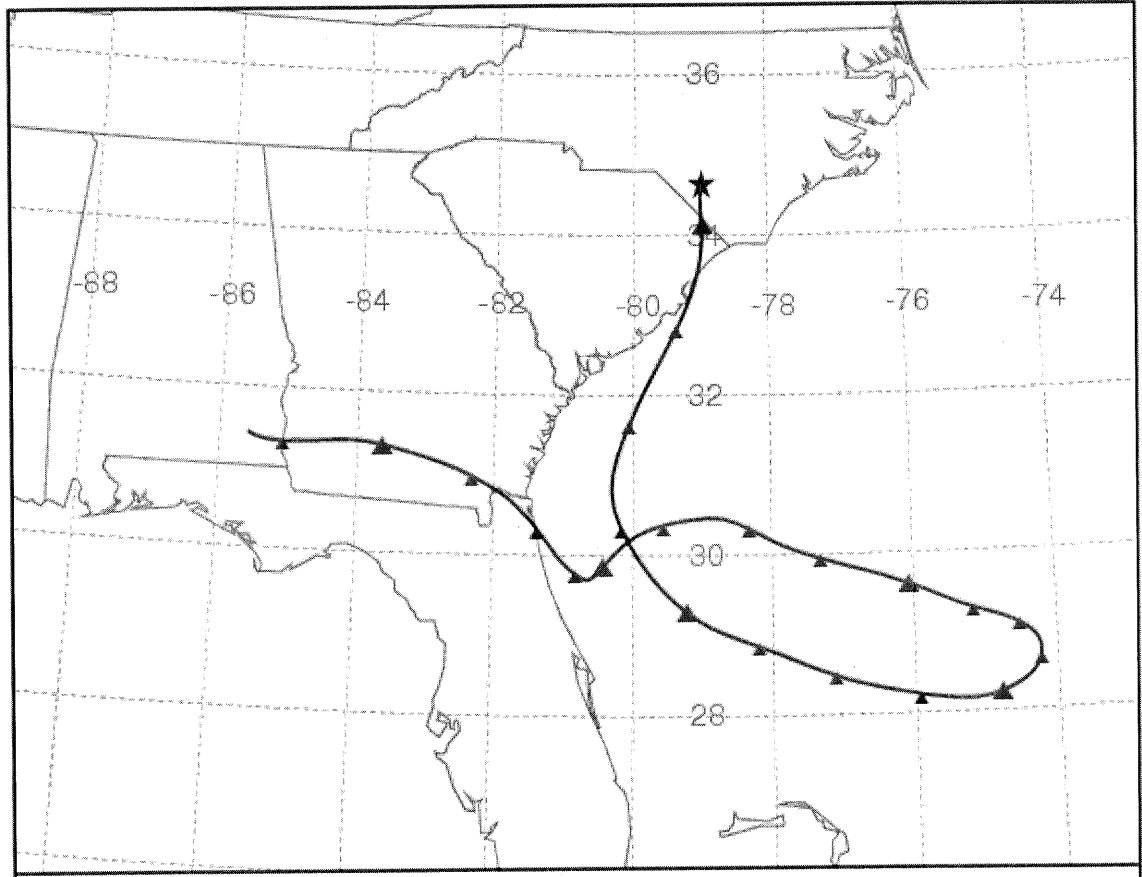
History of "Z-time" (UTC,GMT,etc) by Harold Maybeck



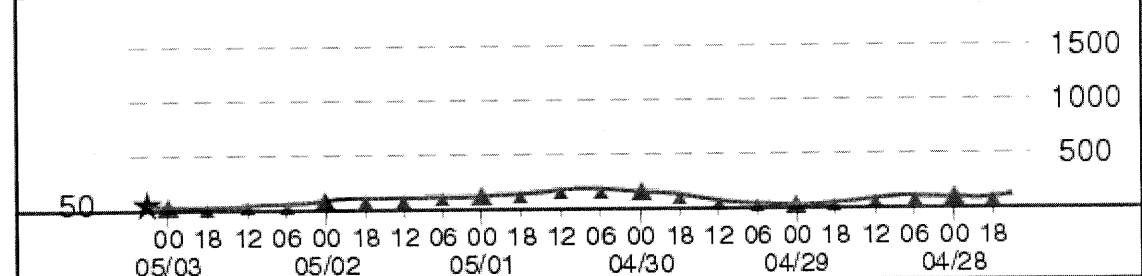
50m Back Trajectories: They pass through the fire; go out to the Atlantic; come right back through the smoke plume; and then head north carrying the smoke towards Linkhaw. Linkhaw exceeded the PM_{2.5} FRM daily standard on May 3, 2007 at 36.25 ug/m³.

NOAA HYSPLIT MODEL
 Backward trajectory ending at 03 UTC 03 May 07
 EDAS Meteorological Data

Source ★ at 34.64 N 78.99 W



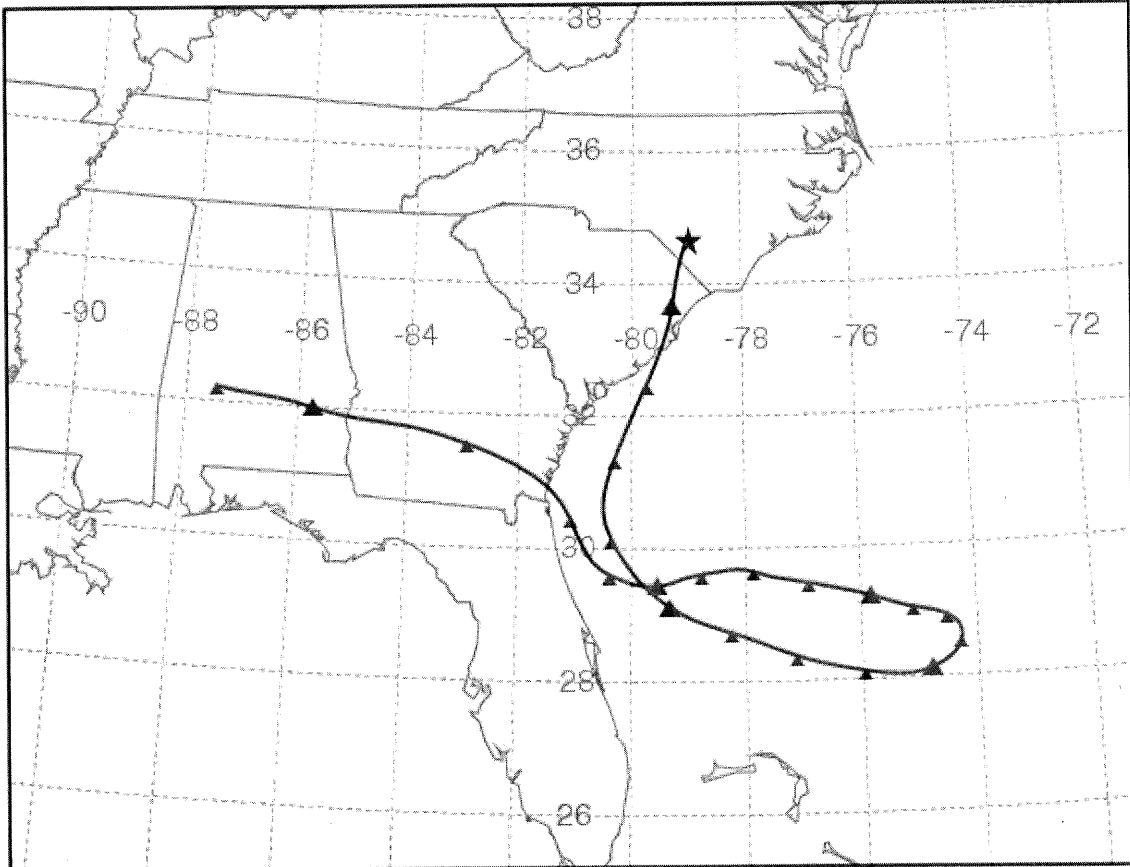
Meters AGL



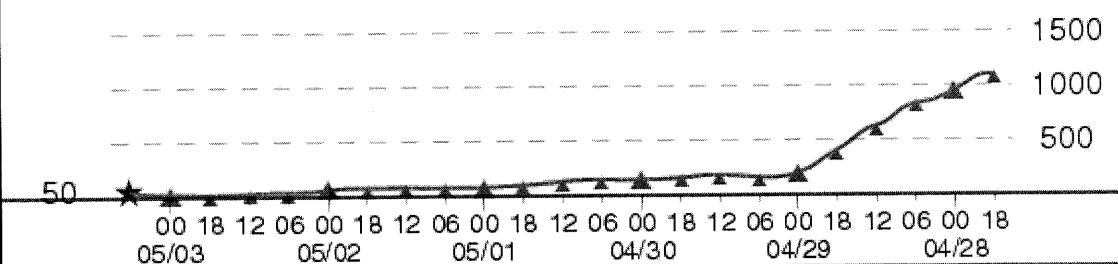
Job ID: 357571 Job Start: Fri Sep 28 15:34:56 GMT 2007
 Source 1 lat.: 34.6425 lon.: -78.99028 height: 50 m AGL
 Trajectory Direction: Backward Duration: 132 hrs Meteo Data: EDAS40
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Backward trajectory ending at 06 UTC 03 May 07
 EDAS Meteorological Data

Source ★ at 34.64 N 78.99 W



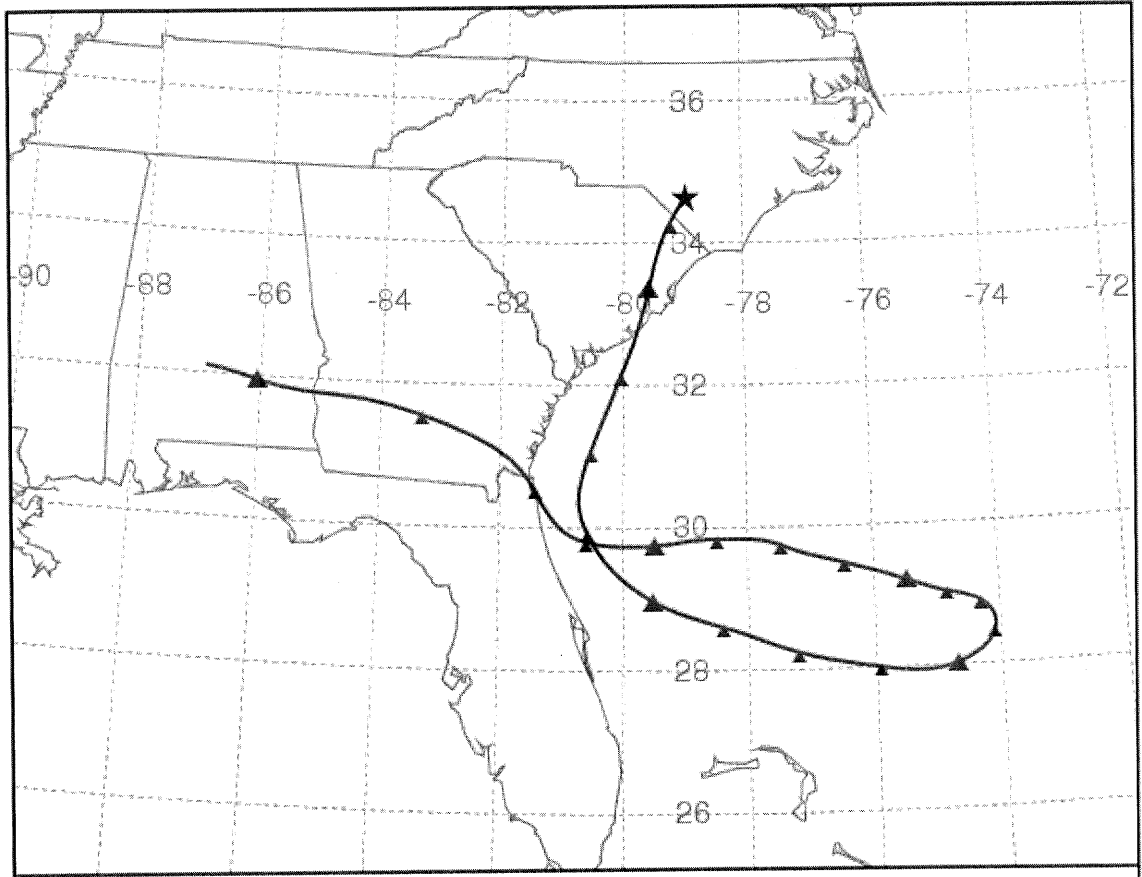
Meters AGL



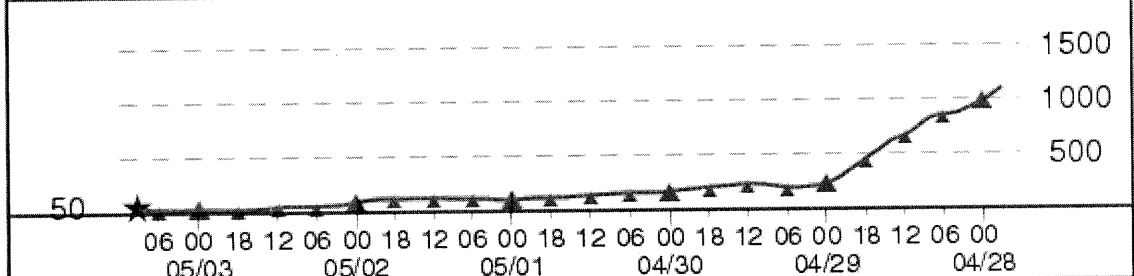
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 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Backward trajectory ending at 09 UTC 03 May 07
 EDAS Meteorological Data

Source ★ at 34.64 N 78.99 W



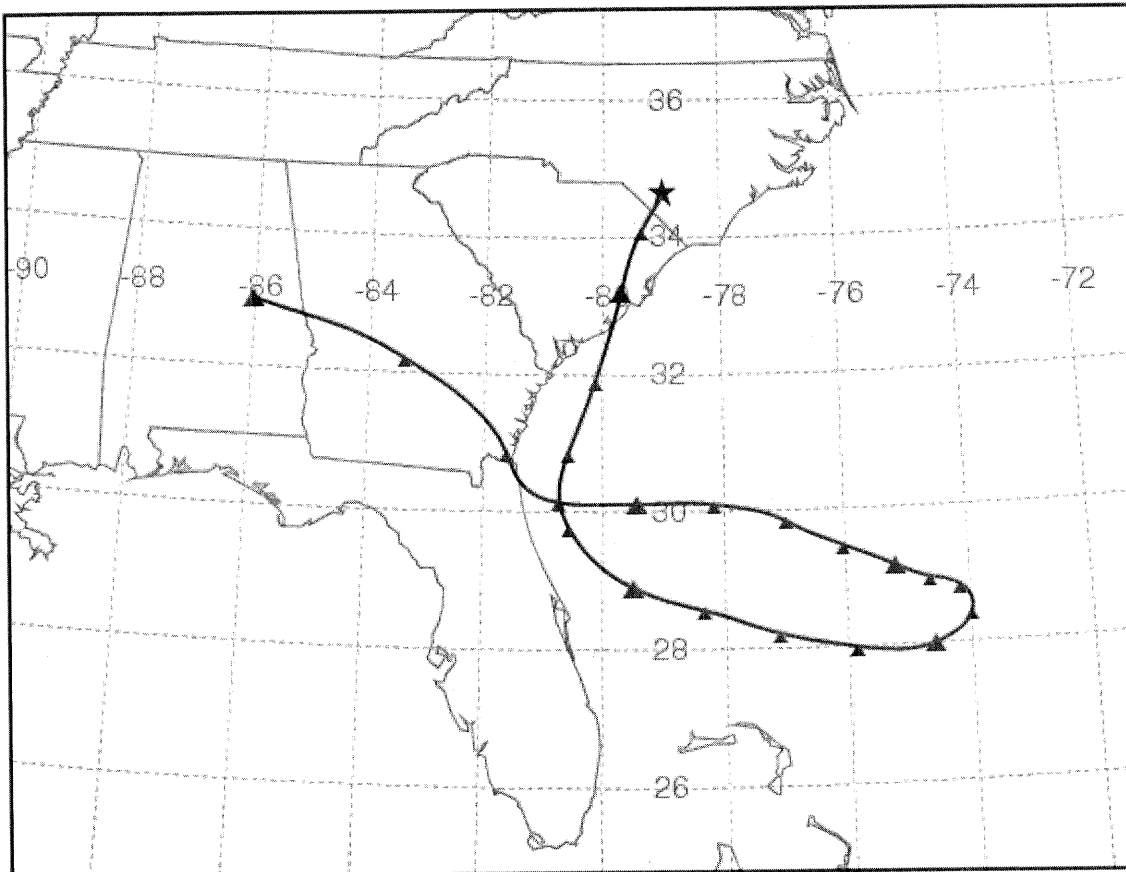
Meters AGL



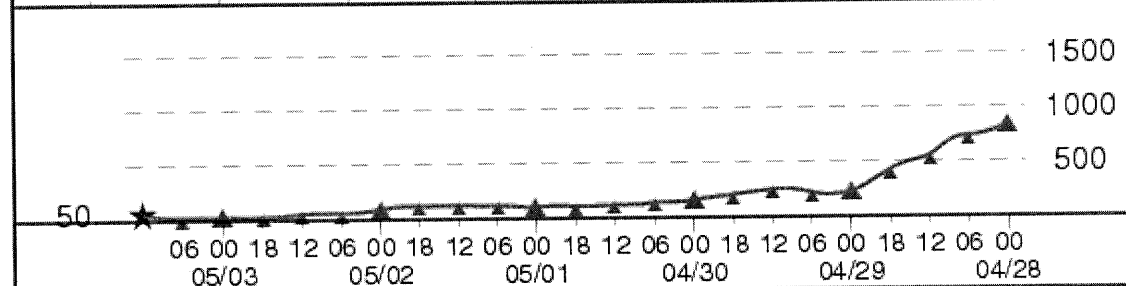
Job ID: 357307 Job Start: Fri Sep 28 15:24:59 GMT 2007
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 Trajectory Direction: Backward Duration: 132 hrs Meteo Data: EDAS40
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Backward trajectory ending at 12 UTC 03 May 07
 EDAS Meteorological Data

Source ★ at 34.64 N 78.99 W



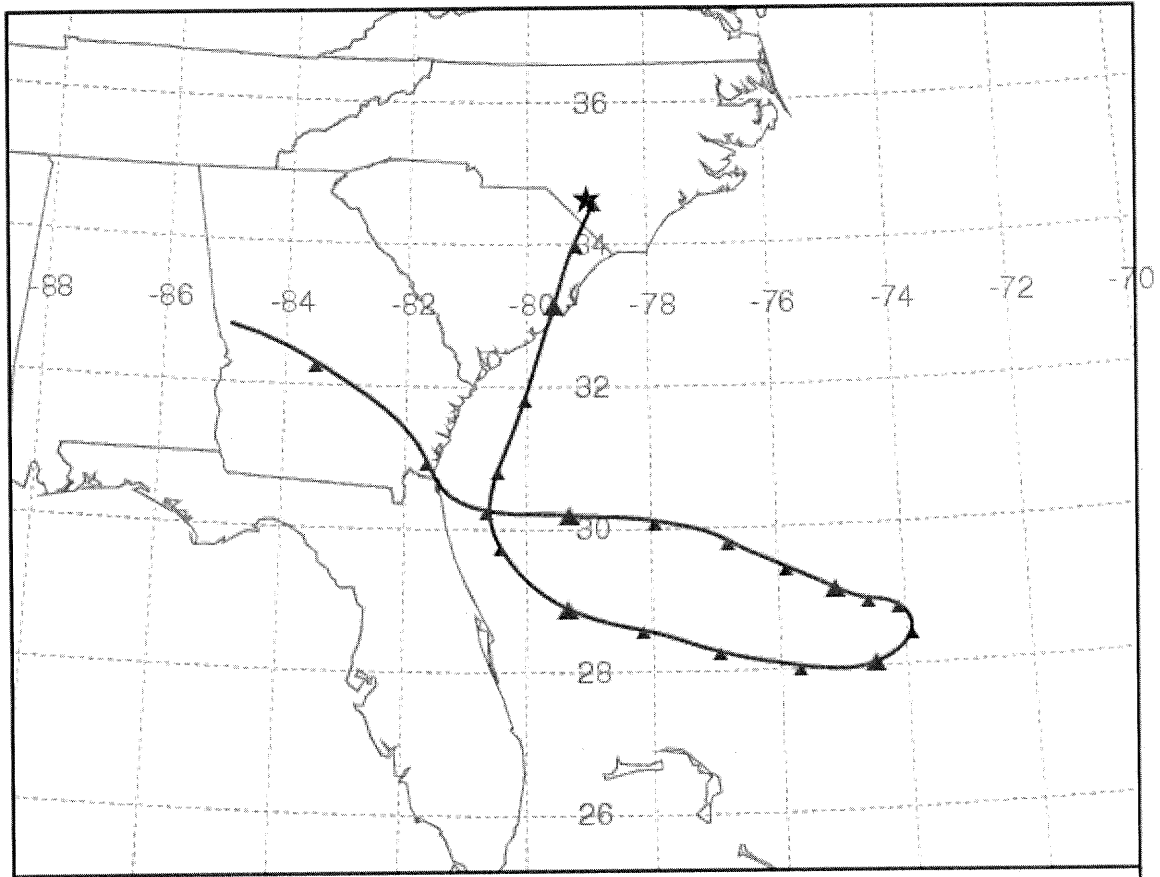
Meters AGL



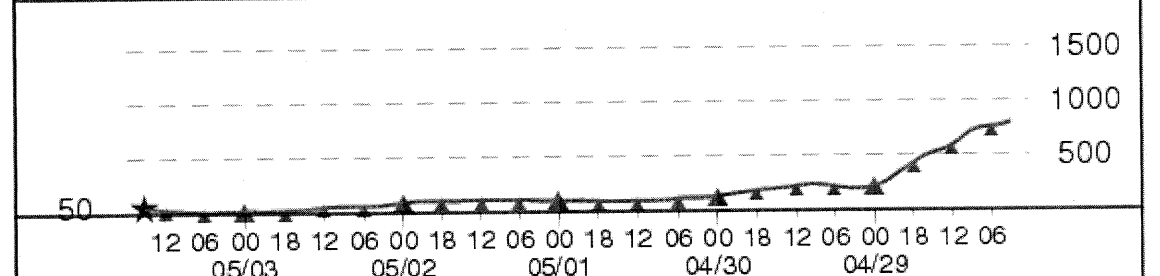
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 Source 1 lat.: 34.6425 lon.: -78.99028 height: 50 m AGL
 Trajectory Direction: Backward Duration: 132 hrs Meteo Data: EDAS40
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Backward trajectory ending at 15 UTC 03 May 07
 EDAS Meteorological Data

Source ★ at 34.64 N 78.99 W



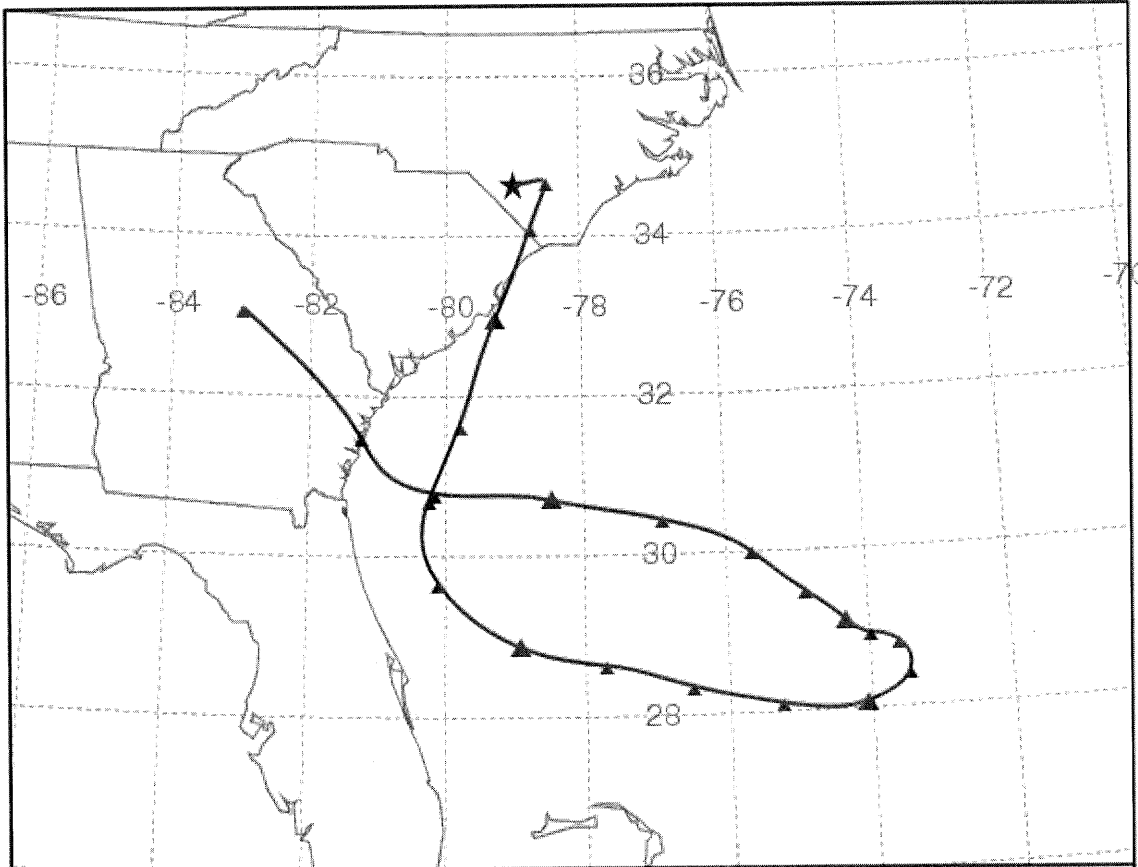
Meters AGL



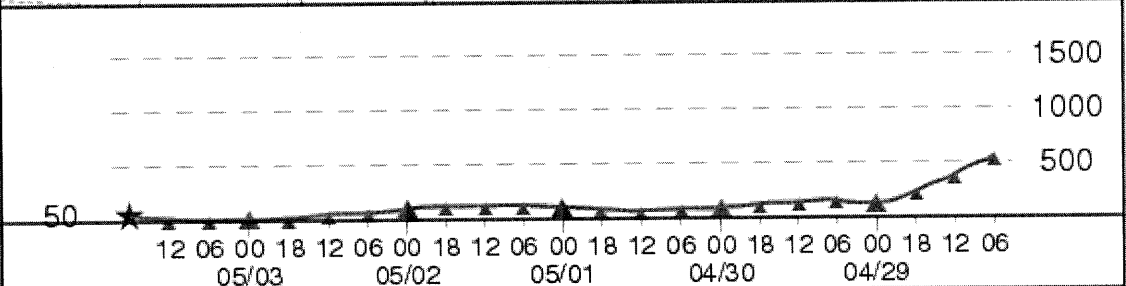
Job ID: 358068 Job Start: Fri Sep 28 16:07:50 GMT 2007
 Source 1 lat.: 34.6425 lon.: -78.99028 height: 50 m AGL
 Trajectory Direction: Backward Duration: 132 hrs Meteo Data: EDAS40
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Backward trajectory ending at 18 UTC 03 May 07
 EDAS Meteorological Data

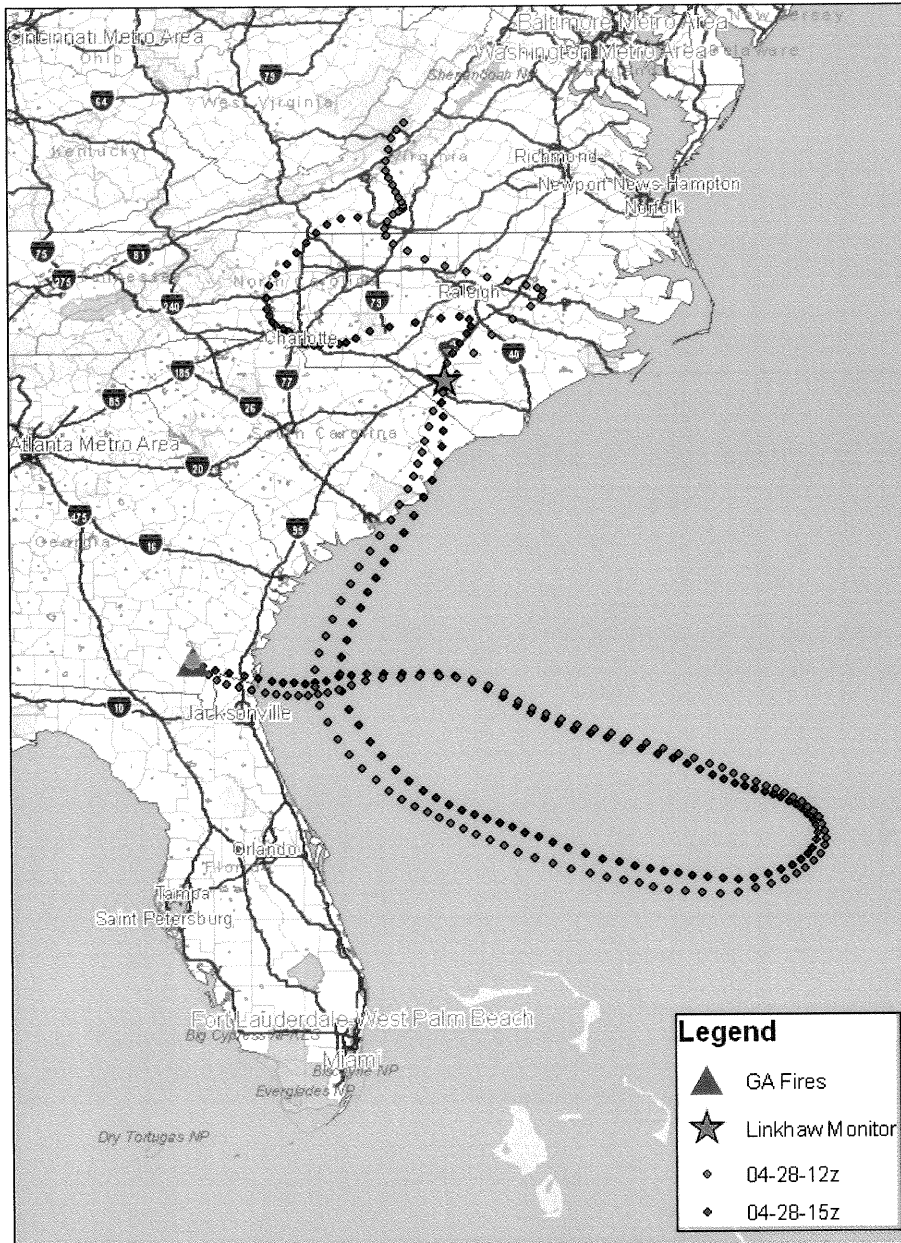
Source ★ at 34.64 N 78.99 W



Meters AGL



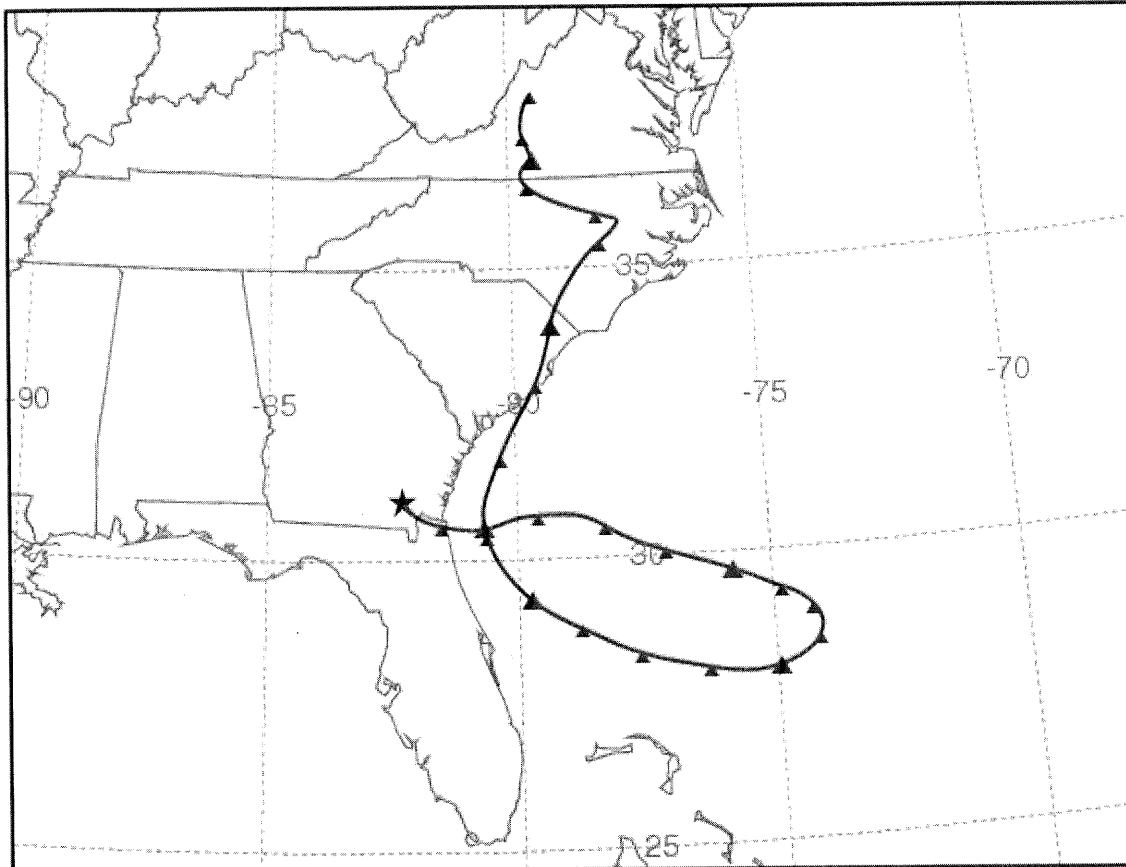
Job ID: 358107 Job Start: Fri Sep 28 16:08:55 GMT 2007
 Source 1 lat.: 34.6425 lon.: -78.99028 height: 50 m AGL
 Trajectory Direction: Backward Duration: 132 hrs Meteo Data: EDAS40
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)



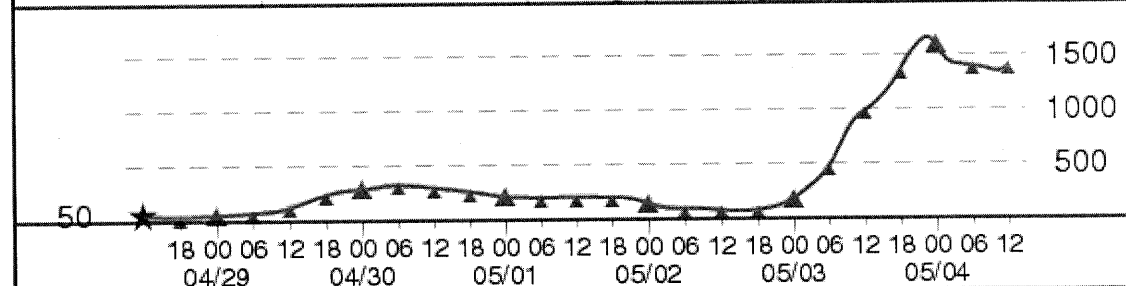
50m Forward Trajectories (the forward path followed by an air parcel starting from the fire and ending at the Linkhaw monitor).

NOAA HYSPLIT MODEL
 Forward trajectory starting at 12 UTC 28 Apr 07
 EDAS Meteorological Data

Source ★ at 31.00 N 82.30 W



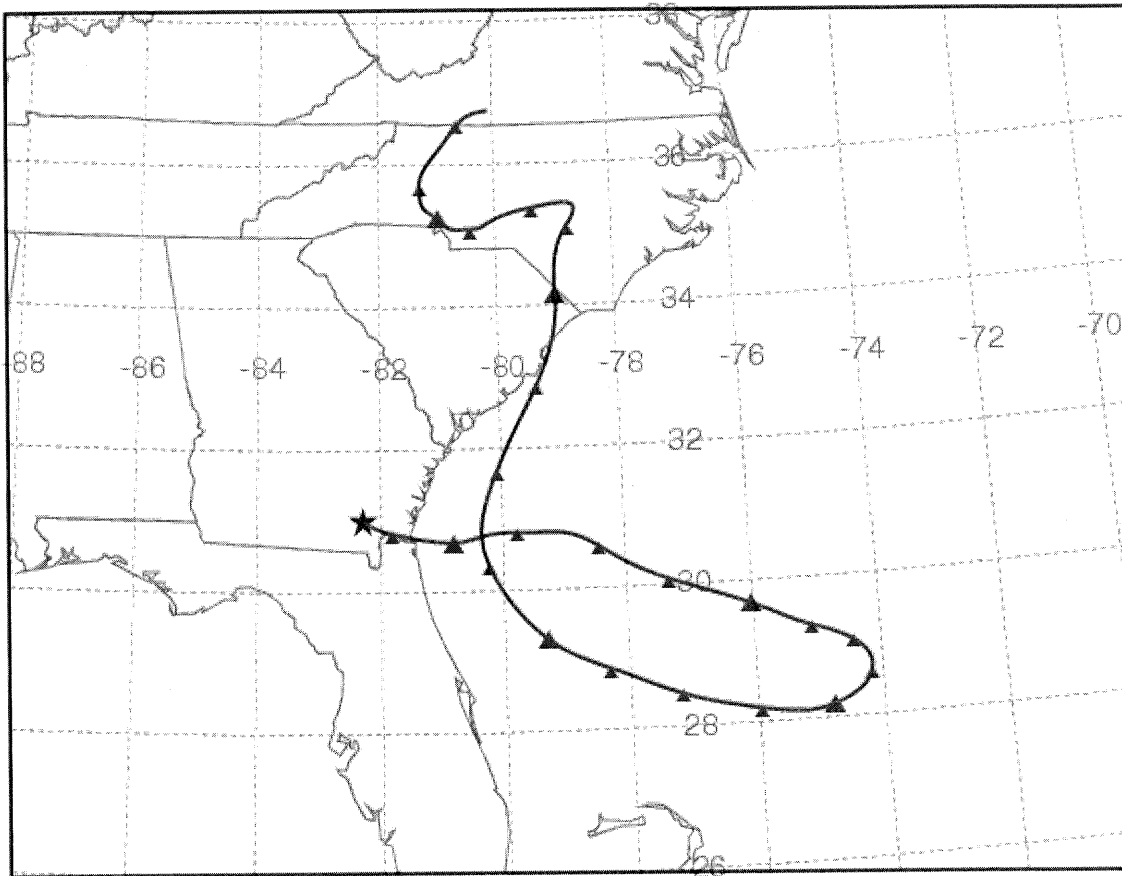
Meters AGL



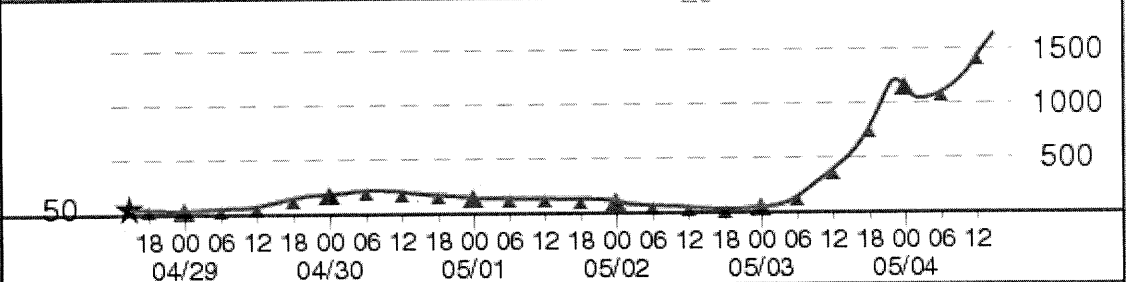
Job ID: 360092 Job Start: Fri Sep 28 19:08:54 GMT 2007
 Source 1 lat.: 31 lon.: -82.3 height: 50 m AGL
 Trajectory Direction: Forward Duration: 144 hrs Meteo Data: EDAS40
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

NOAA HYSPLIT MODEL
 Forward trajectory starting at 15 UTC 28 Apr 07
 EDAS Meteorological Data

Source ★ at 31.00 N 82.30 W



Meters AGL



Job ID: 360142 Job Start: Fri Sep 28 19:13:50 GMT 2007
 Source 1 lat.: 31 lon.: -82.3 height: 50 m AGL
 Trajectory Direction: Forward Duration: 144 hrs Meteo Data: EDAS40
 Vertical Motion Calculation Method: Model Vertical Velocity
 Produced with HYSPLIT from the NOAA ARL Website (<http://www.arl.noaa.gov/ready/>)

"Atypical" Analysis for Linkhaw 3 May 2007 Exceedance

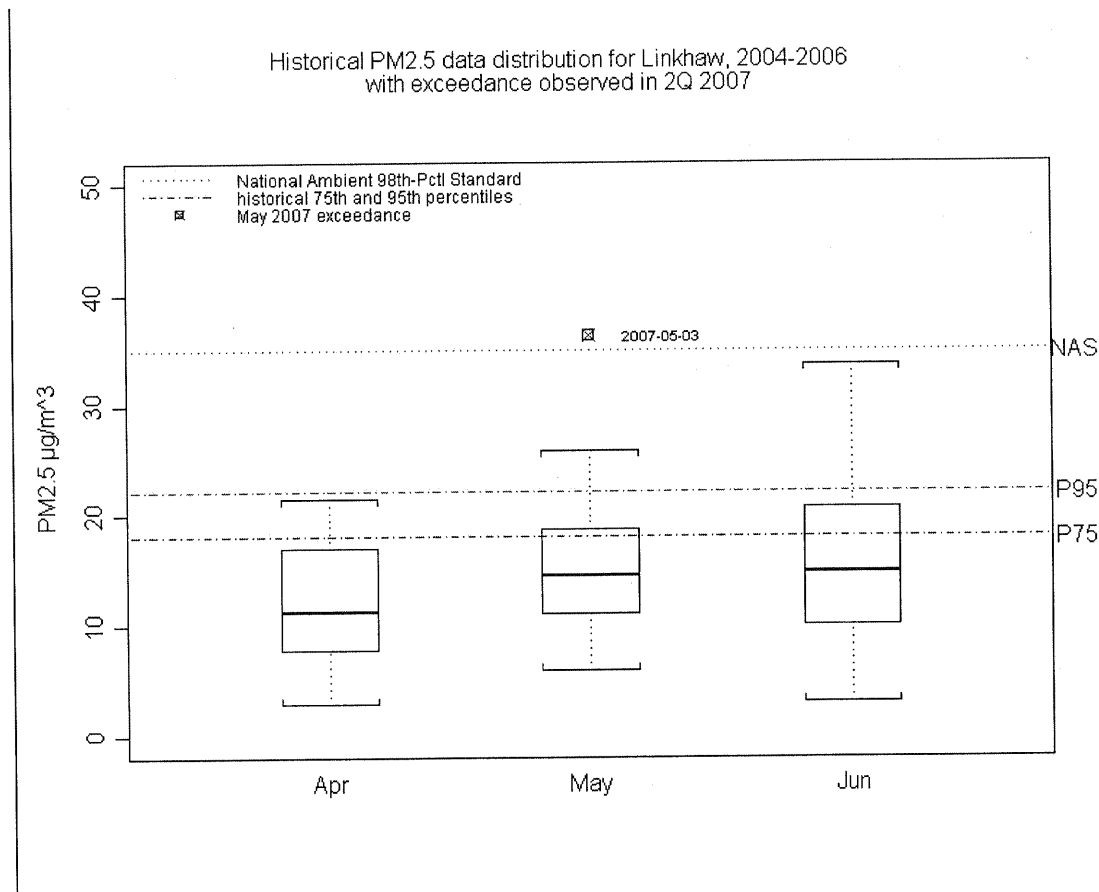


Figure 3.1 - shows "normal historical fluctuations" of PM2.5 data for the Linkhaw (Lumberton) monitoring station during the second calendar quarter in the form of boxplots for the individual *monthly* distributions with reference lines showing the historical levels of the 75th and 95th percentile levels as well as the level of the National Ambient 98th-percentile Standard (18.1 $\mu\text{g}/\text{m}^3$, 22.1 $\mu\text{g}/\text{m}^3$, 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 22.1 $\mu\text{g}/\text{m}^3$. The 3 May 2007 exceedance exceeds the historical 95th percentile level by 64 percent.

"Atypical" Analysis for Linkhaw 3 May 2007 Exceedance (Cont'd)

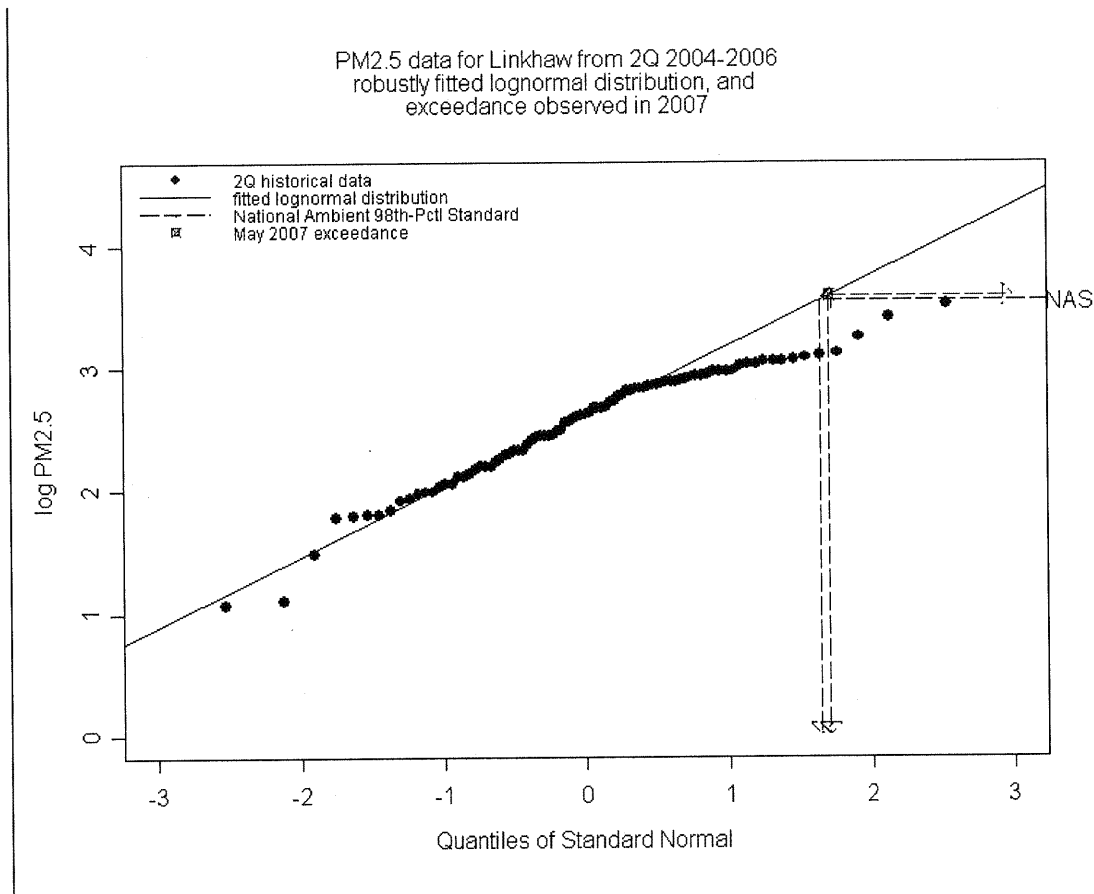


Figure 3.2 - shows "normal historical fluctuations" of PM2.5 data for the Linkhaw monitoring station during the second calendar quarter in the form of a lognormal distribution quantile plot.

Particulate pollution data are often well approximated by lognormal distributions, although Figure 3.2 offers a strong suggestion that concentrations below and above about $16 \mu\text{g}/\text{m}^3$ do not fit the same lognormal distribution. 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 3 May 2007 exceedance ($y=3.59$) 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 5.0 percent (1.64 standard deviations greater than the lognormal mean value), and the expected probability of "unexceptional data" exceeding the level observed on 18-19 June 2007 is less than 4.4 percent (more than 1.70 standard deviations greater than the lognormal mean value). The estimated parameters of the lognormal approximation are:

- median PM2.5 = 13.6
- mean PM2.5 = 16.1
- 98th pctl PM2.5 = 44.3

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

Executive summary

To demonstrate that the Roundabout wildfire in Georgia caused an exceedance of the daily fine particle standard of 35 micrograms per cubic meter at the Linkhaw monitor on May 3, 2007, we need to find a way to either estimate (1) what the fine particle concentration value would have been on May 3, 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 May 3, 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 May 3, 2007, we opted to develop a model using meteorological measurements to estimate what the fine particle concentration value would have been on May 3, 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 May 3, 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 May 3, 2007, with a certain probability. If we calculate the maximum expected value using a 99 percent probability and it is less than 35 micrograms per cubic meter, then there is at most a 1 percent probability that a value above the standard would have occurred at Linkhaw on May 3, 2007, if there had not been wildfires in the area.

Using the developed model and calculating the maximum expected value using a 99 percent probability indicates that there is a 1 percent probability that a value exceeding 24.54 micrograms per cubic meter would have occurred at Linkhaw on 5/3/2007. Thus, without the wildfire, there is less than 1 percent probability that the National Ambient Air Quality Standard would have been exceeded on that day. As a result, we believe that the value of 36.25 micrograms per cubic meter, which exceeded the daily fine particle standard, would not have occurred at Linkhaw if there had not been a wildfire in Georgia around the day of May 3, 2007.

Data Description

For each day in the 2nd quarter of 2004, 2005, 2006 and 2007 on which there was a valid PM2.5 concentration I acquired the following met data 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 RN24.lag1 because it had a missing value on the exceedance day, which prevents any model that uses this variable from making a prediction.

Method of analysis

1. Define a covariate for each exceptional event, setting its value at +1 on the the day of the event and 0 on all other dates. PM.e1 is the covariate for 05/03/2007 (actual concentration 36.2).
2. Define the response variable PM2.5 as follows:

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

= 0.0 if there is an exceedance

3. Fit linear model as defined in the model below. The coefficient associated with PM.e1 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 + RN24 + WS24 + VWD24 + PM.e1, data = LHtest002.df, na.action = na.exclude)

Residuals:				
Min	1Q	Median	3Q	Max
-9.605	-2.99	-0.5629	2.866	11.93

Coefficients:				
	Value	Std. Error	t value	Pr(> t)
(Intercept)	437.1580	226.2512	1.9322	0.0615
AT	0.4734	0.2472	1.9154	0.0636

RH	-0.5673	0.2965	-1.9131	0.0639
RN24	-2.5581	2.3075	-1.1086	0.2752
WS24	-0.7075	0.3924	-1.8032	0.0800
VWD24	-0.0031	0.0098	-0.3219	0.7494
PM.e1	-12.1355	5.3341	0.2652	0.7924
Residual standard error: 5.125 on 35 degrees of freedom				
Multiple R-Squared: 0.2809				
F-statistic: 2.278 on 6 and 35 degrees of freedom, the p-value is 0.05828				
77 observations deleted due to missing values				

Discussion

The linear model explains less than one-third of the observed variation in PM_{2.5} 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 in the context of normal approximations. The expected values are as shown in the Coefficients tables, and $2.325 \times$ 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 "99% probability upper limit" takes the standard error into account and shows a threshold that there is less than 1 percent probability of exceeding. On this day, the expected concentration was $12.1 \mu\text{g}/\text{m}^3$, and the 99-percent upper probability limit slightly less than $25 \mu\text{g}/\text{m}^3$. This suggests a less than one percent probability that the concentration on the exceptional event day would have exceeded the threshold of the annual standard under observed conditions that are independent of the event.

Table 5. Linkhaw Exceptional Event Concentration Statistics on 3 May 2007.

Date	actual	expectation	99% probability upper limit
3 May 2007	36.2	12.14	24.54