

Modeling Source Particulate Matter from Prescribed Burns

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About 40% of U.S. Forest land is in the 13 Southern States.

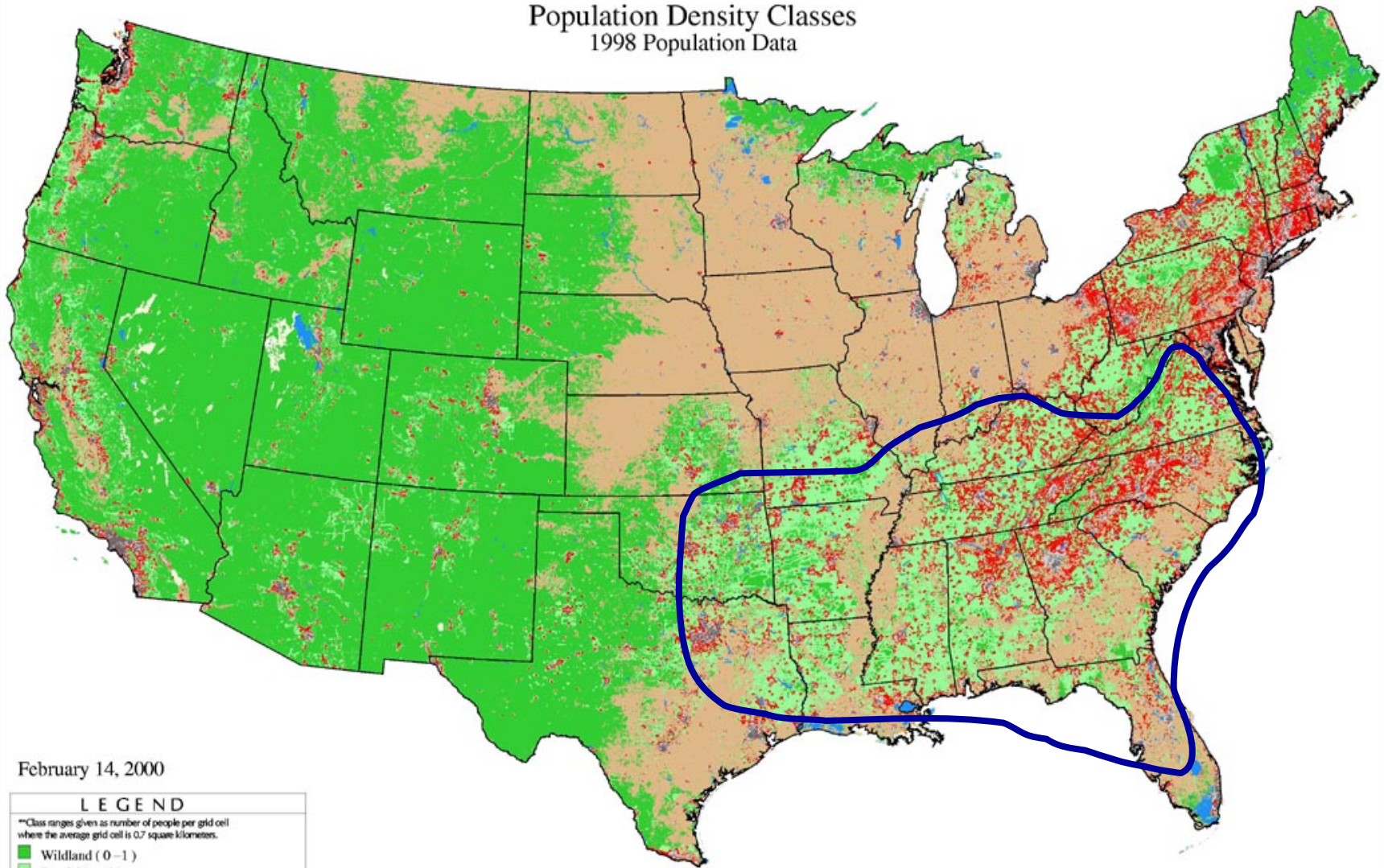
Approximately 70% of this forest land is privately held.

Approximately 6 million acres per year are subject to prescribed fire.

Acreage burned 40-400 acres with blocks as large as 1000 acres.



Population Density Classes 1998 Population Data



February 14, 2000

LEGEND

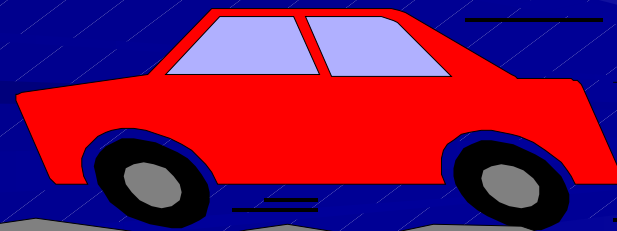
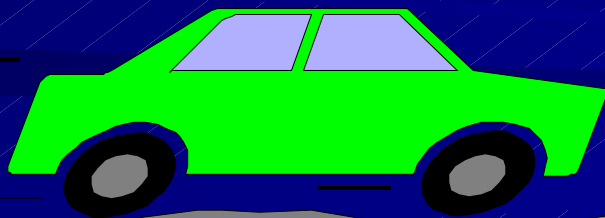
**Class ranges given as number of people per grid cell where the average grid cell is 0.7 square kilometers.

- Wildland (0 - 1)
- Rural (2 - 10)
- Wildland-Urban Interface (11 - 100)
- Suburban (101 - 500)
- Urban (> 500)
- Agriculture
- Water
- Other

Map Date: October 26, 1998

T & E Species Act
Forest Health
Wildlife Management
Ecosystem Restore
Timber Products
Carbon Sequestration

Clean Air Act
Human Health
Nuisance Smoke
Visibility
Transportation Hazard



The Forest Smoke Problem

- There is pressure on land managers to increase number of acres burned.
- Increased fire leads to increased smoke production.
- Land managers must plan their prescribed burns to minimize smoke impacts on surrounding populations.

Our Mission

- Accurately model prescribed burns in the manner the burns are engineered by land managers.
- Provide prescribed burn/smoke expertise to the AQ community.
- Develop accurate prescribed burn data sets for the AQ community
- Make sure that current AQ models include smoke data in ways consistent with the conduct of the burns.

How Smoke can be Managed

- Seasonal Time Scale – burning done during certain seasons based on plant ecology
- Weather Time Scale – burning done on select days within the month according to prescription (stability, winds, temperature, relative humidity, past precipitation (KBDI), ventilation).
- Dispersion Time Scale – a burn may last several hours during the most opportune part of the day.
- Engineering Time Scale – land manager can engineer burn (head fire, back fire, aerial ignition, strip fire) to concentrate combustion during a narrow window of the day.
- Plume Time Scale – plume will ramp up and ramp down during burn.
- Residual Smoke – stays near ground, gets entrapped at night, could be the biggest smoke problem.

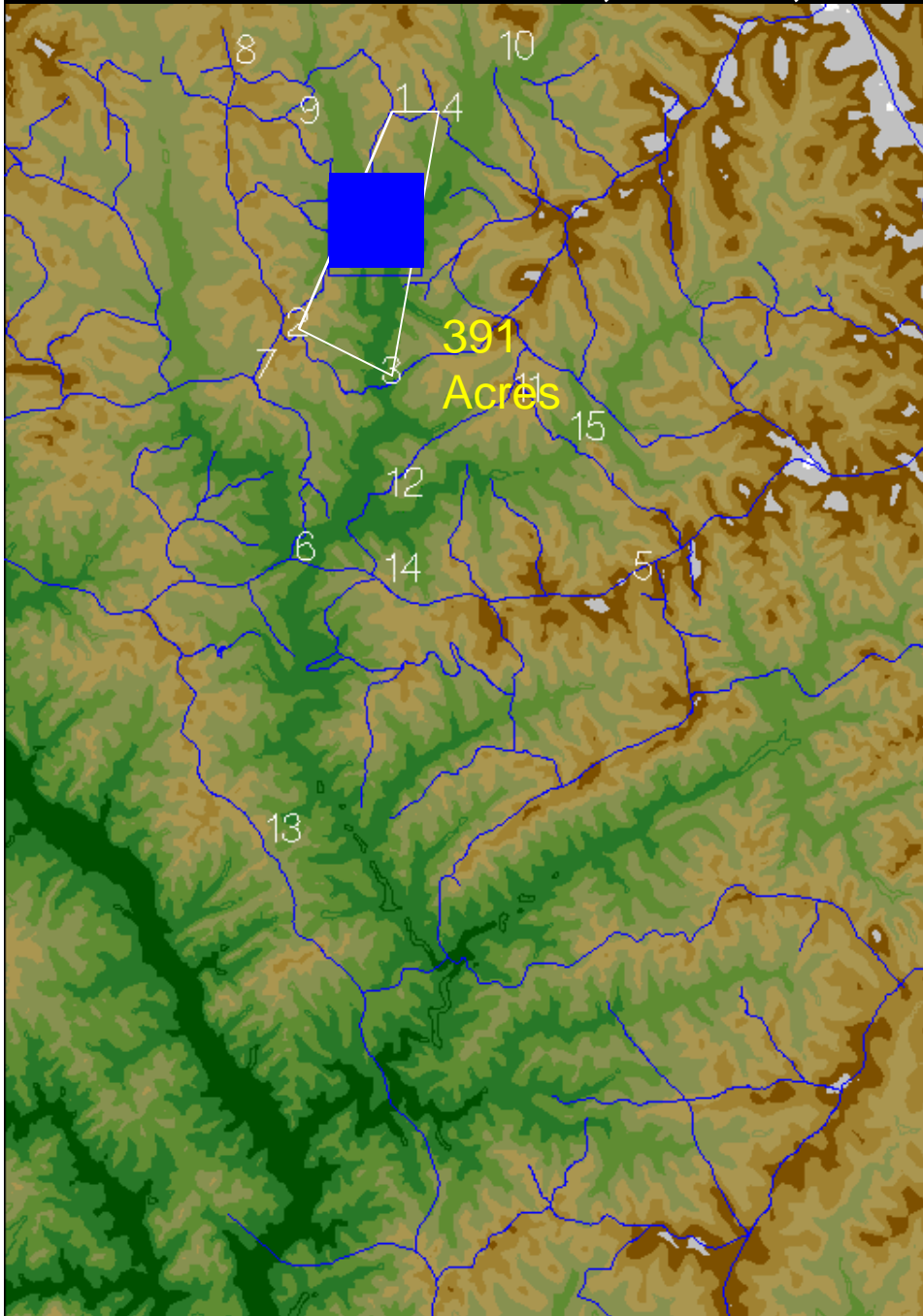
SMT Modeling Plan

- Local Night – PB models (PB-Piedmont, PB-Coastal Plain, PB-Mountains)
- Local Day – Daysmoke
- Local/Regional – BlueSky
- Regional – BlueSky, 4S/CMAQ(Daysmoke) (as pertains to forest/agriculture burning)
- Basic research models for fire behavior and plume behavior.

Local Night: PB-Piedmont

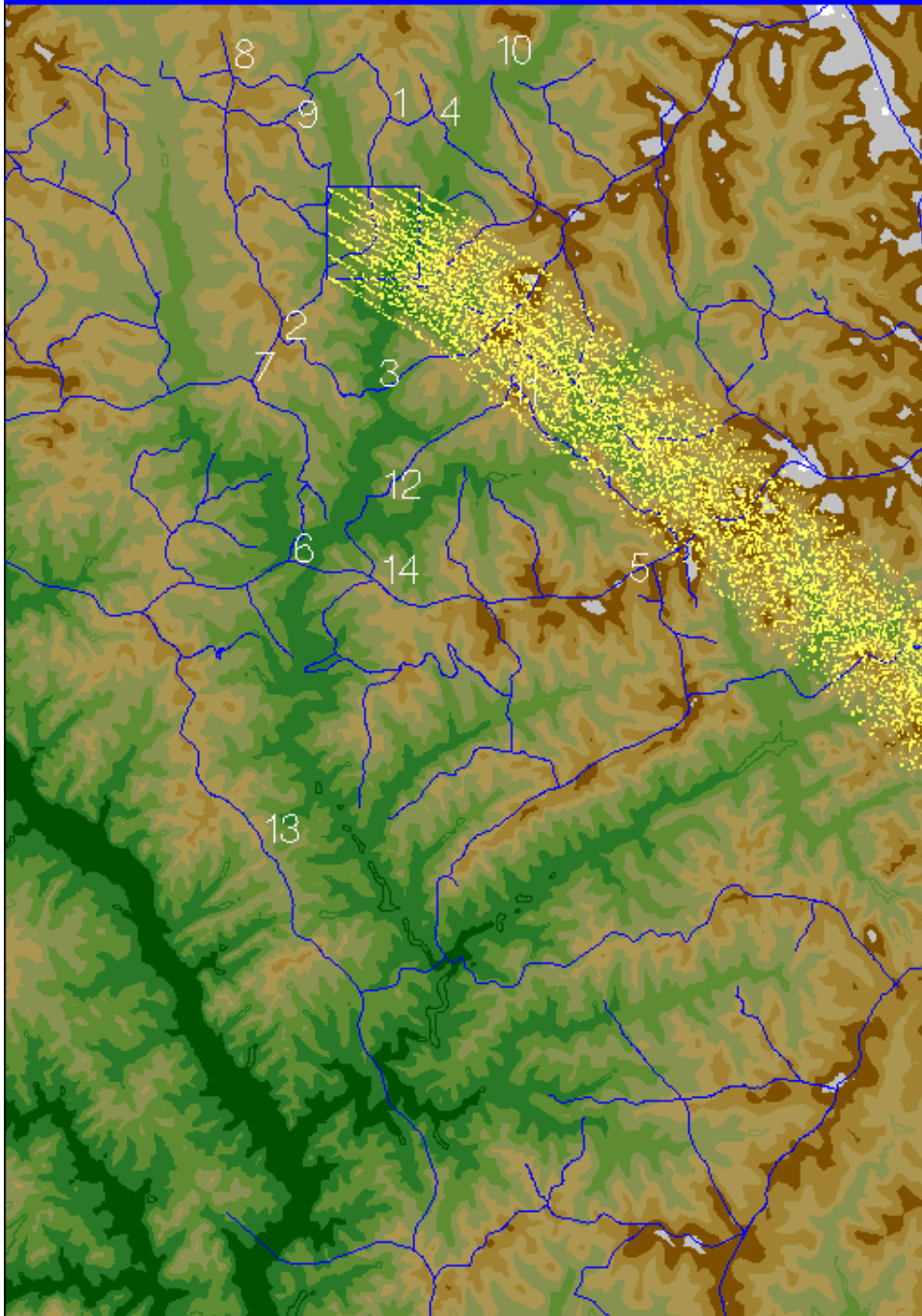
- If I burn tomorrow, will I smoke up a road tomorrow night?
- Now that I have burned, where is my smoke most likely to go?

PB-Piedmont domain, roads, observation points 15 January 2003



- Blue square: model burn area
- 1,2,3,4: corners of actual burn area
- 5: light smoke
- 6: smoke
- 7: smoke
- 8: smoke boundary
- 9: smoke
- 10: smoke boundary
- 11: light smoke
- 12: smoke
- 13: smoke boundary - smoke south
- 14: smoke boundary
- 15: no smoke

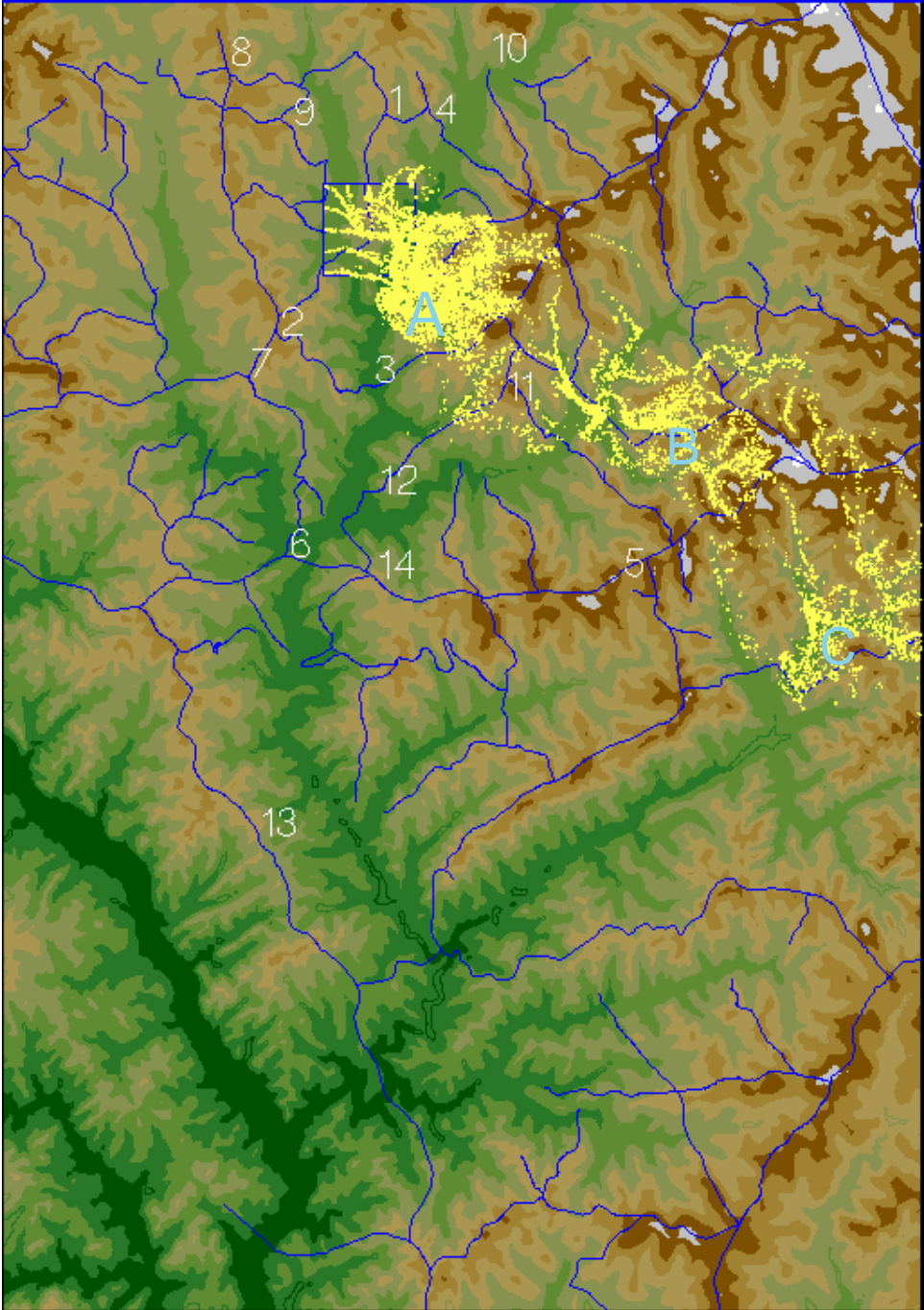
iter	elapsed time	cycle time	model time	DT
102	00:52:38	26.90 sec	18:00:04	14



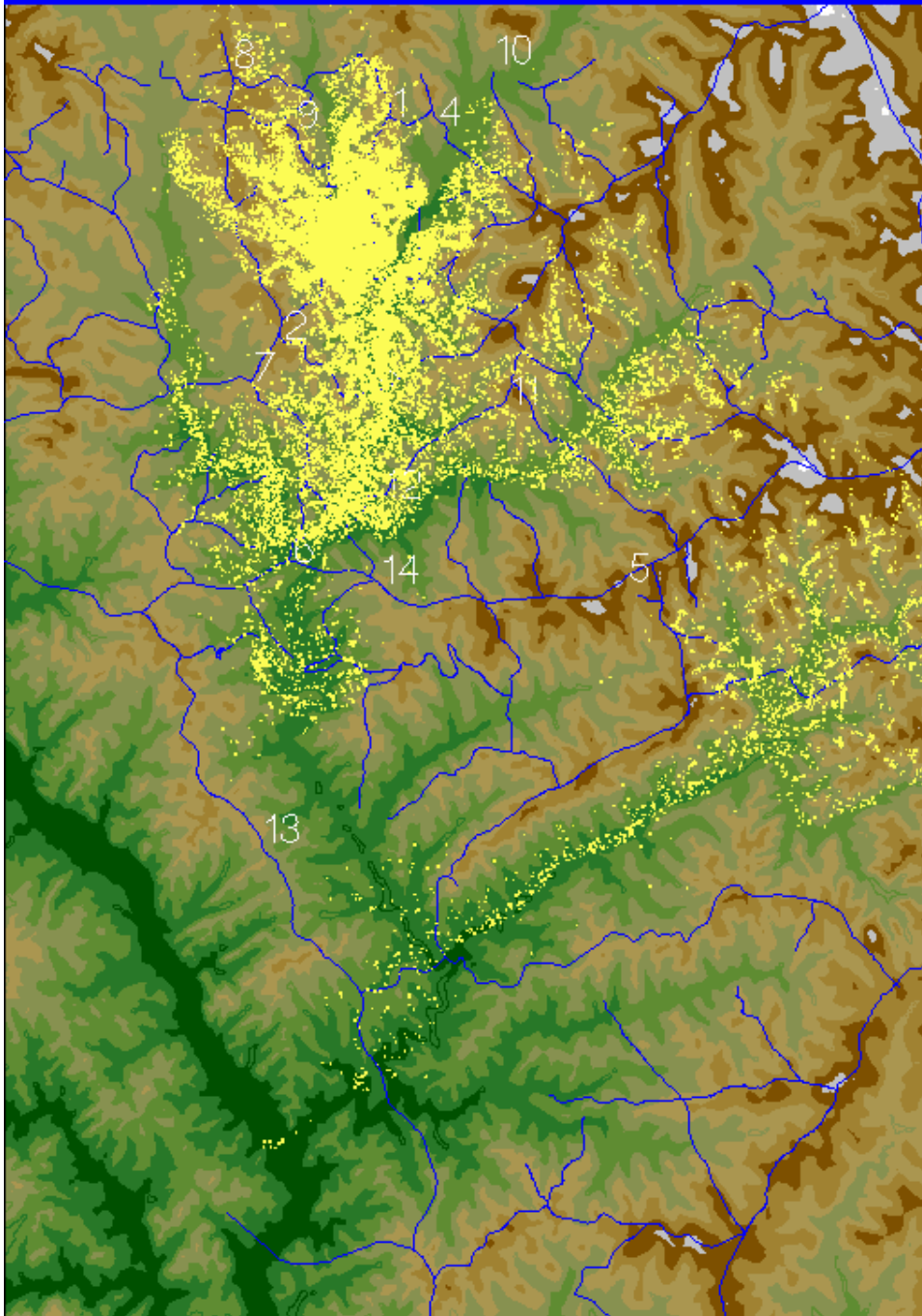
The modeled location of smoke on the ground assume smoldering is coming from everywhere within the model burn area. The time is 1800 EST, approximately 15 minutes after sunset.

iter	elapsed time	cycle time	model time	DT
170	03:21:27	28.22 sec	19:00:04	11

Drainage forcing in PB-Piedmont at 1900 EST

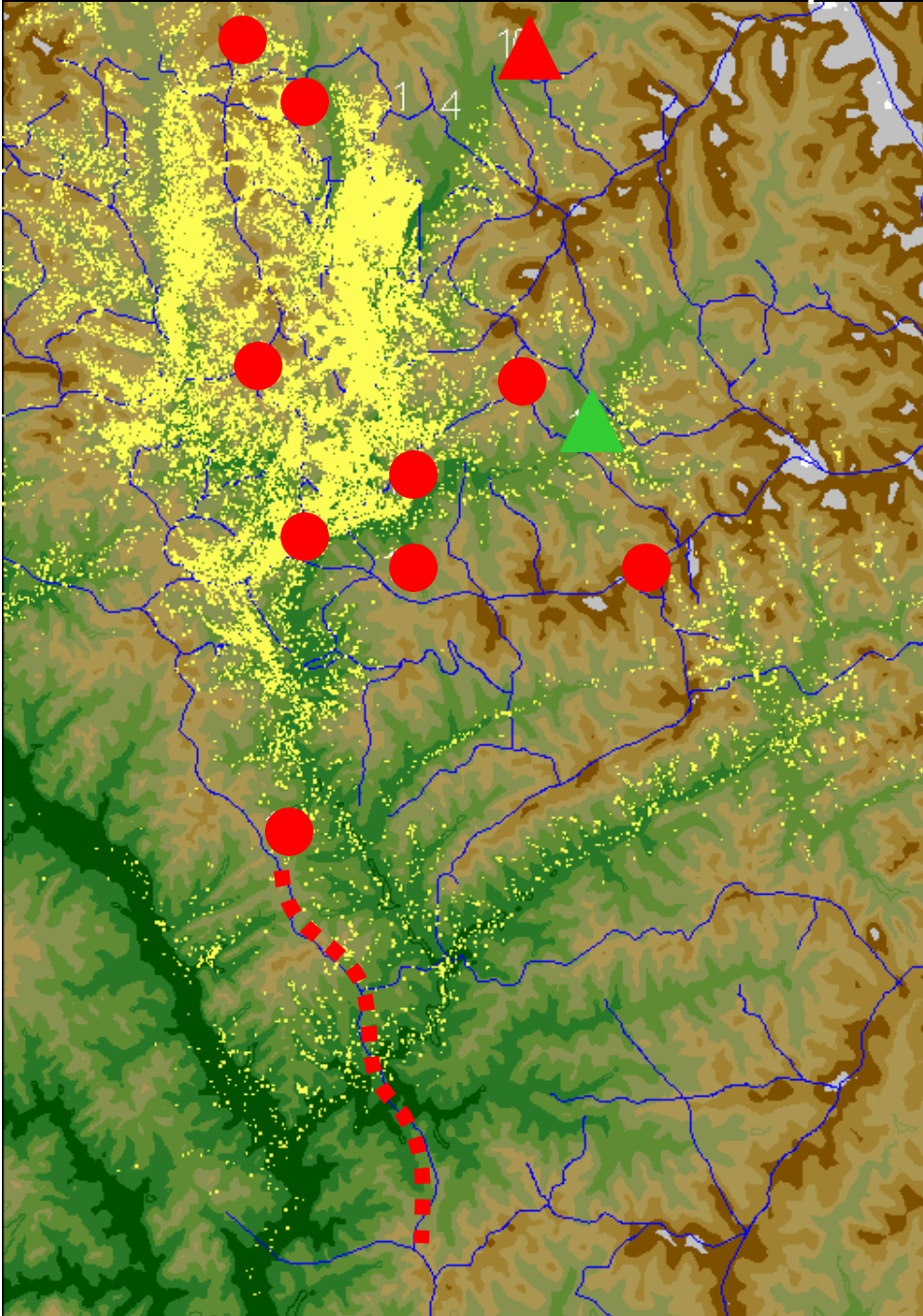


iter	elapsed time	cycle time	model time	DT
111	20:15:01	44.26 sec	02:00:13	16



PB-Piedmont simulated smoke at
0200 EST 16 January 2003.

PB-Piedmont observation points 0800 EST 16 January 2003



5: Light smoke (0811)

6: Smoke (0820)

7: Smoke (0825)

8: Smoke boundary (0832)

9: Smoke (0837)

10: Smoke boundary (0856)

11: Light smoke (0904)

12: Smoke (0908)

13: Smoke boundary south (0920)

14: Smoke boundary (0954)

15: No smoke (0800)

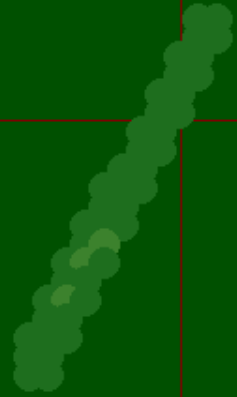
Click left mouse button to view
observation points.

Local Day: Daysmoke

- How can I best engineer my burn so to minimize ground-level smoke impacts?
- Daysmoke links with
 - Fire activity data
 - Models to calculate emissions, heat production, fire behavior

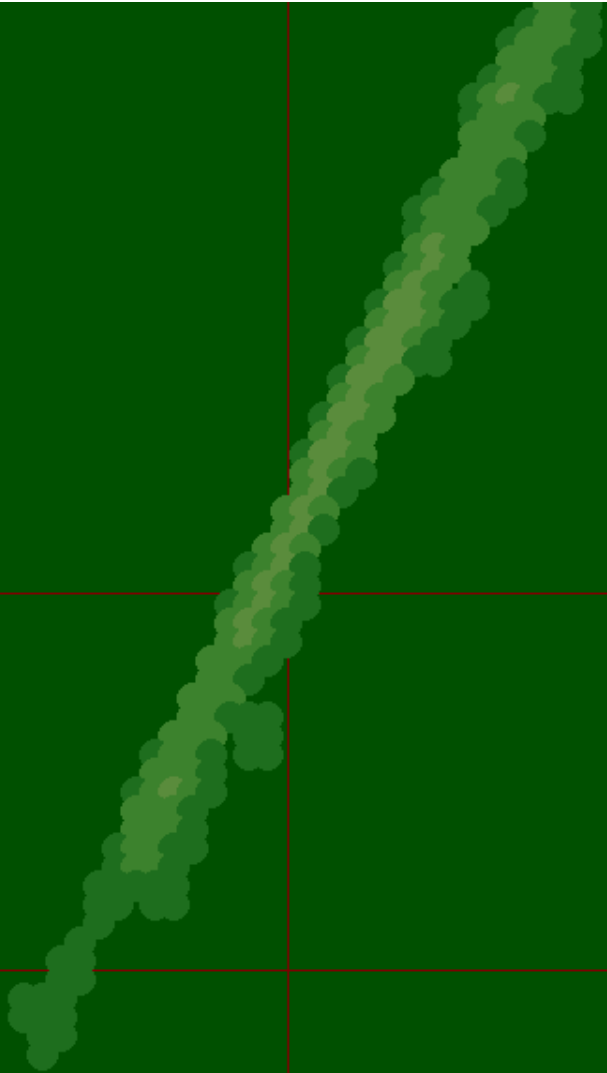
133 927
10:44:20

11



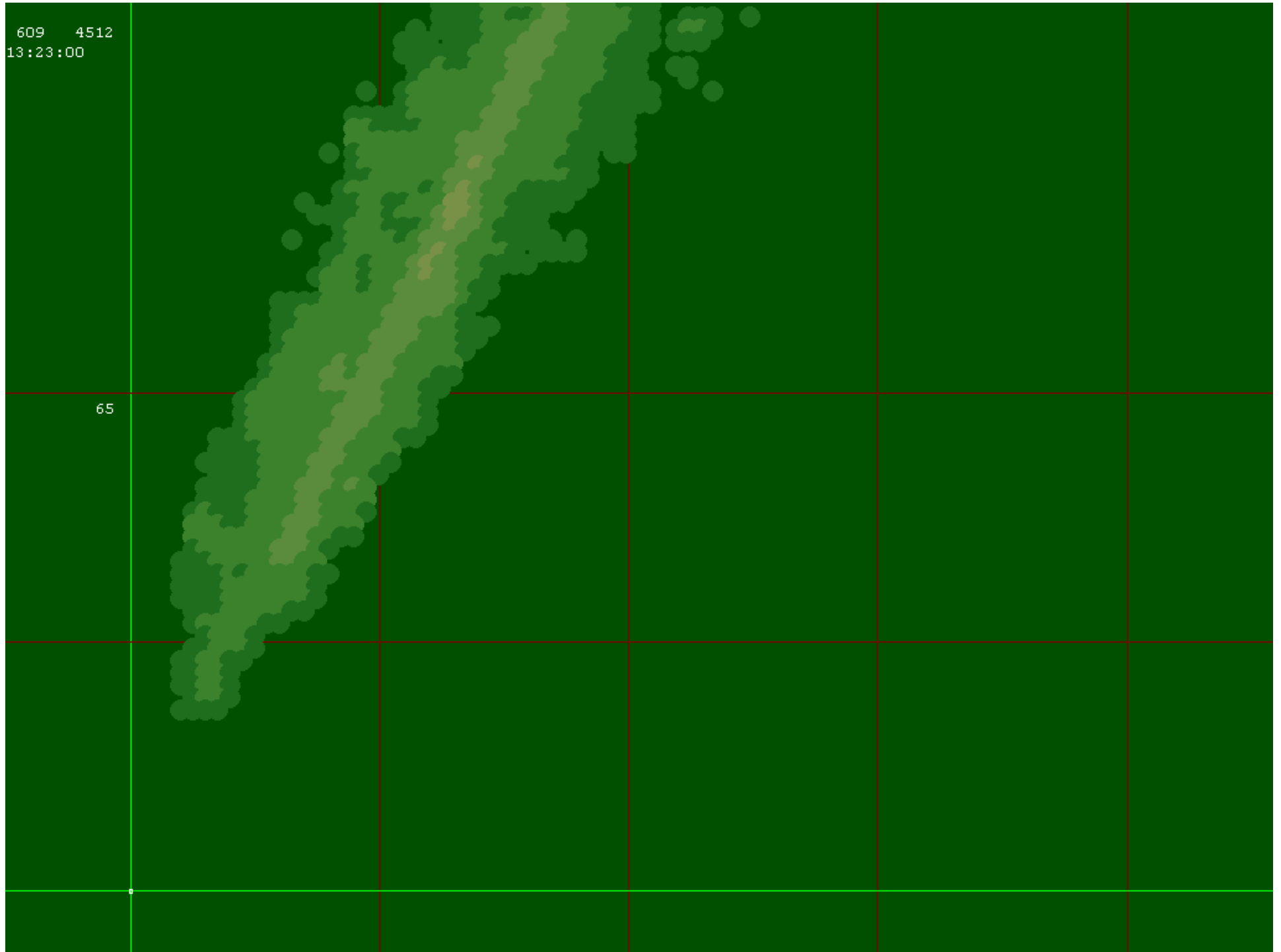
251 4818
11:23:40

38



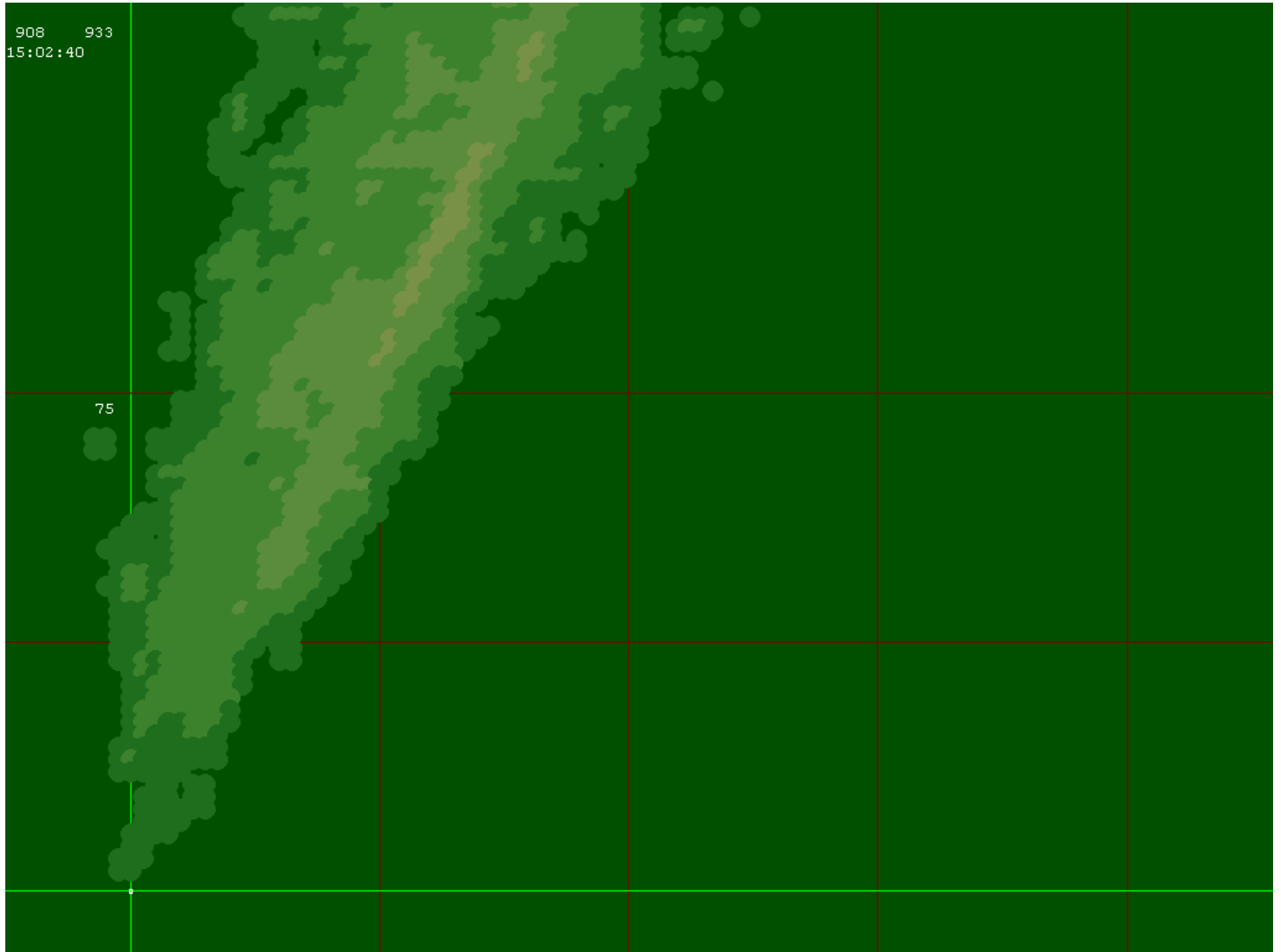
609 4512
13:23:00

65



908 933
15:02:40

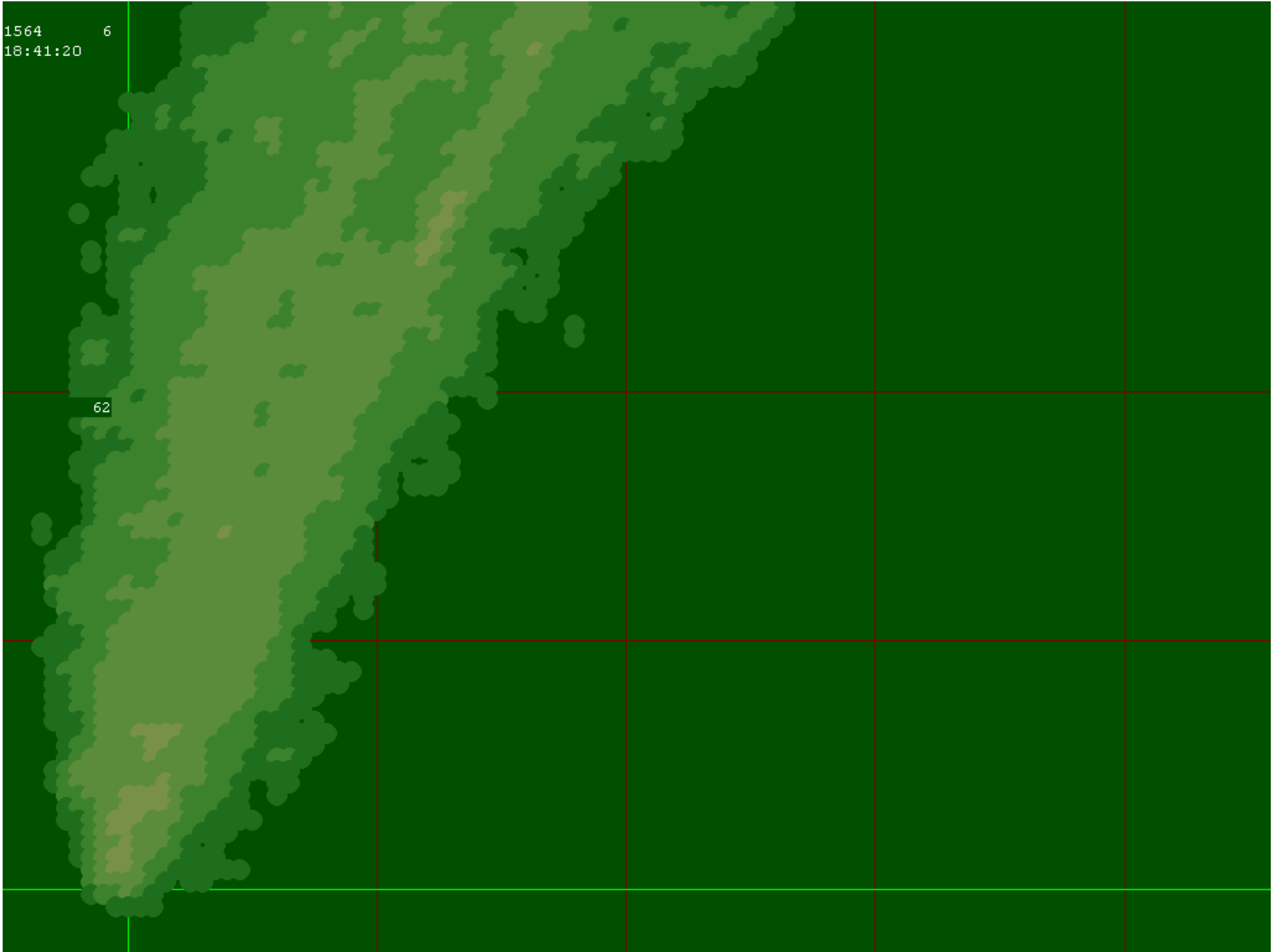
75



1564
18:41:20

6

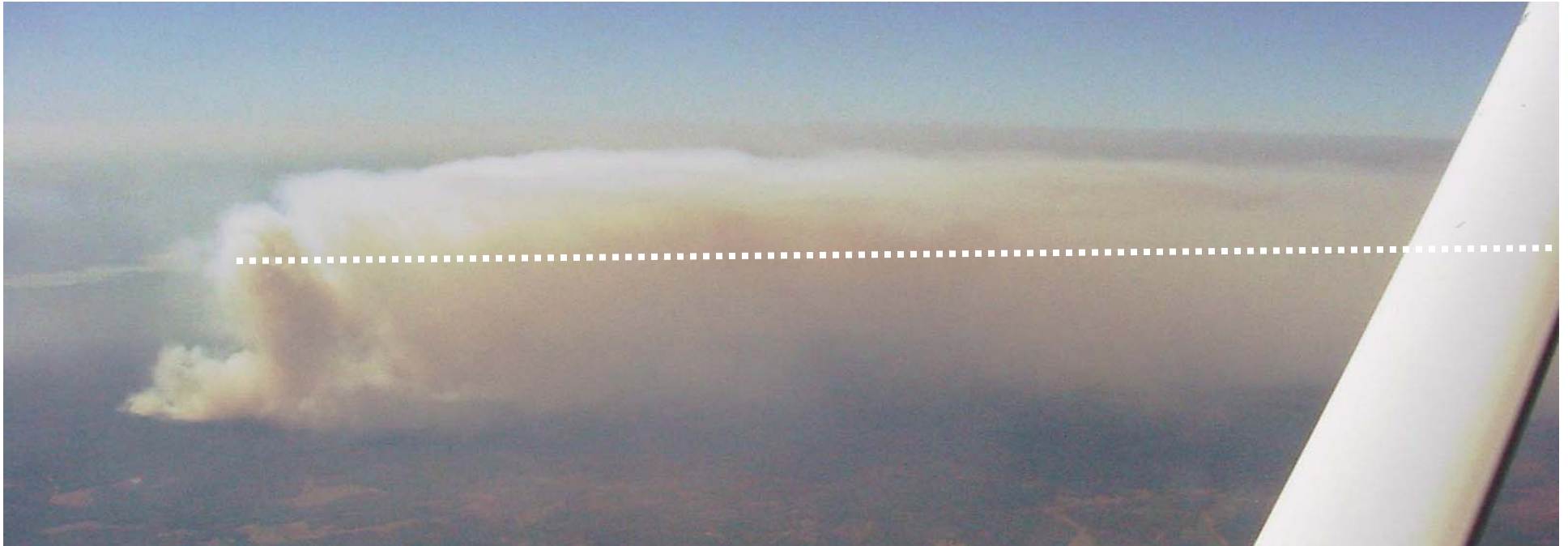
62



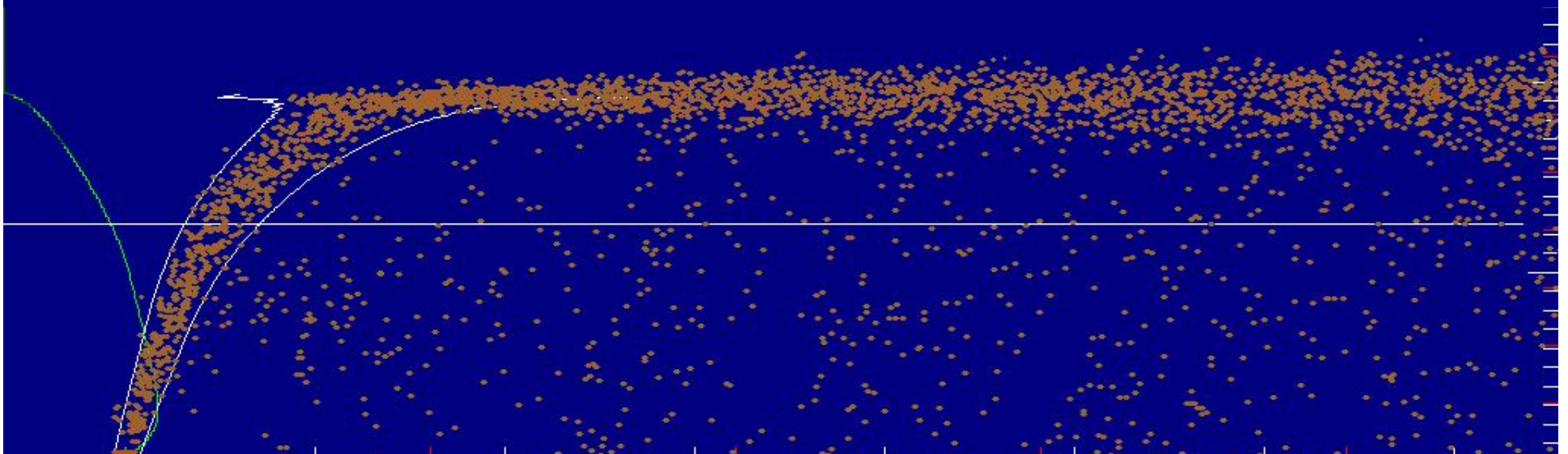
Summary Daysmoke PM2.5 Concentrations with SRS Observations

ATL (CHS) stands for Daysmoke run using ATL (CHS) 1200 GMT sounding. Augusta surface temperature used to modify boundary layer. Concentrations in ug/m3 averaged over 22 hour.

■ Date	Acres	ATL	CHS	OBS
■ 17APR 2003	120	110	86	114
■ 29JAN 2003	400	57	28	47
■ 23FEB 2003	980	28	--	72
■ 01MAR 2004	2745	115	77	164

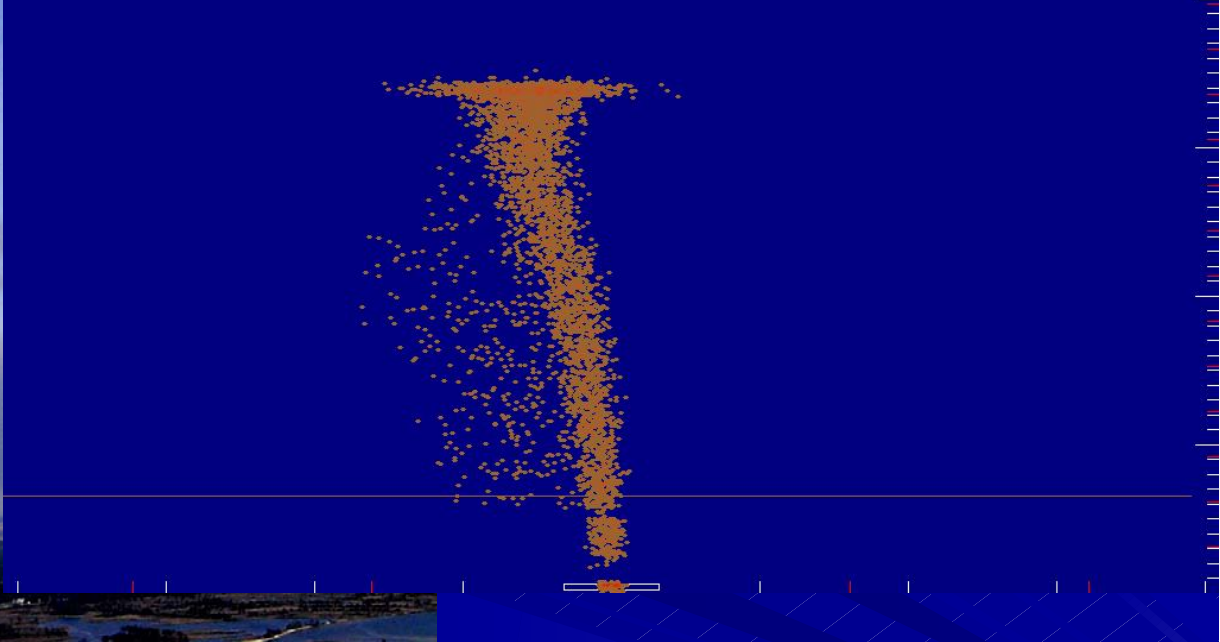


06 March 2002: Airborne photo above, Daysmoke simulation below. 850 acre prescribed burn at Oconee National Forest. Each particle = 1 kg PM_{2.5}. Horizontal line marks top of the mixing layer. ~1400 LST.



420 19474
12:20:00

Burn Complete



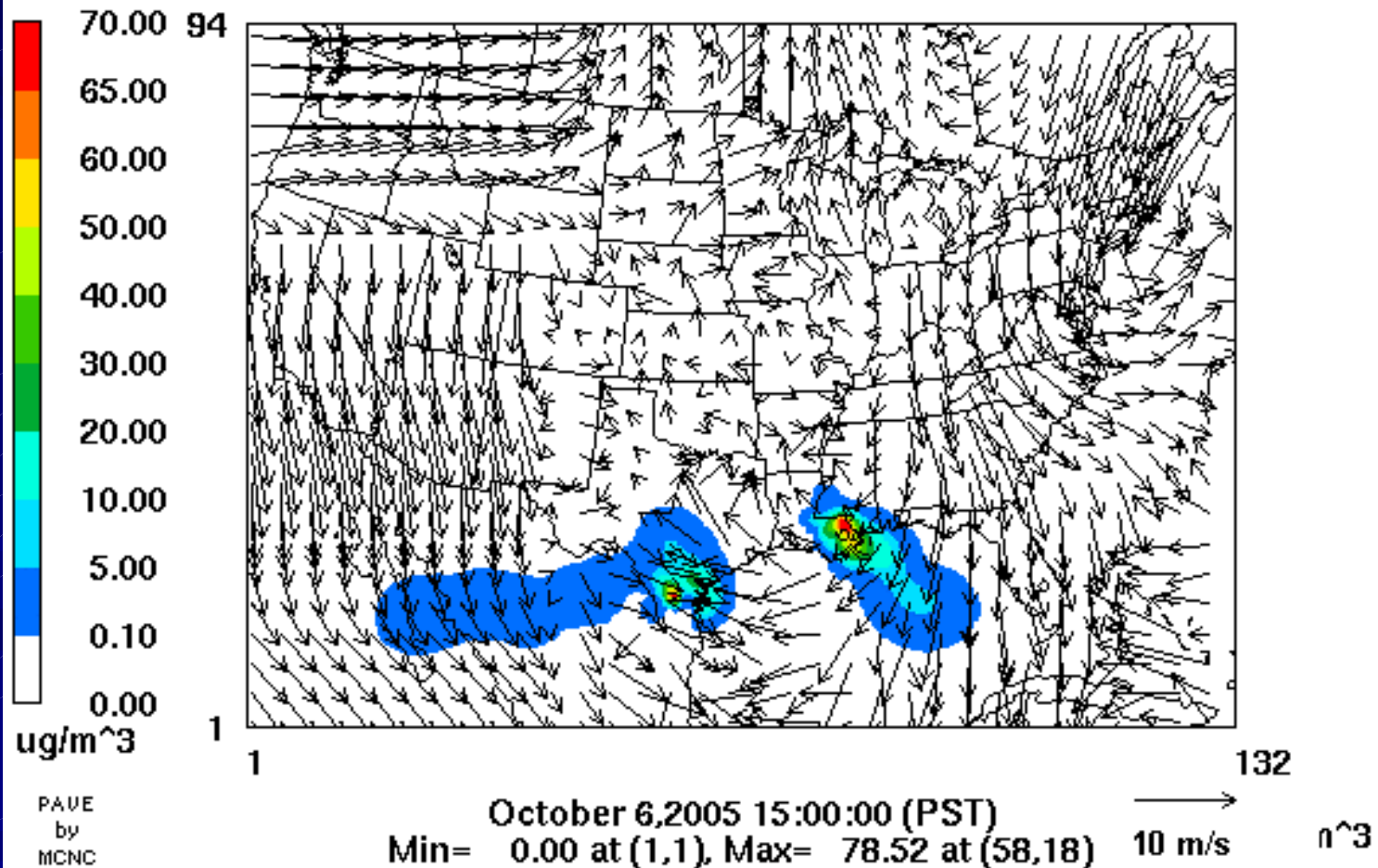
Main plume Cedar Island burn 6
April 2005 looking generally
north. 4934 acres. ~1300 LST

Daysmoke simulation of Cedar Island
plume looking downwind at ~1300
LST. Altitude of both plumes is about
12,000 feet.

Local/Regional BlueSky

Prescribed Fire & Wildfire Simulation

MM5 Forecast: 2005100500
PM2.5 (NAAQS = 65 micrograms/m³, 24hr avg)



Regional: 4S/CMAQ/Daysmoke

- How is smoke from prescribed burns distributed vertically in the atmosphere?
- How are smoke products from Southern prescribed burns distributed regionally?

Southern Smoke Simulation System (Overview)

Fire Data

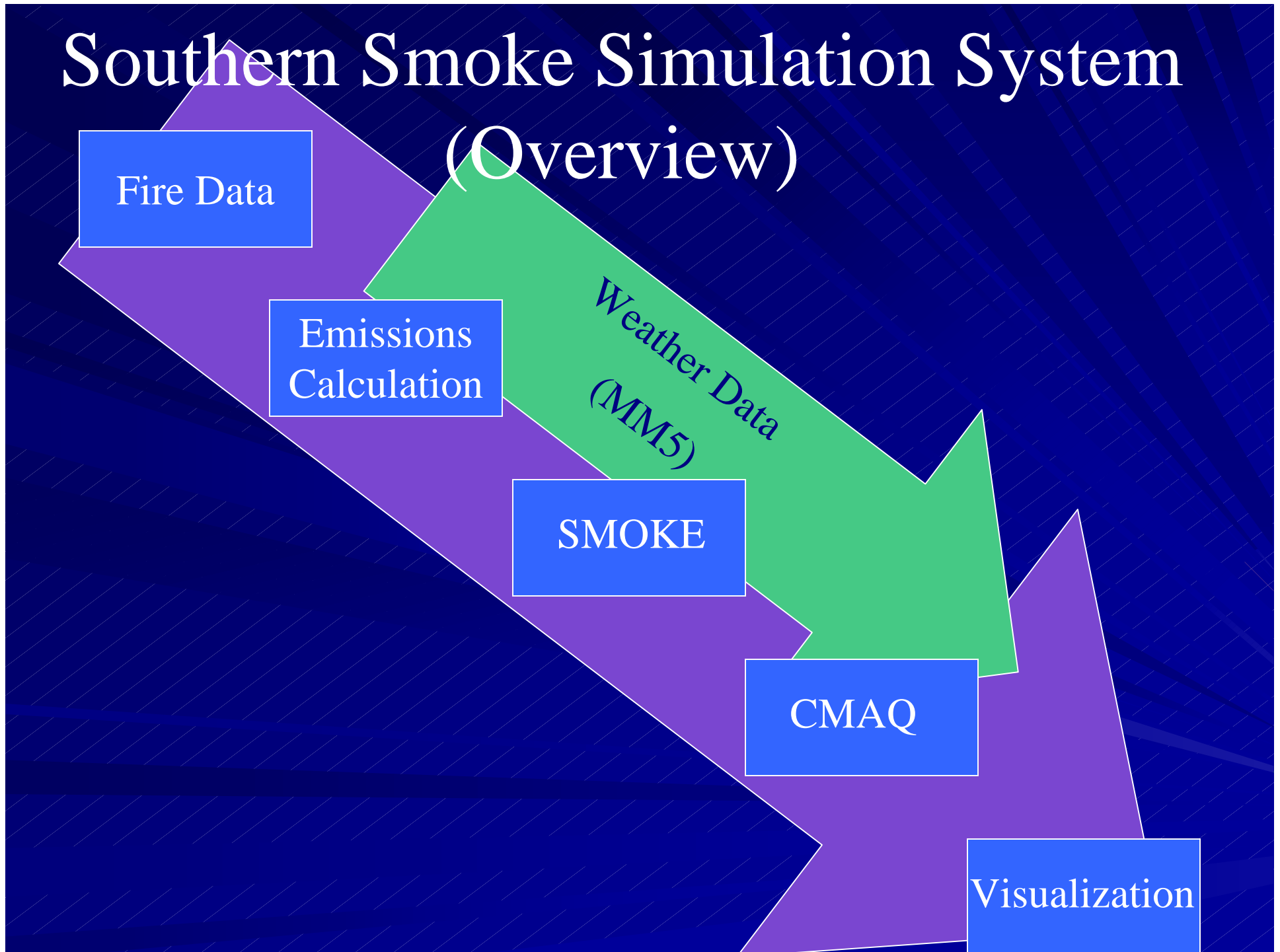
Emissions
Calculation

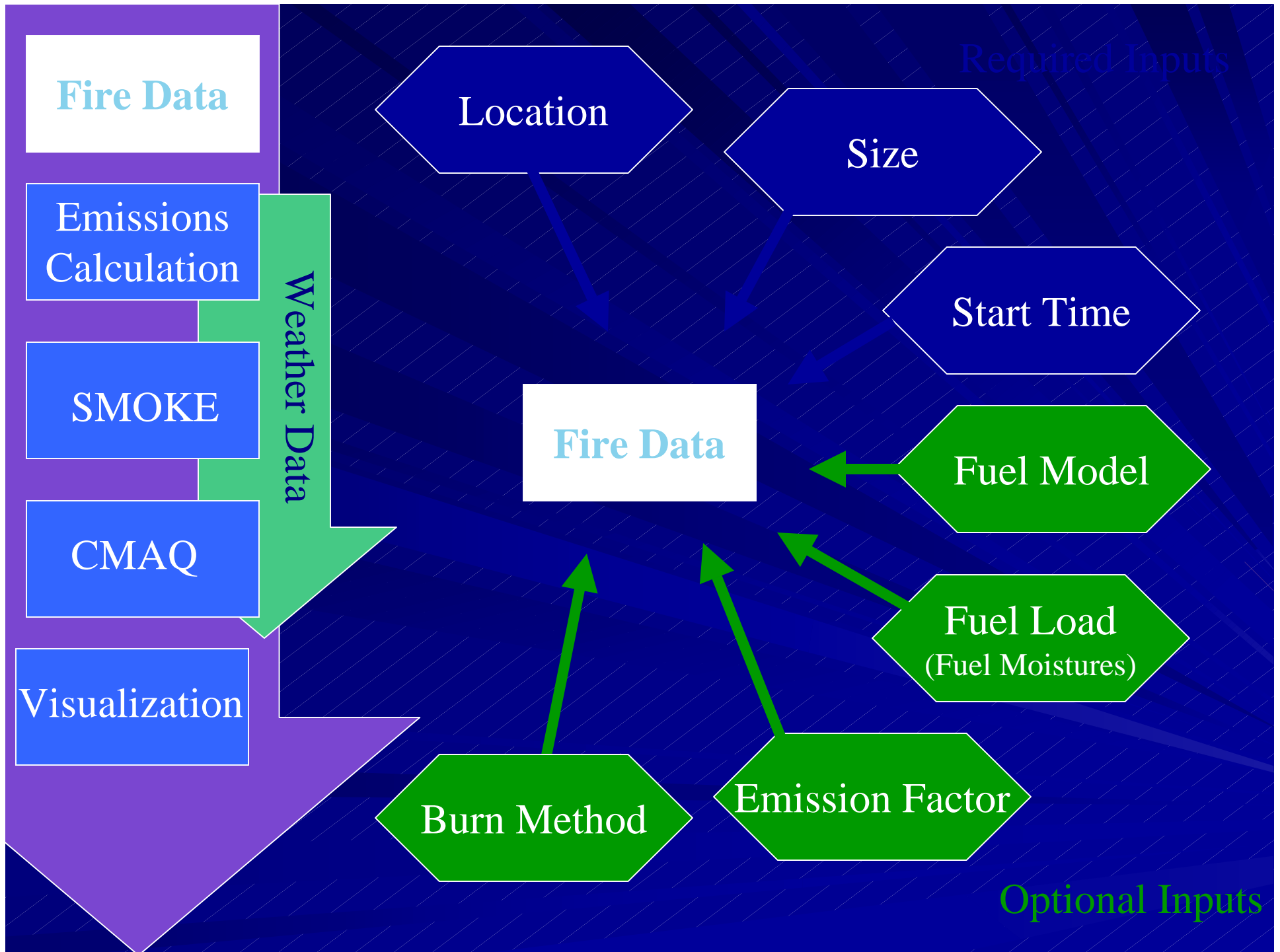
SMOKE

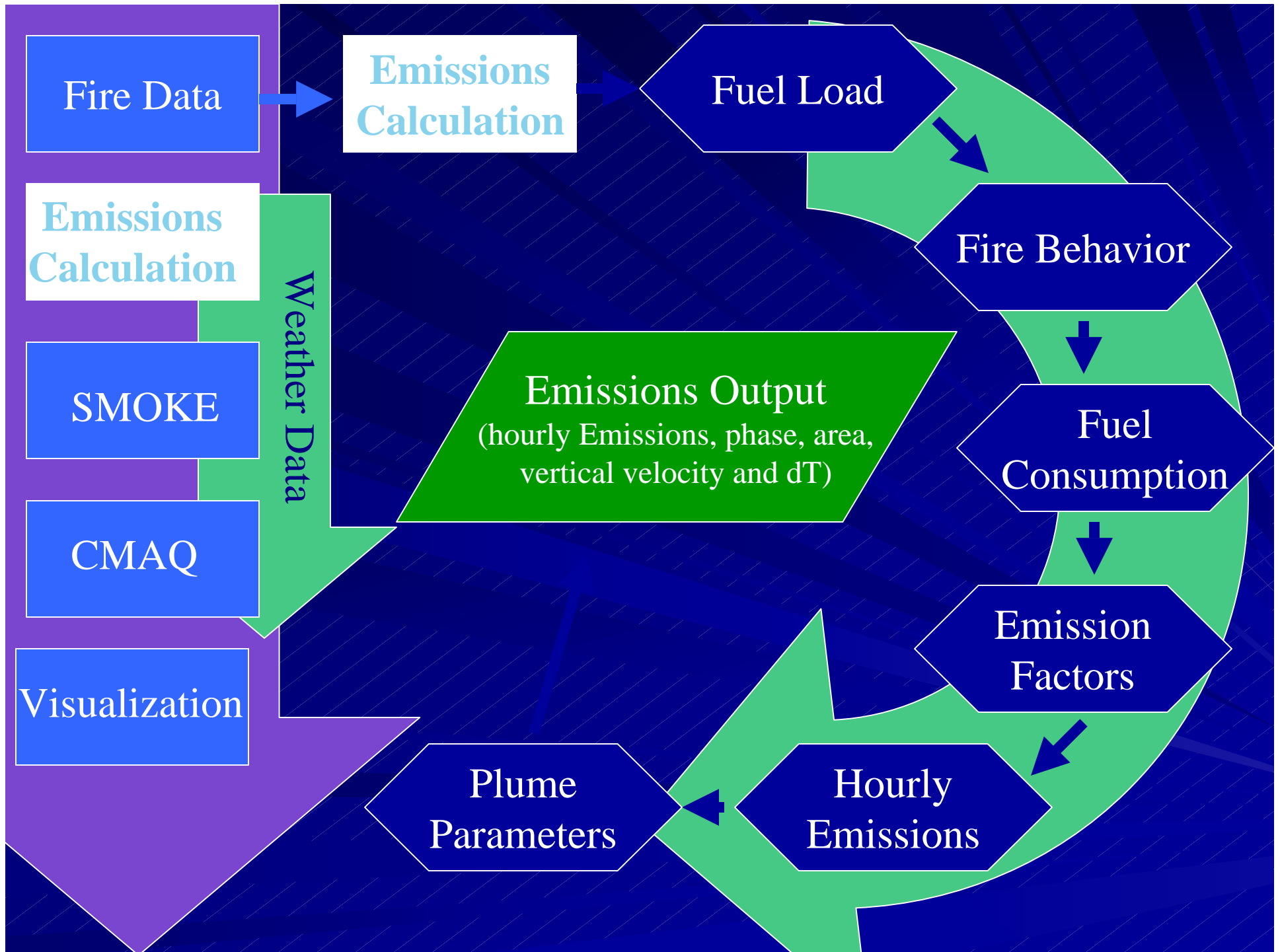
CMAQ

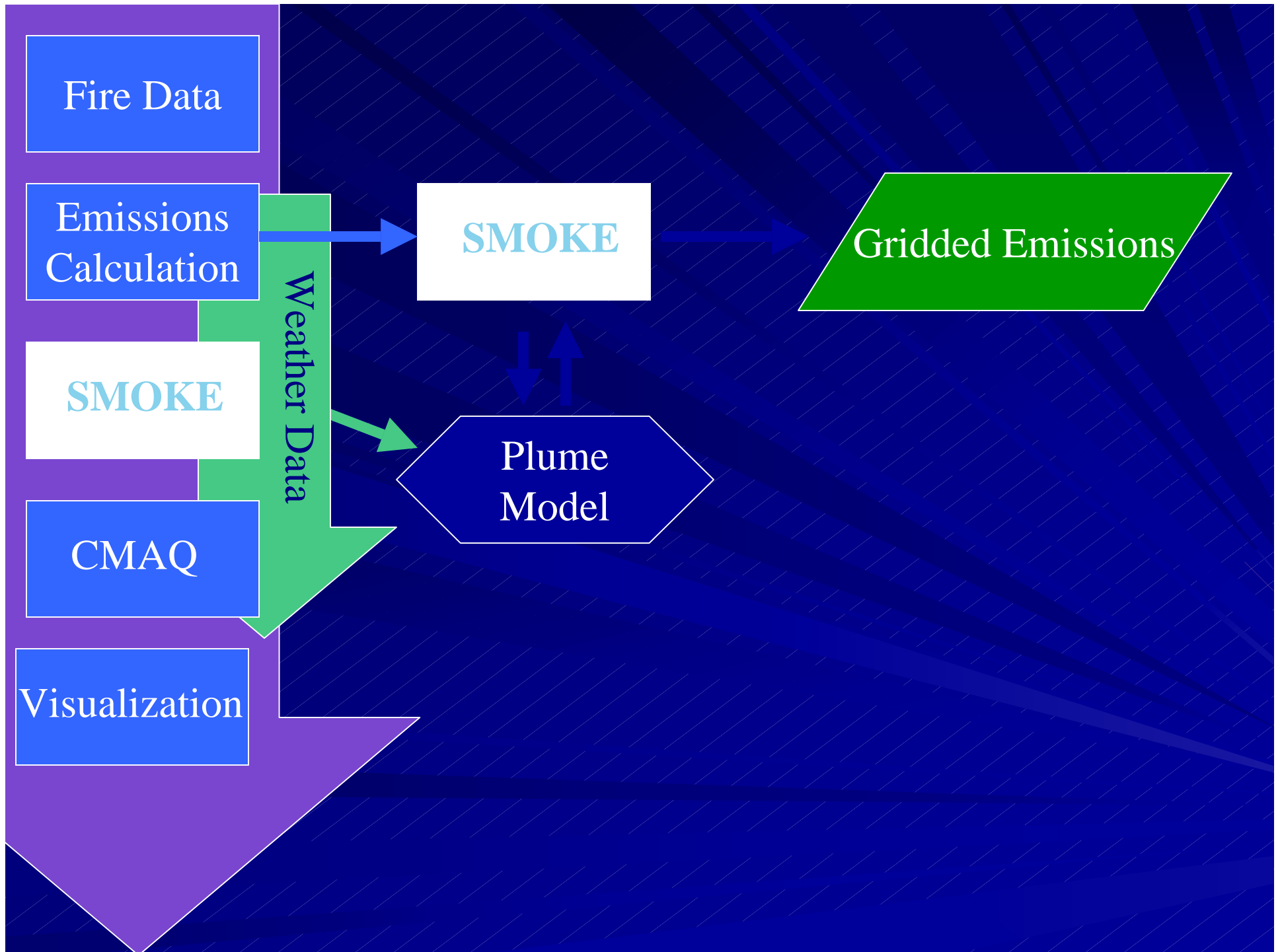
Visualization

Weather Data
(MM5)

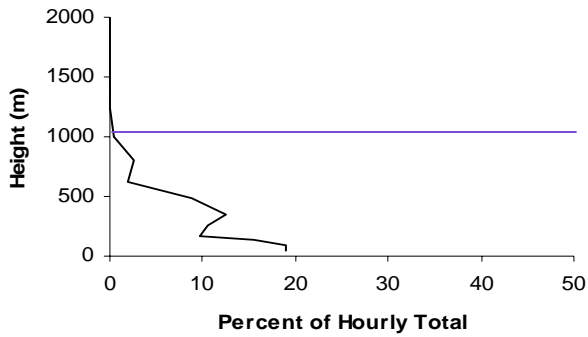




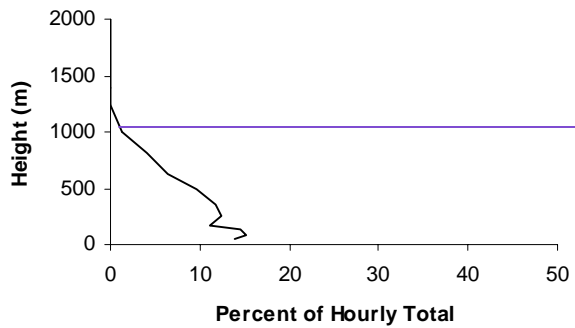




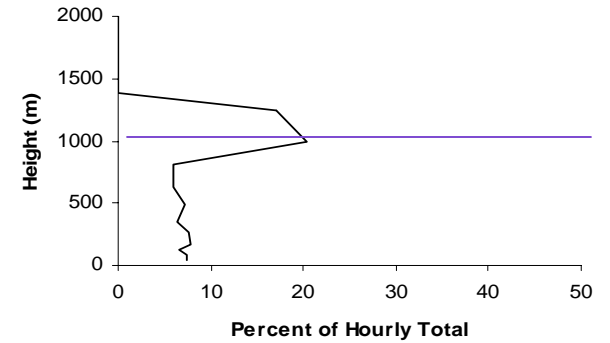
Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1000 LST = 101



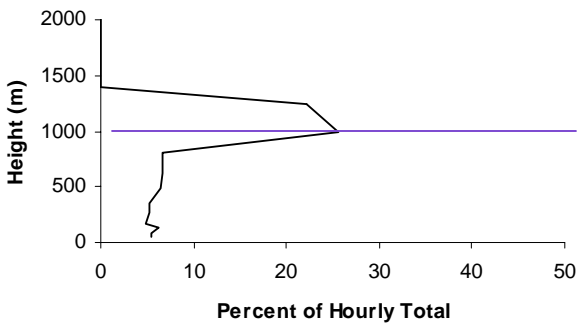
Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1100 LST = 1609



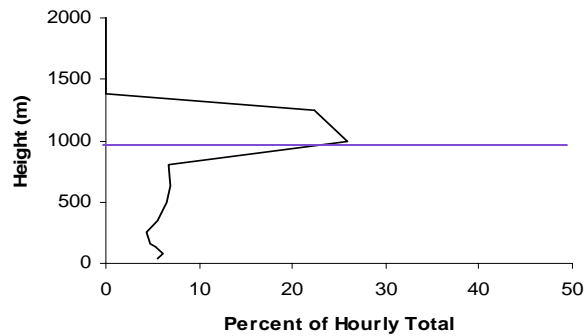
Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1200 LST = 7607



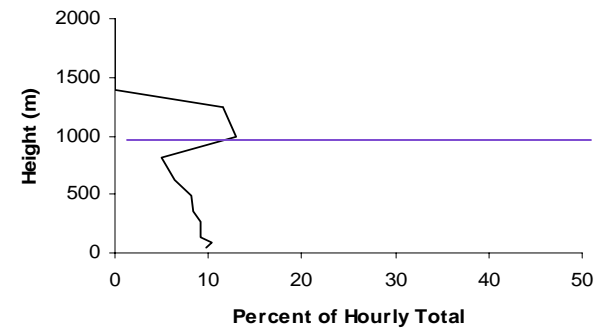
Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1300 LST = 10106



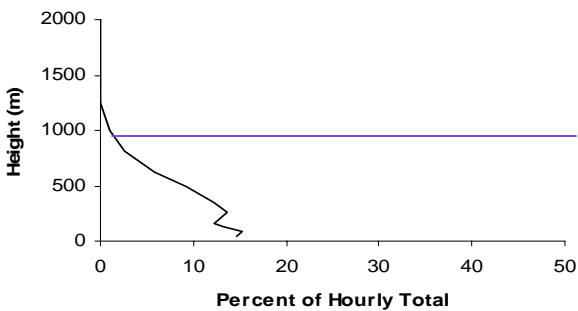
Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1400 LST = 10128



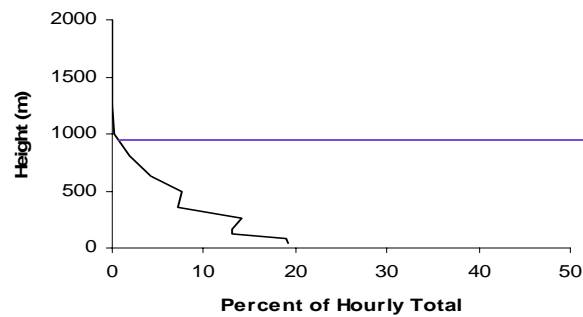
Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1500 LST = 5236



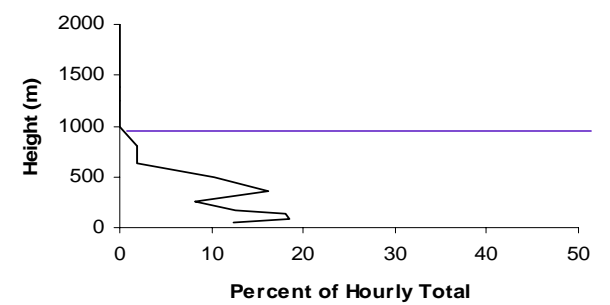
Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1600 LST = 1714



Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1700 LST = 491

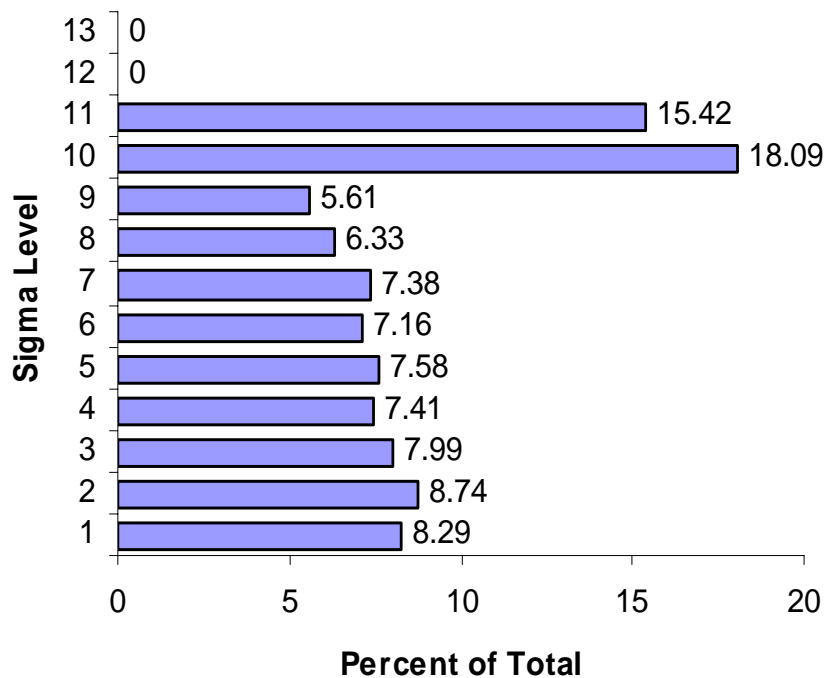


Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles at 1800 LST = 78

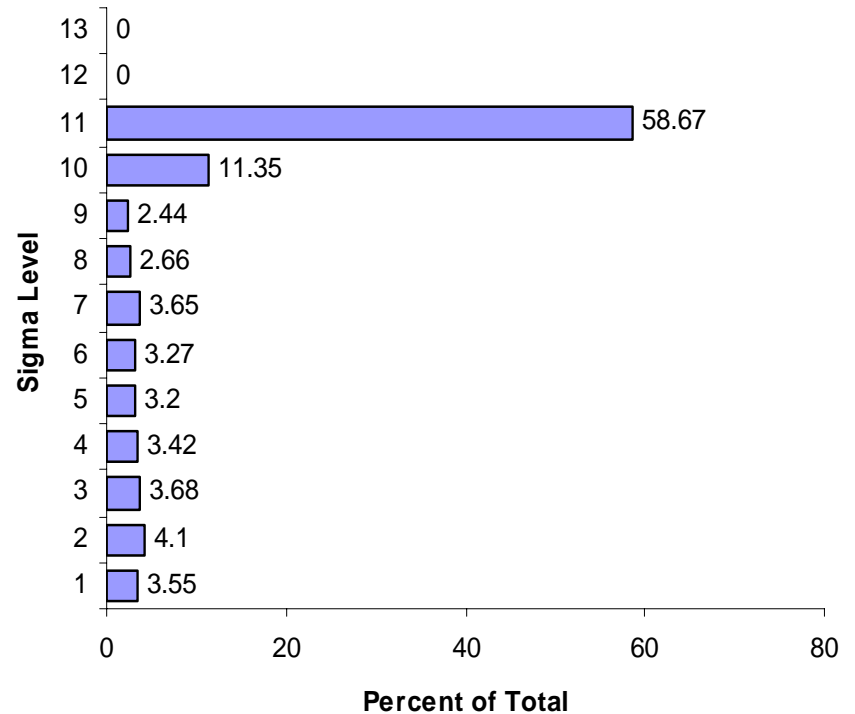


Vertical Smoke Distribution by Daysmoke – Whole Burn

Vertical Profile of Particles for Burn (LAT39-3)
Normalized by CMAQ Layer Thickness.
Total Particles = 37070

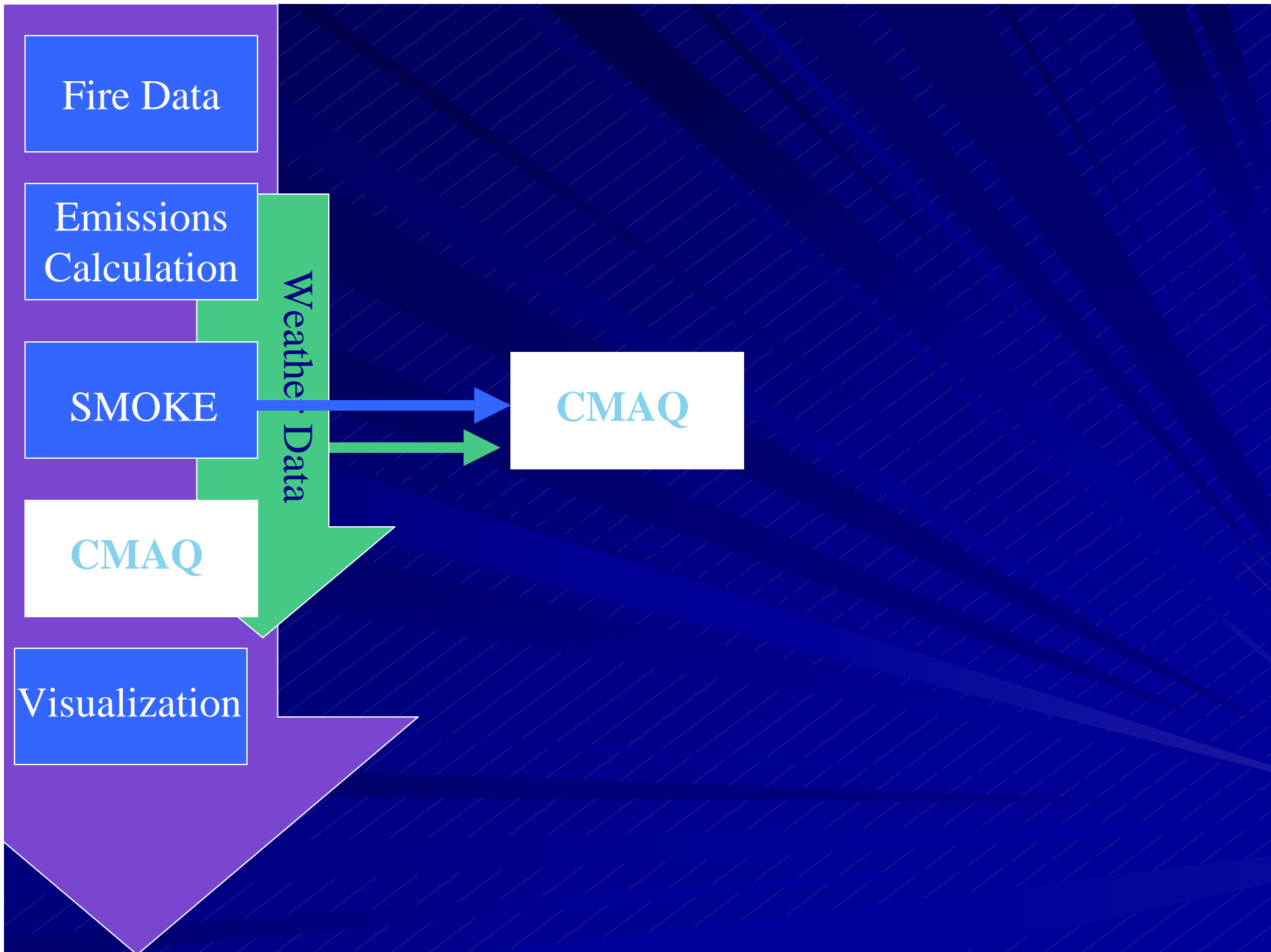


Vertical Profile of Particles for Model Burn
(LAT35-3) Normalized by CMAQ Layer
Thickness. Total Particles = 37074





An example of a plume-dominated fire. Note how smoke at the ground is drawn toward the main plume and thence upward. Above the mixing layer the wind shifts to blow from behind the viewer. You are looking downwind beneath the plume for at least 20 miles with unlimited visibility. No smoke is returning to the ground in this plume.



Fire Data

Emissions
Calculation

SMOKE

CMAQ

Visualization

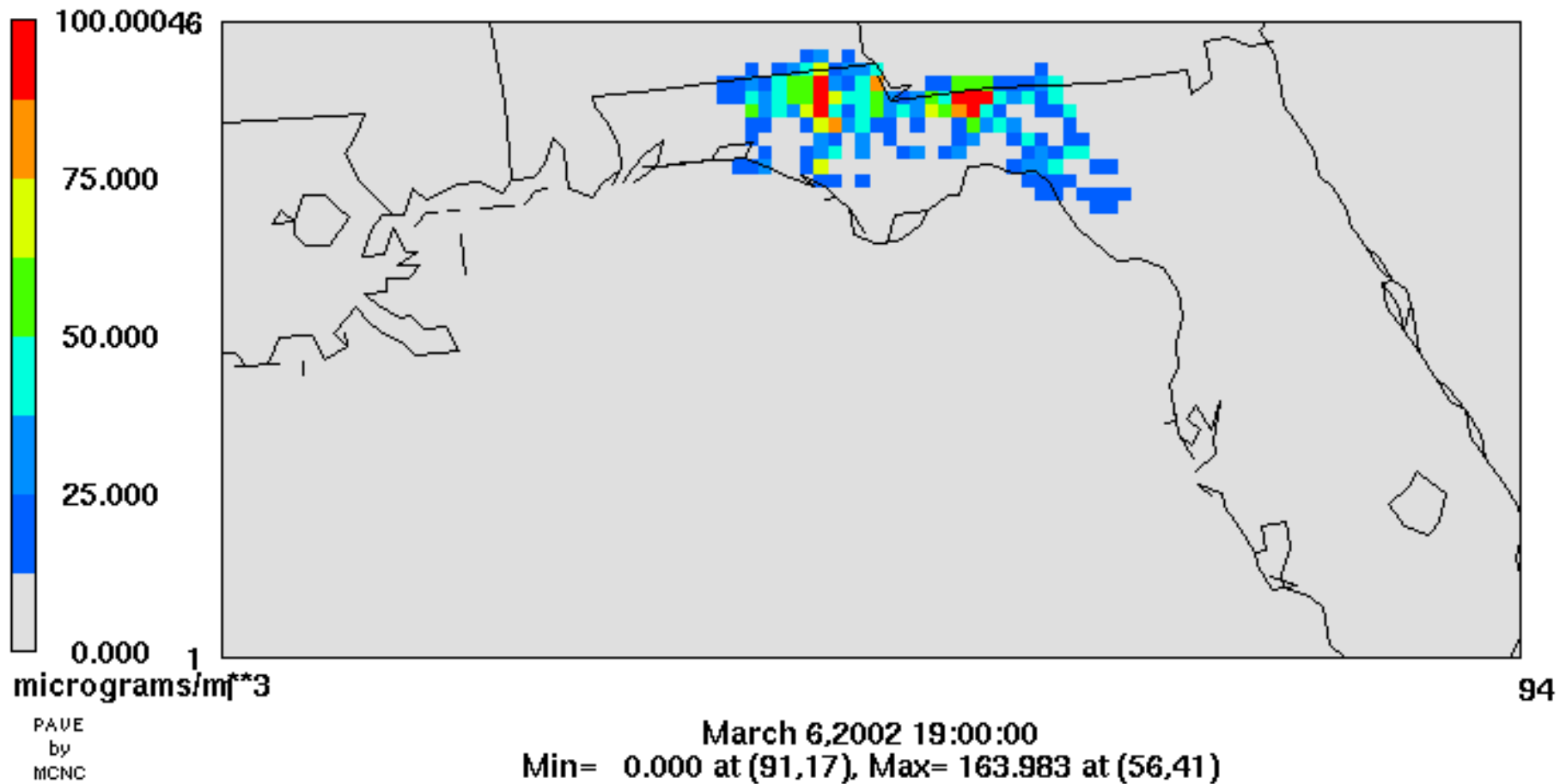
Weather
Data

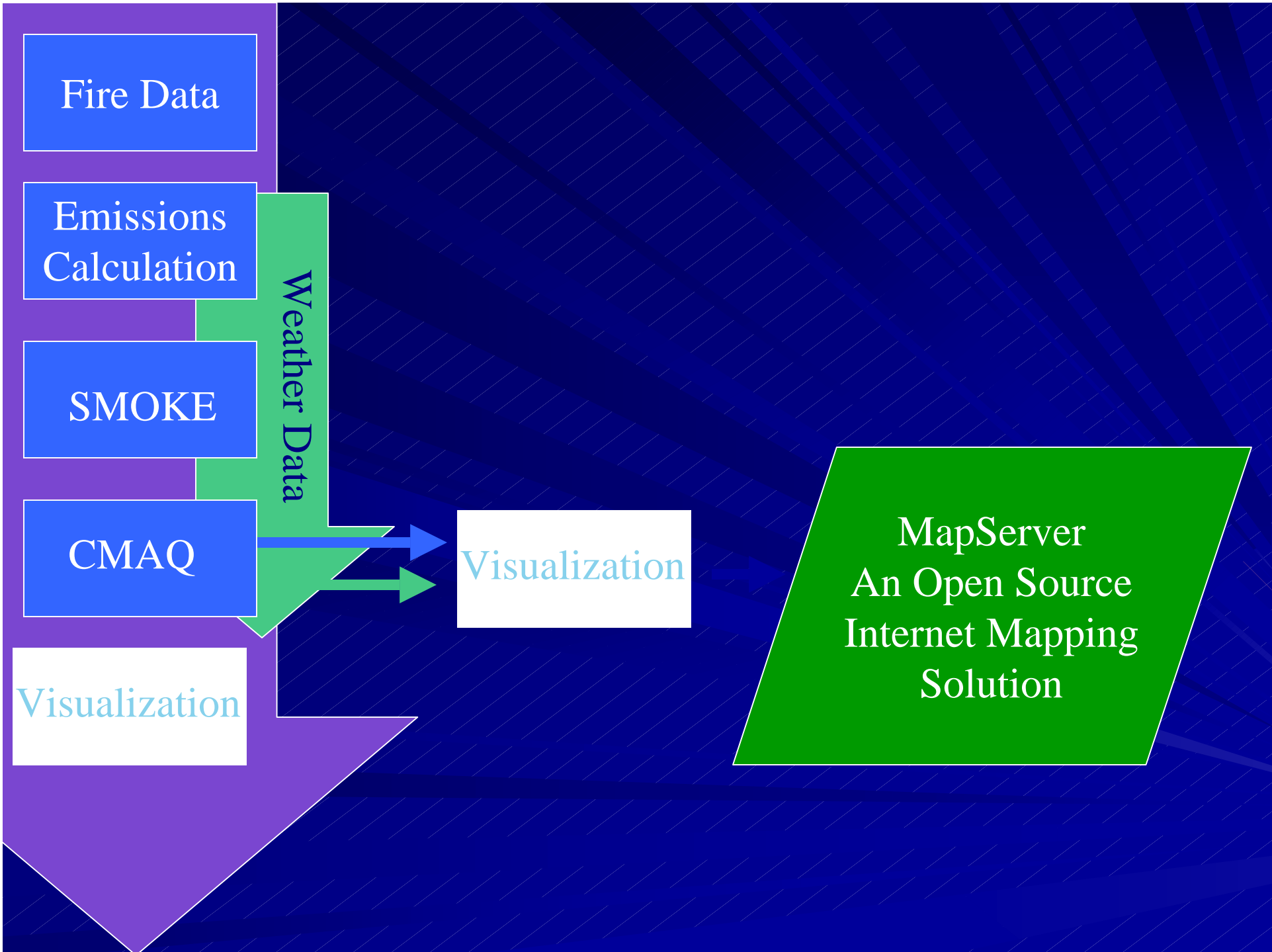
CMAQ

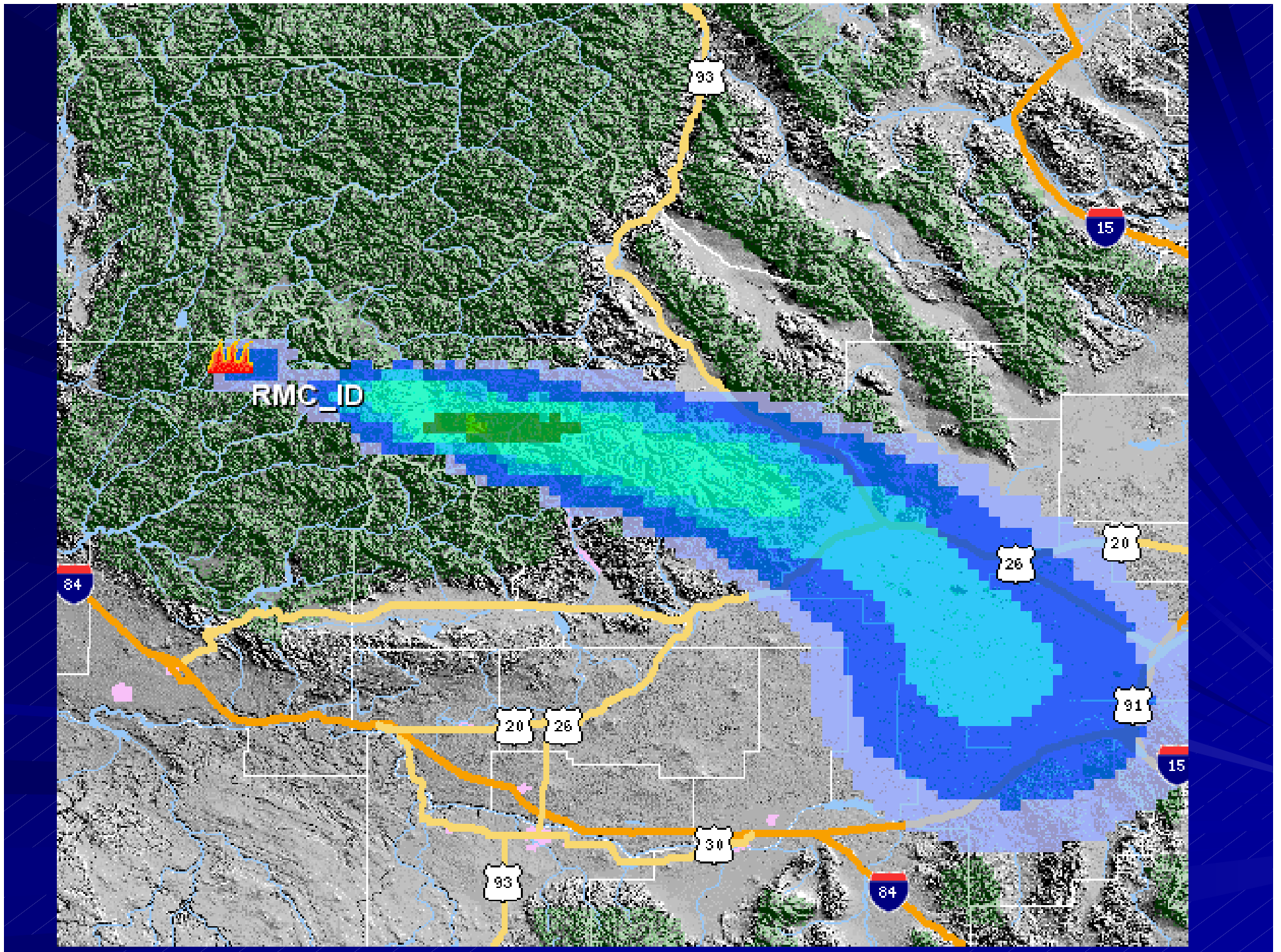
CMAQ

Layer 1 A25Jd

d=CCTM_e2aCONC.e2a_daysmoke







Summary

- To accurately simulate impacts from smoke from southern prescribed burns, AQ models must account for forestry practices including
 - Season -- What month of the year the burn is done
 - Weather -- What day of the month the burn is done
 - Dispersion -- What time of day the burn is done
 - Engineering – What firing technique is used – where smoke is placed in the atmosphere
- To run, these models must have as input basic fire activity data
 - PB-Piedmont – location, time, acres (individual burns)
 - Daysmoke – location, time, acres, fuels (all burns)
 - CMAQ – location, time acres, fuels (all burns)

Summary

- Timing of fire activity data determines what the models can be used for.
 - Historical – basic research, knowledge generation, regulatory baselines, case studies
 - Near real-time – monitor airshed, cease issuing permits, shut down existing burns
 - Pre-burn – game playing, airshed capacity calculations.