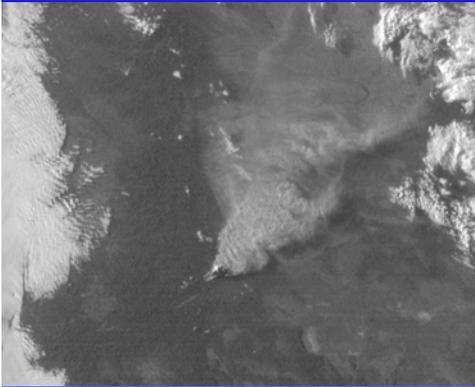


Use of Environmental Satellite Imagery for Smoke Depiction and Transport Model Initialization

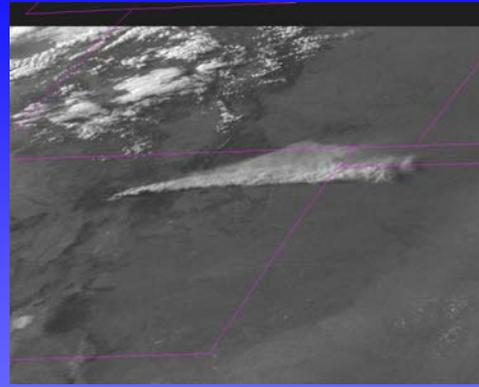


Mark Ruminski
Glenn Rolph
Roland Draxler
Shobha Kondragunta

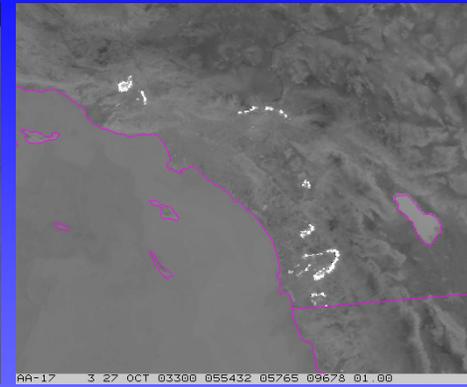
- HAZARD MAPPING SYSTEM OVERVIEW**
- SMOKE DETECTION**
- SMOKE CONCENTRATION**
- INPUT TO HYSPLIT FOR SMOKE TRANSPORT AND DISPERSION**
- HYSPLIT VALIDATION**



GOES-WEST



GOES-EAST



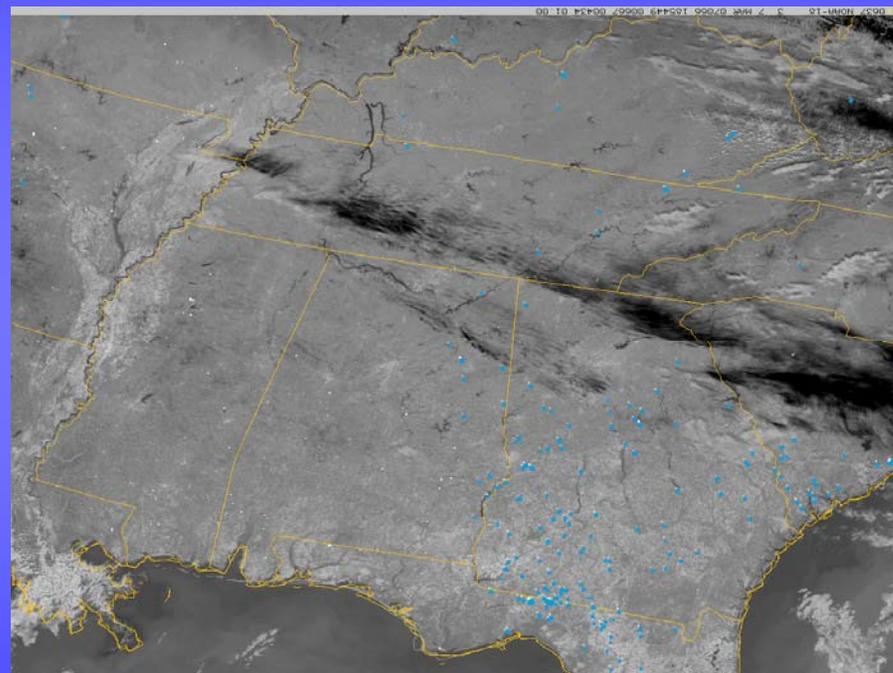
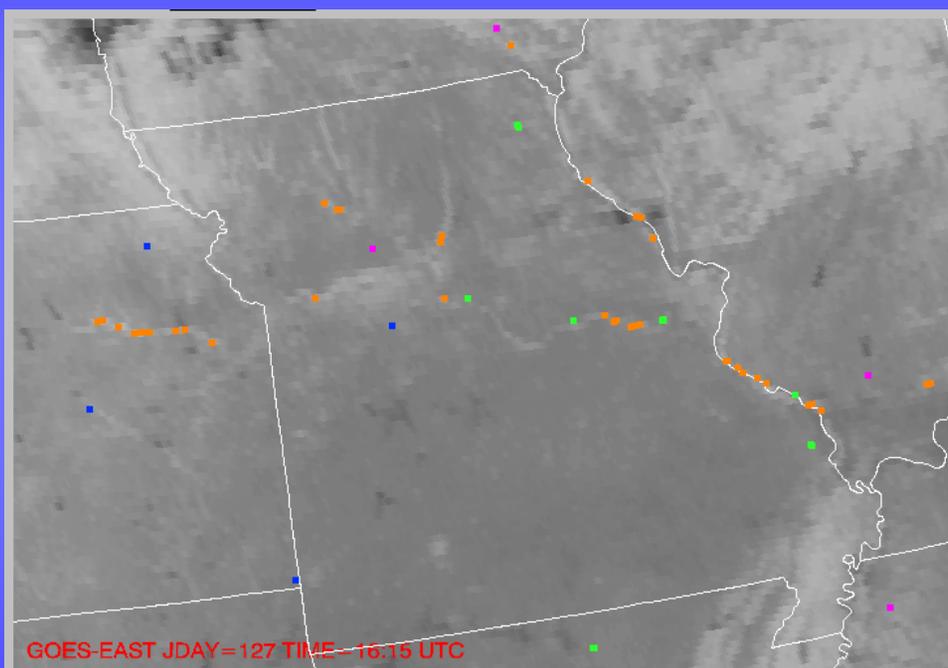
NOAA-AVHRR



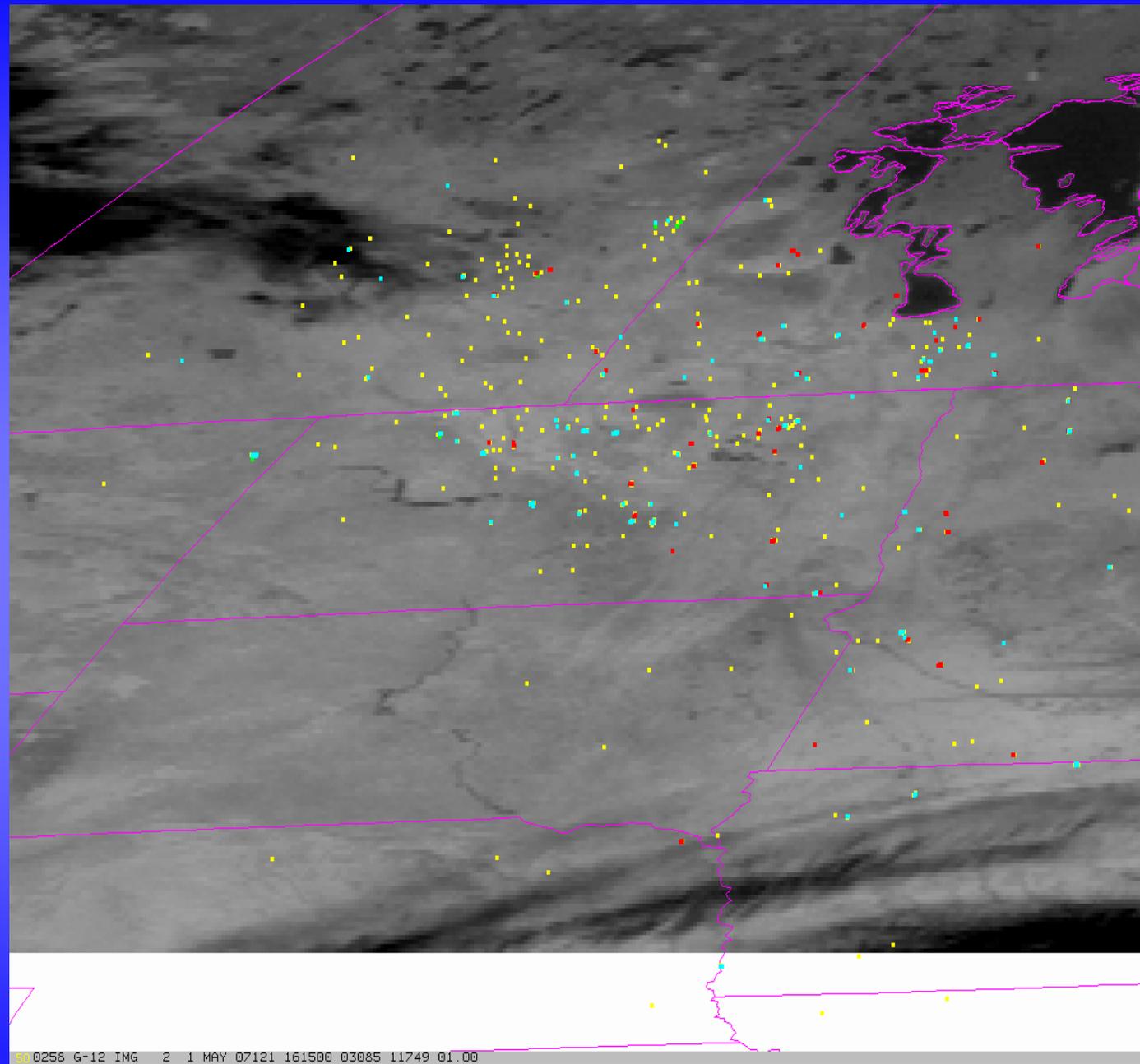
MODIS

- HMS Incorporates 7 satellites – 2 geostationary and 5 polar orbiting
- Over 100 looks per day in areas of overlap
- POES spacecraft provide 2 orbits/day in mid latitudes, more frequent over Alaska/Canada
- Analysis performed year-round for contiguous US and Hawaii, seasonally for Central America, Alaska and Canada

Satellite analysts perform quality control procedures on the automated detections – deleting fires that are believed to be false alarms and adding fires that the algorithms have not detected



Need to get a good handle on the fires to produce a good analysis of smoke emissions (where there's smoke there's fire!)



HMS

MODIS

FIMMA

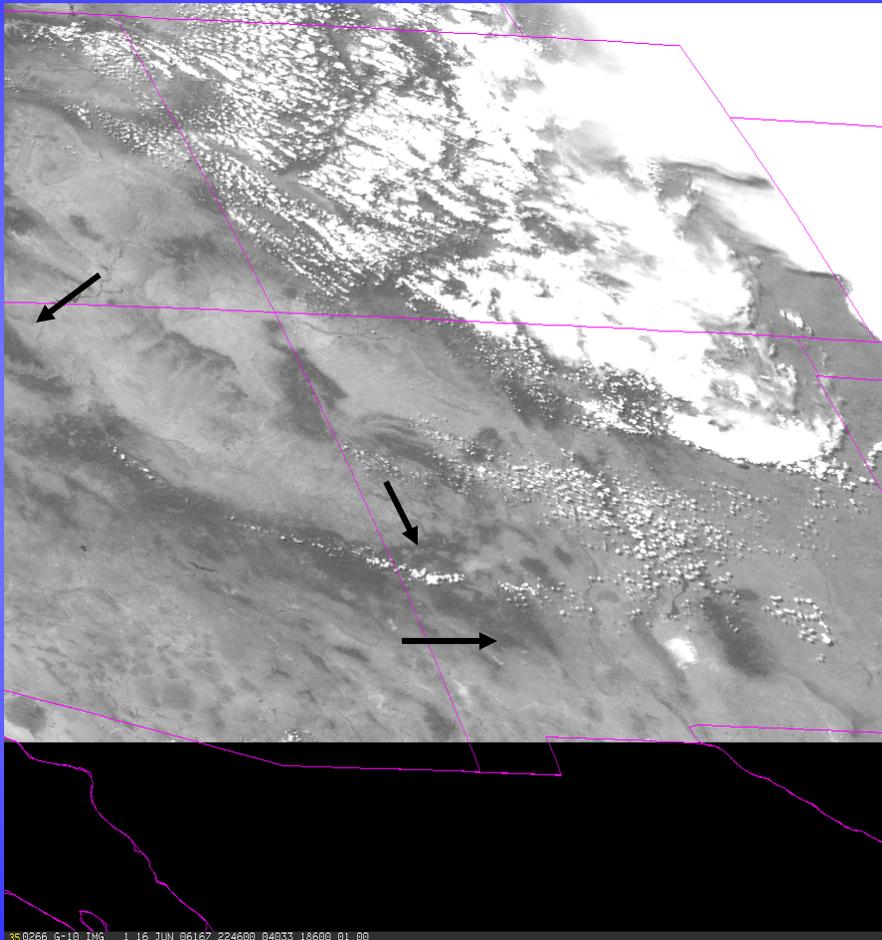
WF-ABBA

0258 G-12 IMG 2 1 MAY 07121 161500 03085 11749 01.00

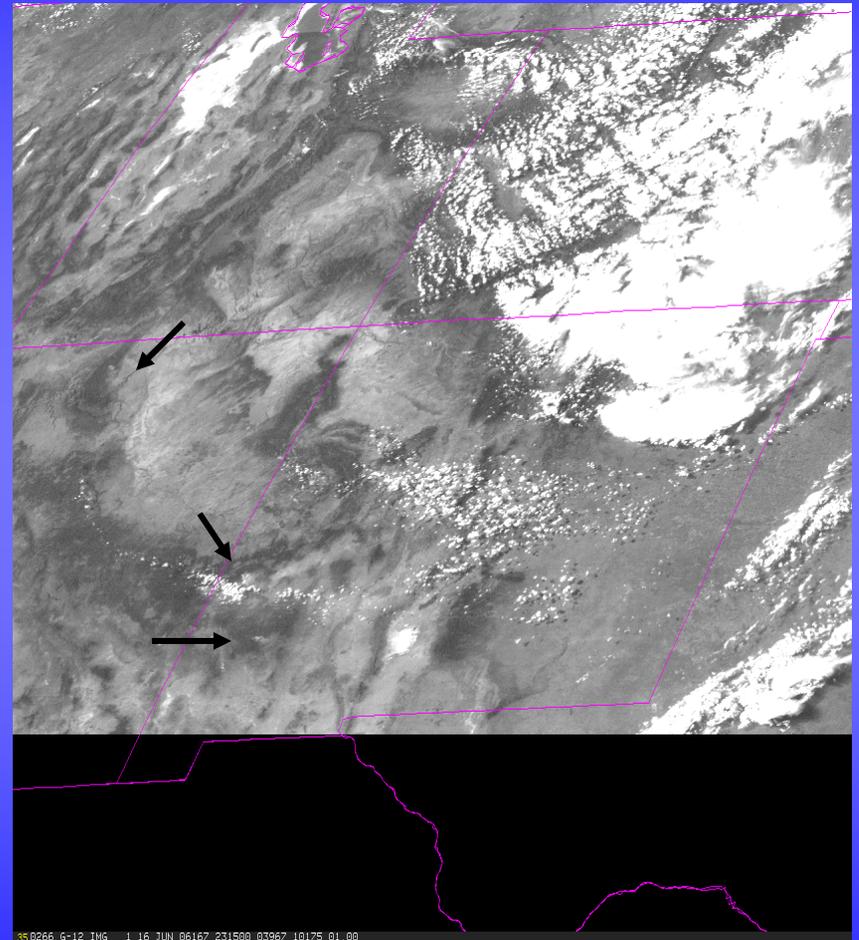
Smoke Analysis consists of:

- ☀ **Graphic of smoke extent and density**
- ☀ **Input to HYSPLIT dispersion and transport model which is used in NWS AQ forecast. Smoke emissions generated by BlueSky**
- ☀ **Text product describing smoke and blowing dust**

SMOKE DETECTION USING VISIBLE BAND IMAGERY: Sun/Satellite Viewing Geometry Makes the Difference

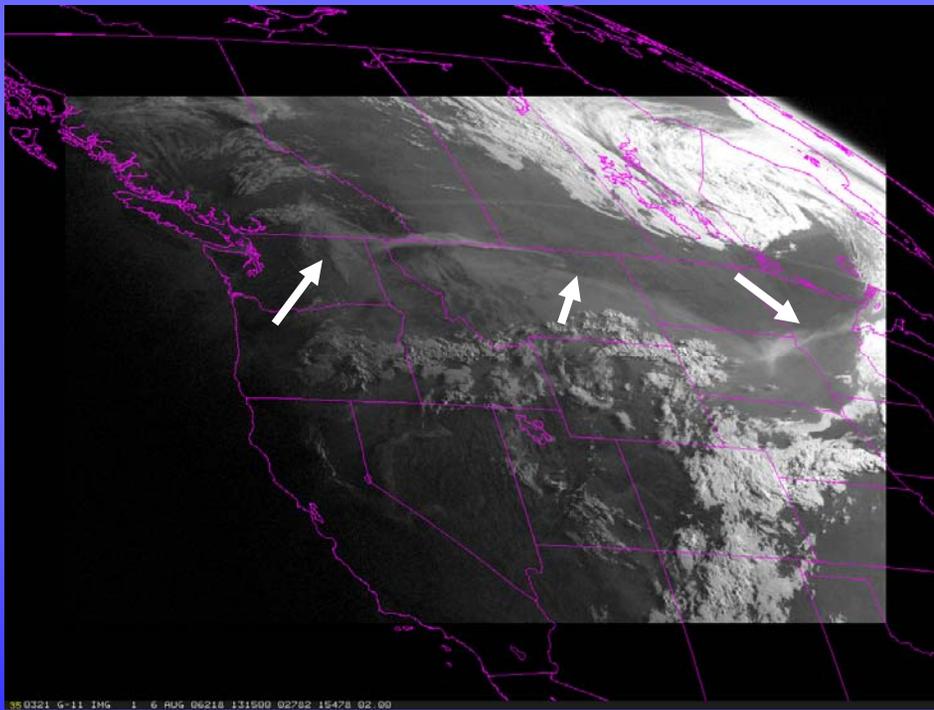


**EVENING VIEW FROM GOES-WEST
16 JUNE 2006**

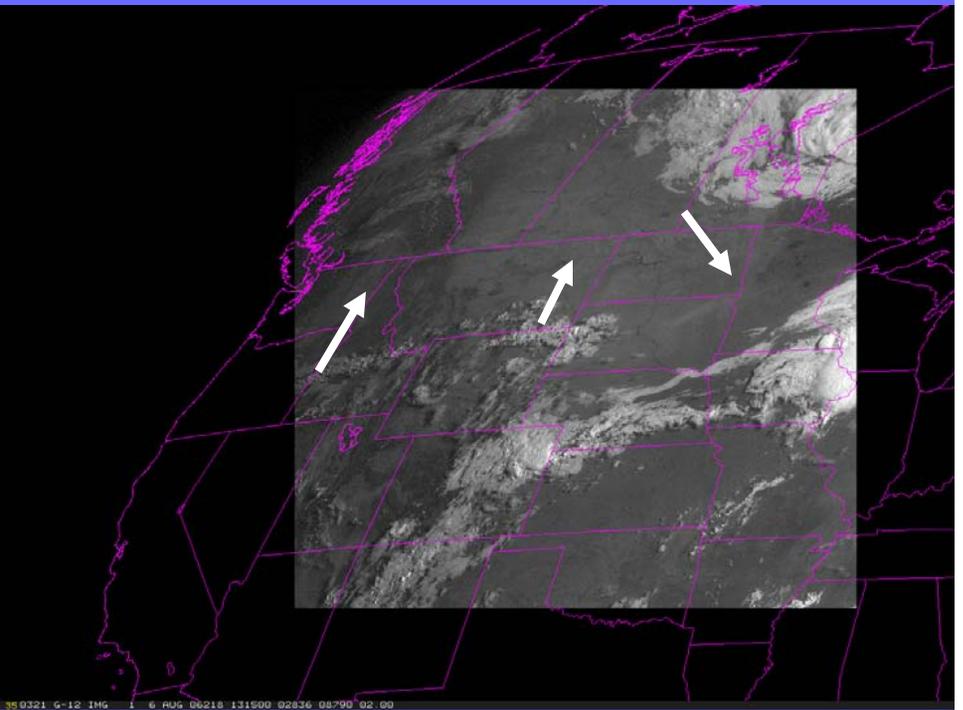


**EVENING VIEW FROM GOES-EAST
16 JUNE 2006**

GOES-WEST: BEST FOR VIEWING SMOKE IN MORNING
GOES-EAST: BEST FOR VIEWING SMOKE IN EVENING



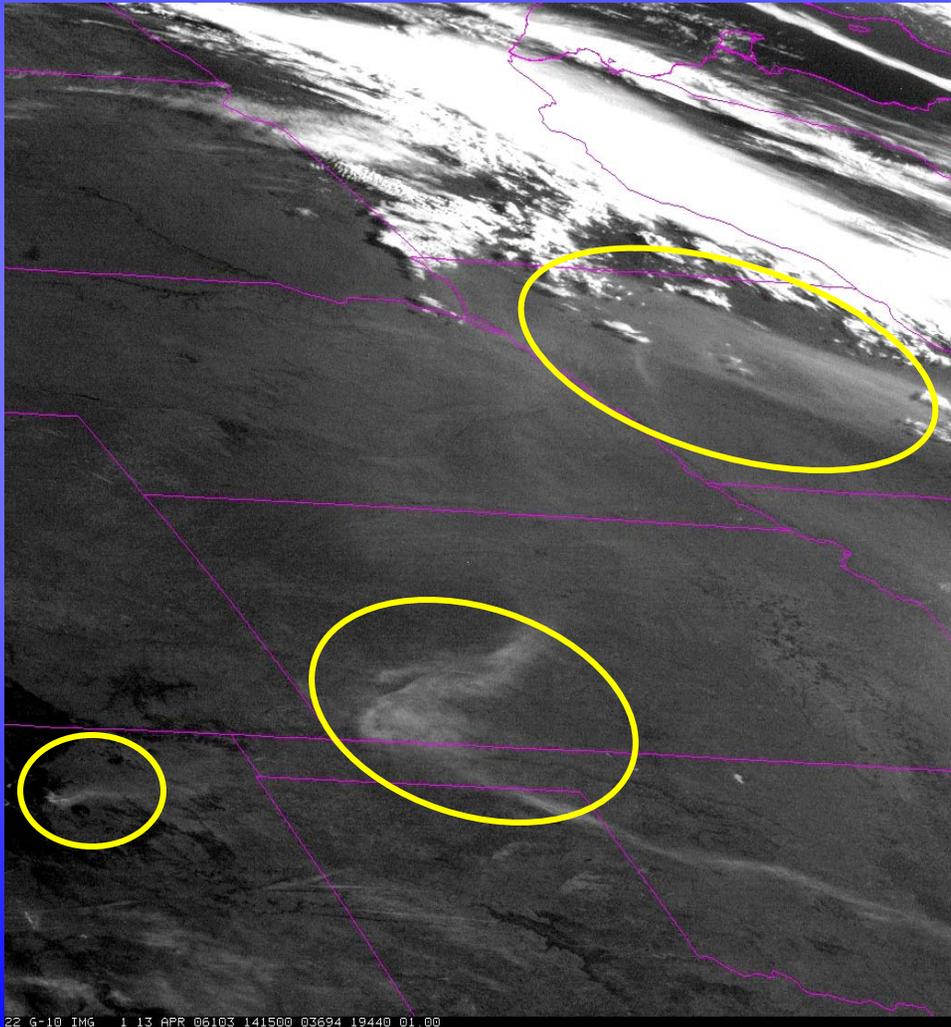
MORNING VIEW FROM GOES-WEST
06 AUGUST 2006



MORNING VIEW FROM GOES-EAST
06 AUGUST 2006

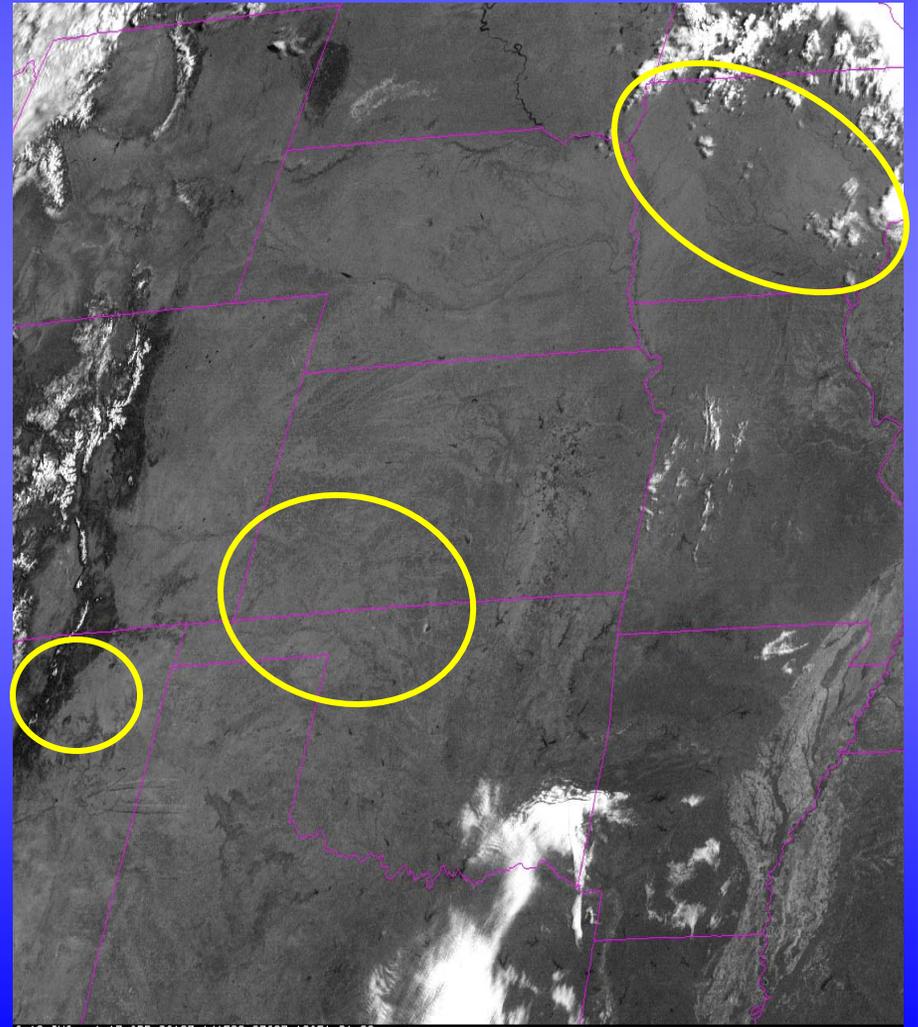
13 APRIL 2006 1415Z

GOES-WEST



22 G-10 IMG 1 13 APR 06103 141500 03694 19440 01.00

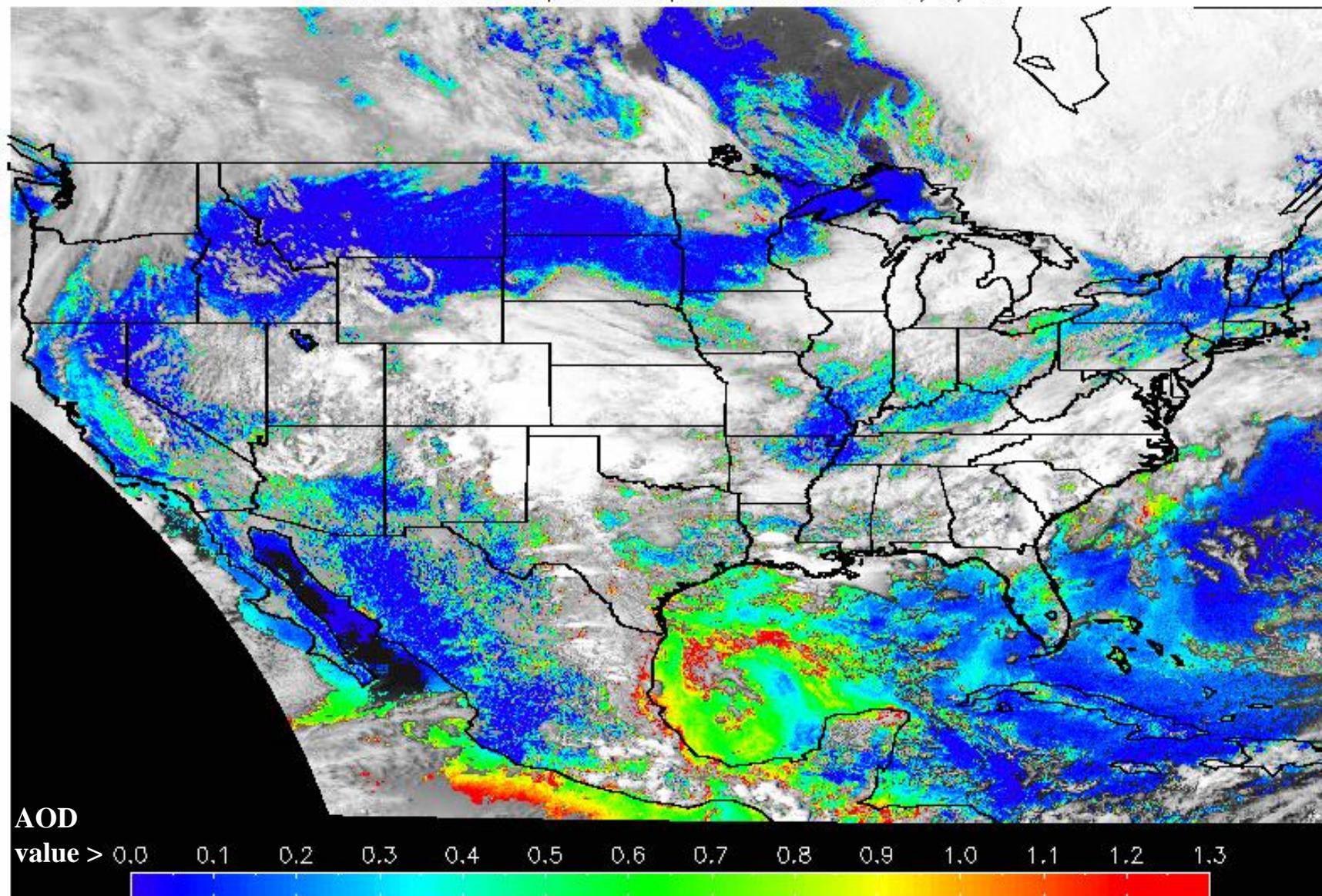
GOES-EAST



6-12 IMG 1 13 APR 06103 141500 03697 10851 01.00

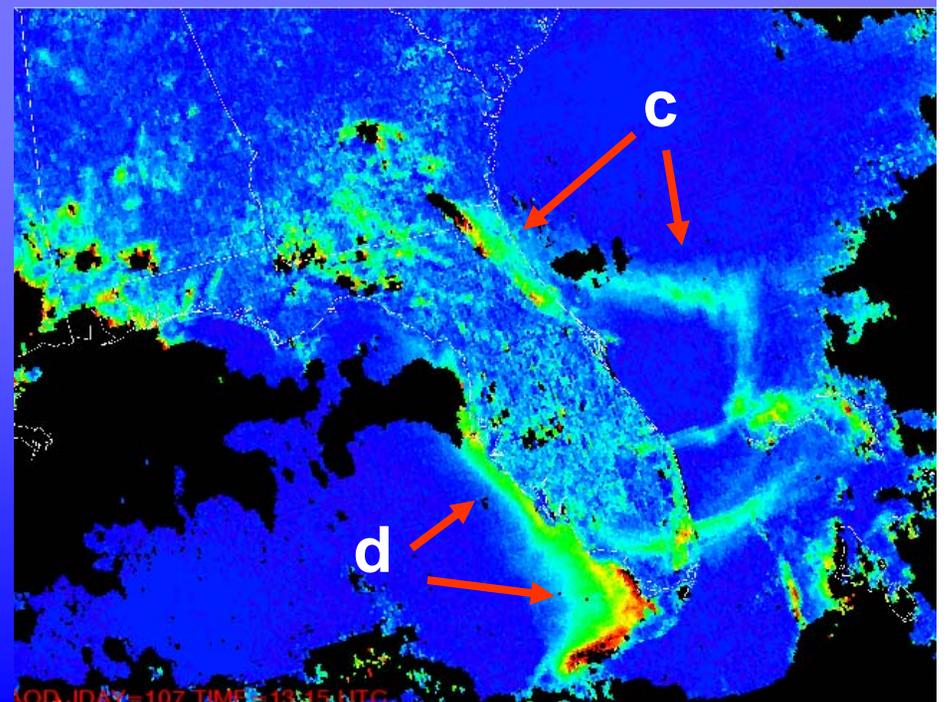
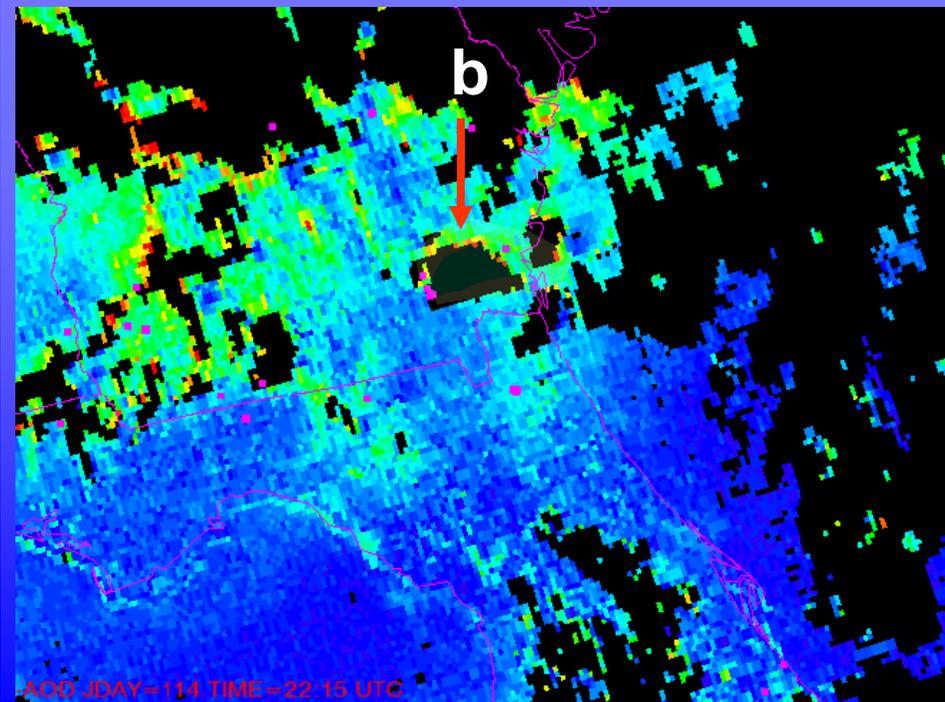
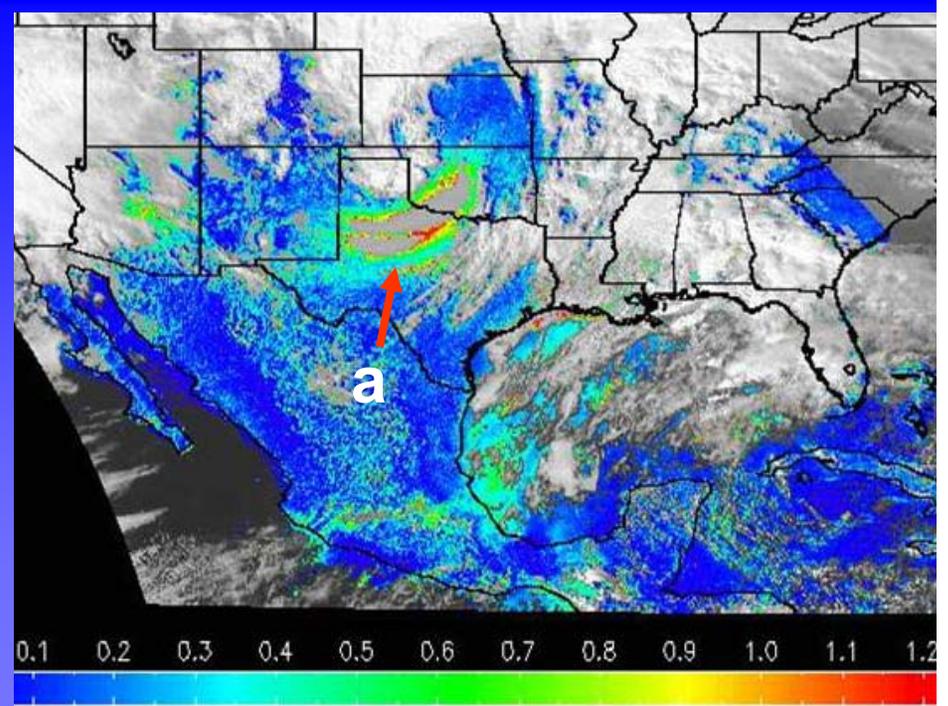
- ☀ **Specification of smoke concentration began November 2006**
- ☀ **Determination of smoke concentration values are aided by the GOES Aerosol and Smoke Product (GASP)**
- ☀ **Values assigned are 5, 16 or 27 $\mu\text{g}/\text{m}^3$ for light, medium and thick smoke**
- ☀ **The value represents the mid-point in a range of values**

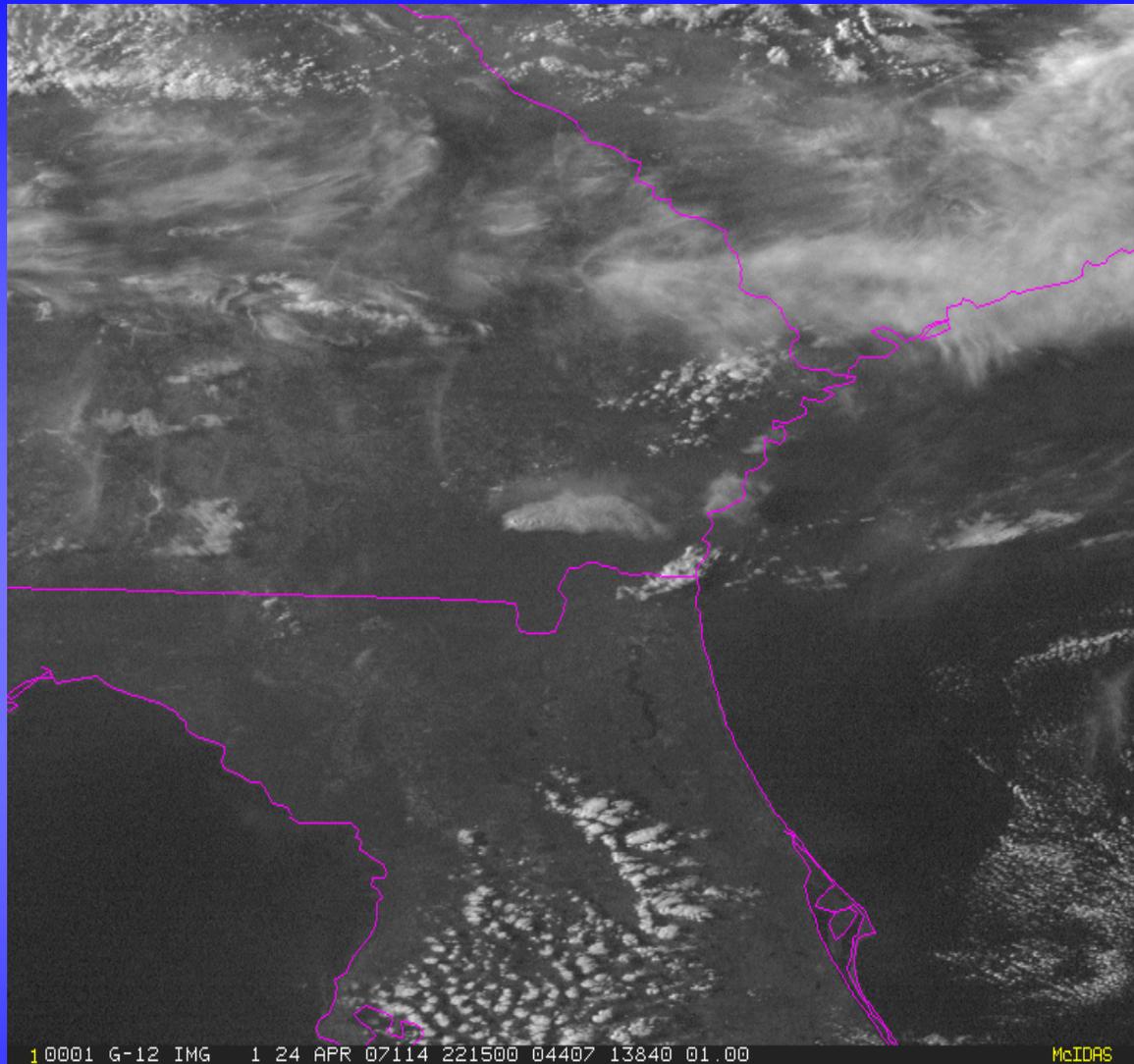
GASP Aerosol Optical Depth 21:45UTC 5/5/06



5 16 27
Smoke concentration value ($\mu\text{g}/\text{m}^3$)

- (a) dust storm
- (b) dense smoke
- (c) moderate smoke
- (d) sea surface feature



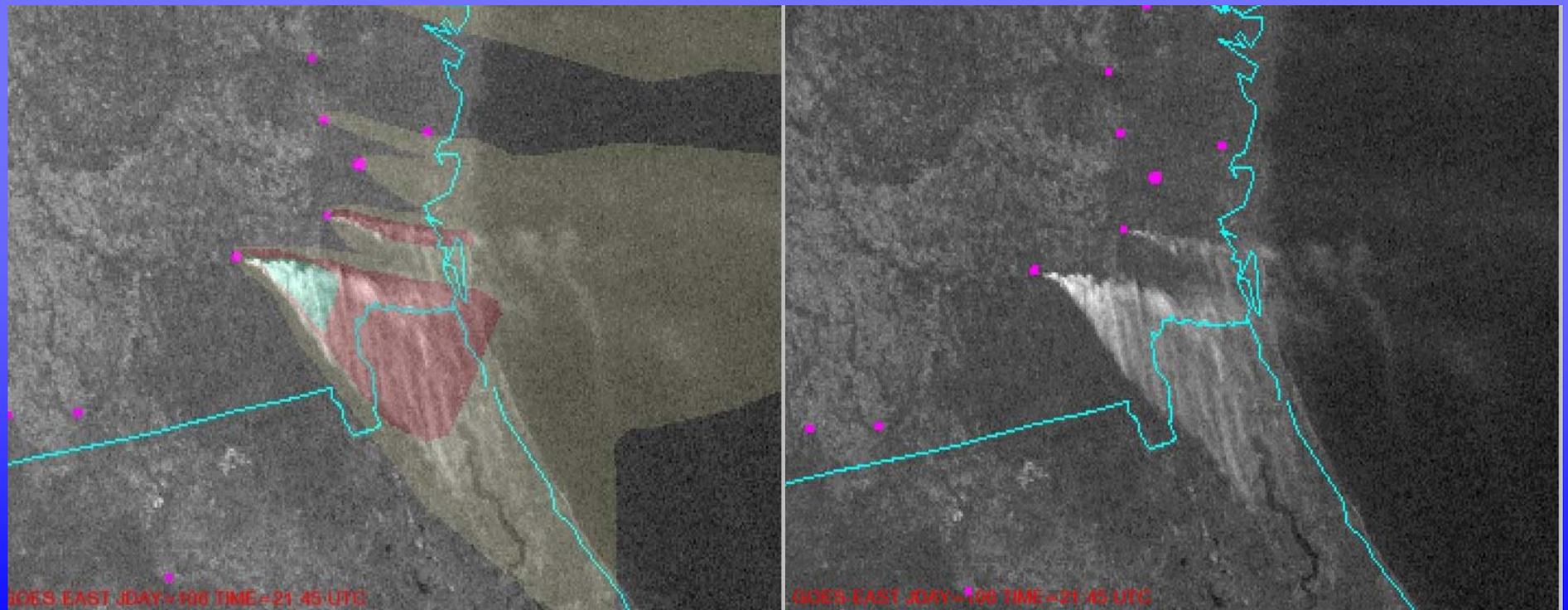


**GOES-12 IMAGE AT
SAME TIME AS
GASP IMAGE IN (b)
IN PREVIOUS SLIDE**

GOES-12 VISIBLE IMAGE

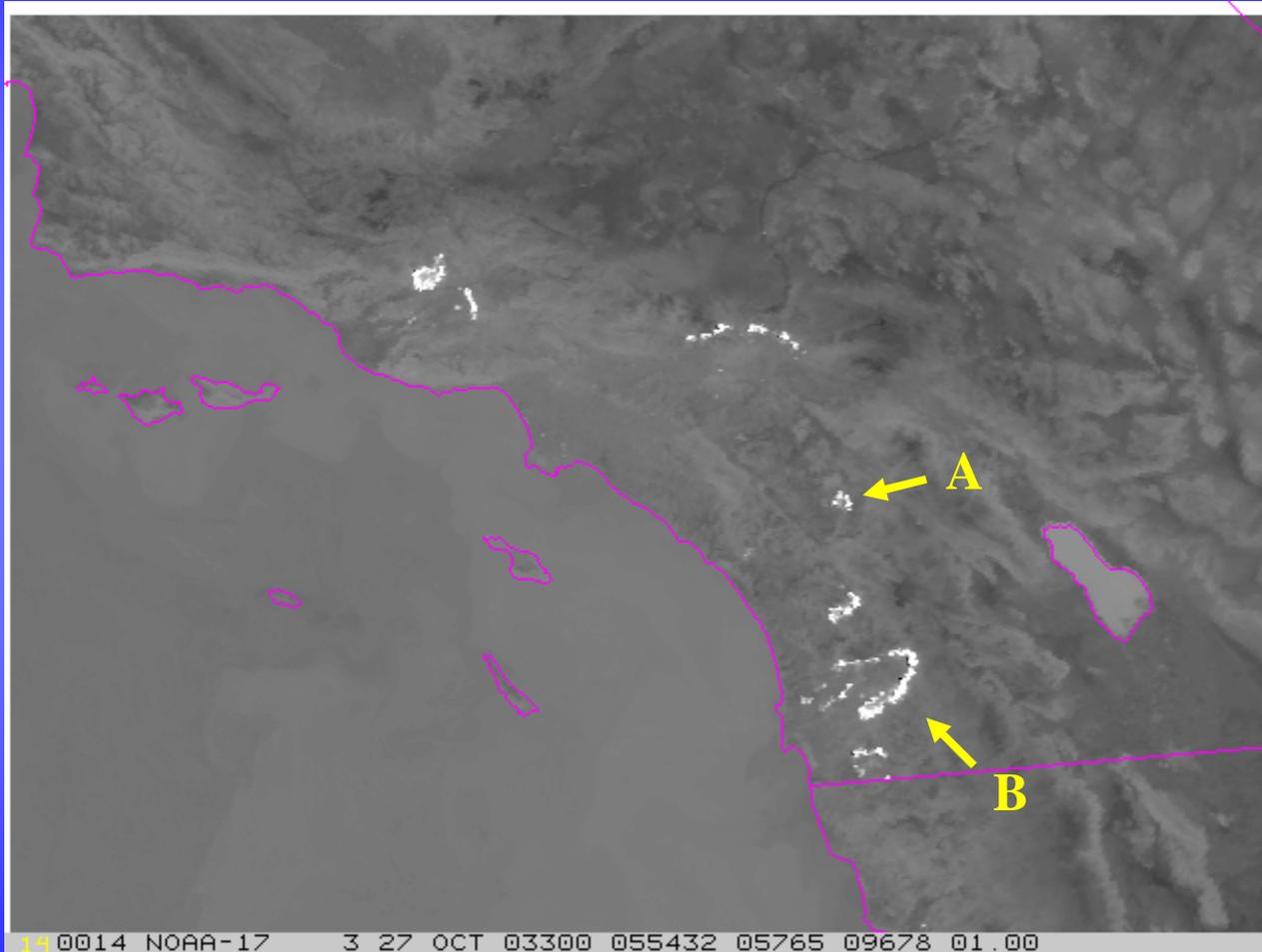
16 April 2007 2145Z

- represents analyzed fire location



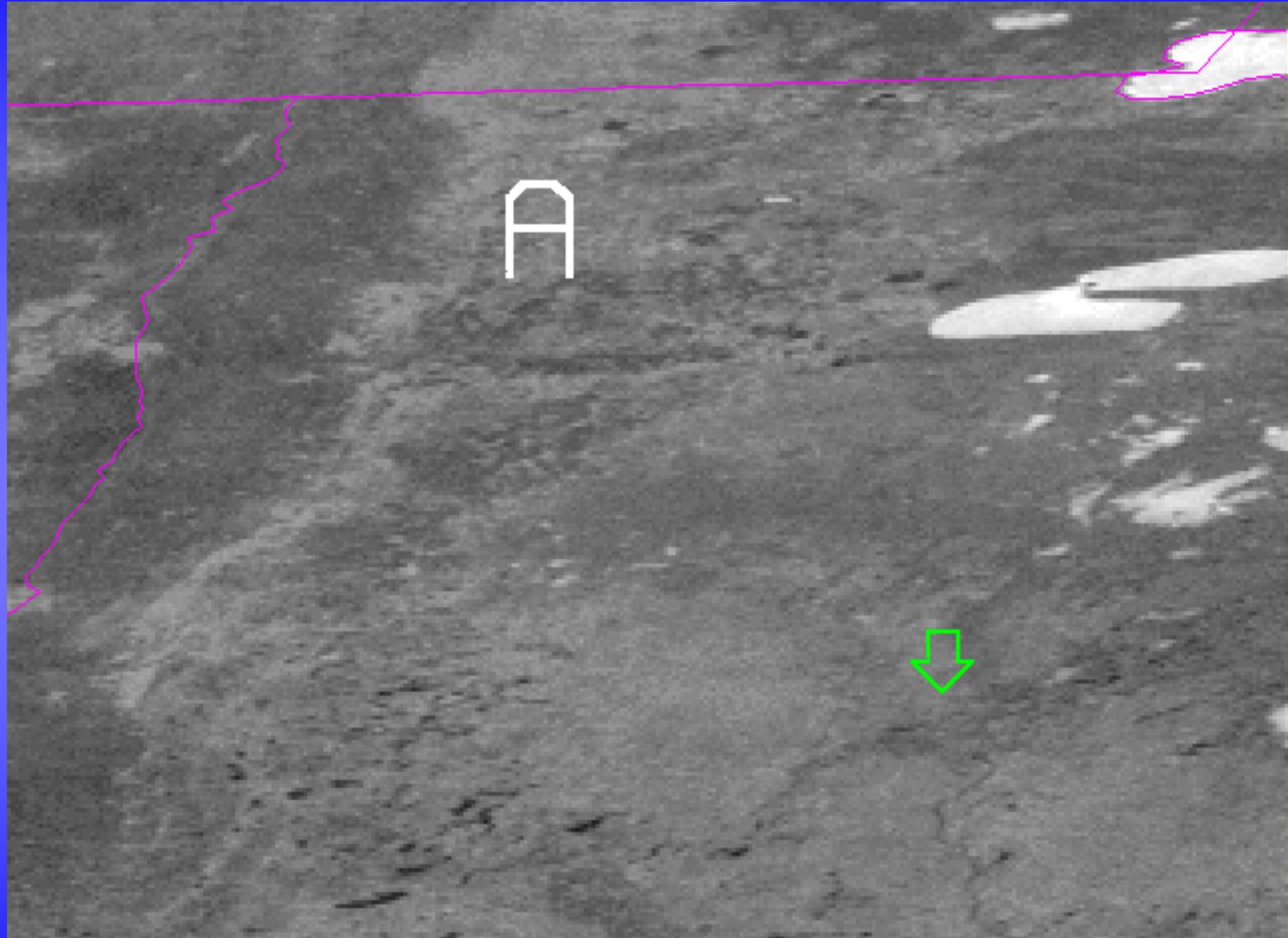
Analyst input to the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) Model which is used in the National Weather Service (NWS) Air Quality Forecast:

- ☀ **Locations of smoke emitting fires**
- ☀ **Each point represents 1 square km**
- ☀ **Start time and duration of smoke emissions**

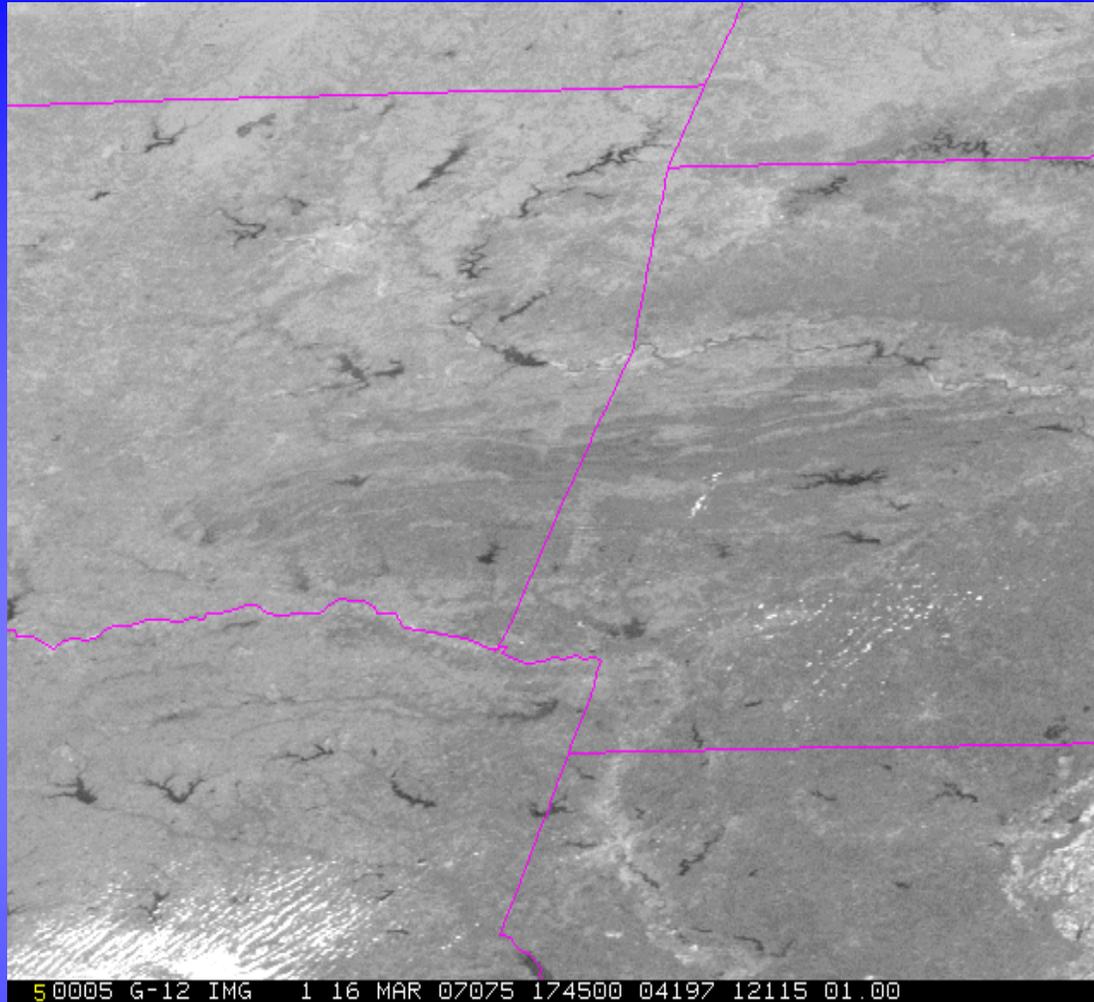


The fire at “A” has less areal coverage and therefore fewer points added to HYSPLIT for emissions than the fire at “B”

- ☀ **Emissions are obtained from BlueSky framework**
- ☀ **Majority of analyzed fires have no detectable smoke plume**
- ☀ **The majority of fires that do have a smoke plume have a limited duration of much less than 24 hours (mainly agricultural and prescribe burns)**



3 0003 G-12 IMG 1 18 APR 07108 174500 03404 12728 00.50



**Note the differences
in the smoke plumes:**

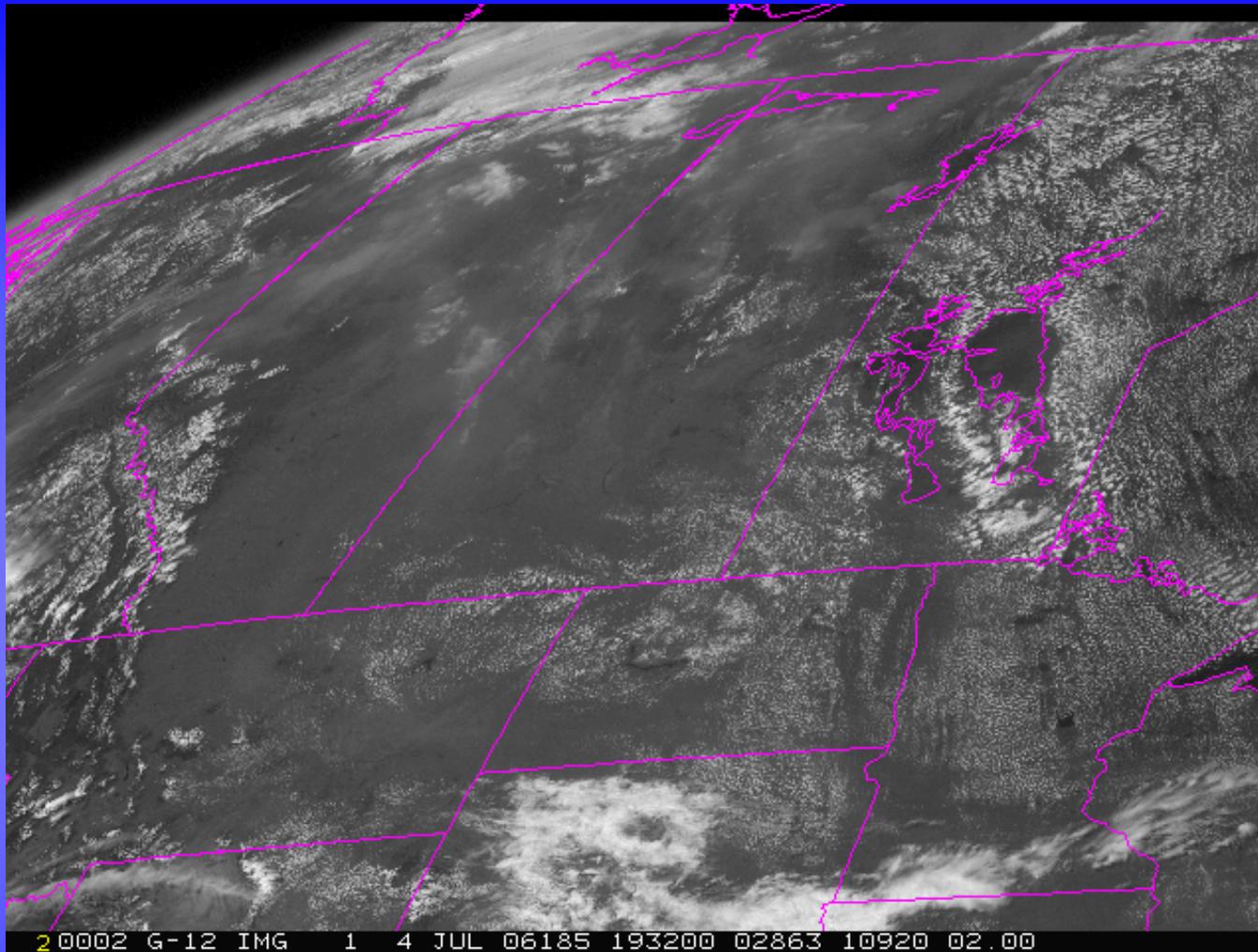
Start times

Smoke density

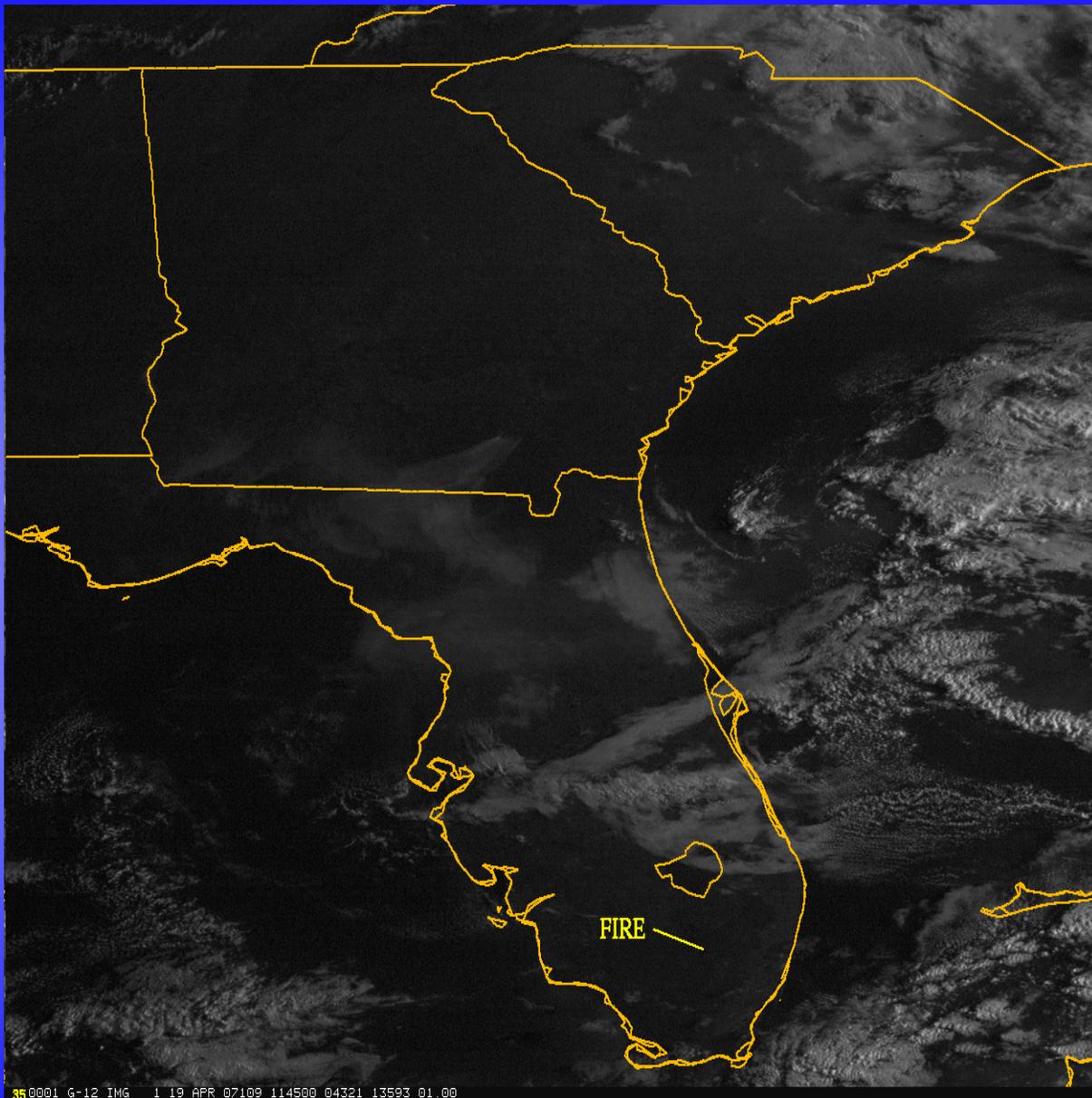
Amount of smoke

**Dynamics within
plume**

Are these wildfires or prescribe burns?



Treated as wildfires burning continuously



These are easily identified as wildfires. However, seabreezes and shifting winds present challenges for transport models

Air Quality Forecast Guidance - CONUS Area

Print Key Help

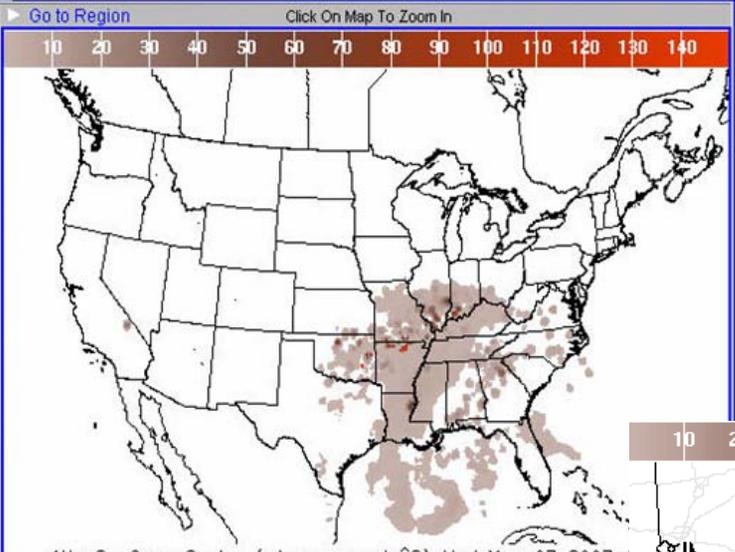
Daily View Loops Point Data

Page Help Go to Region Click On Map To Zoom In

Mouse over or click on the table below to change the guidance image.

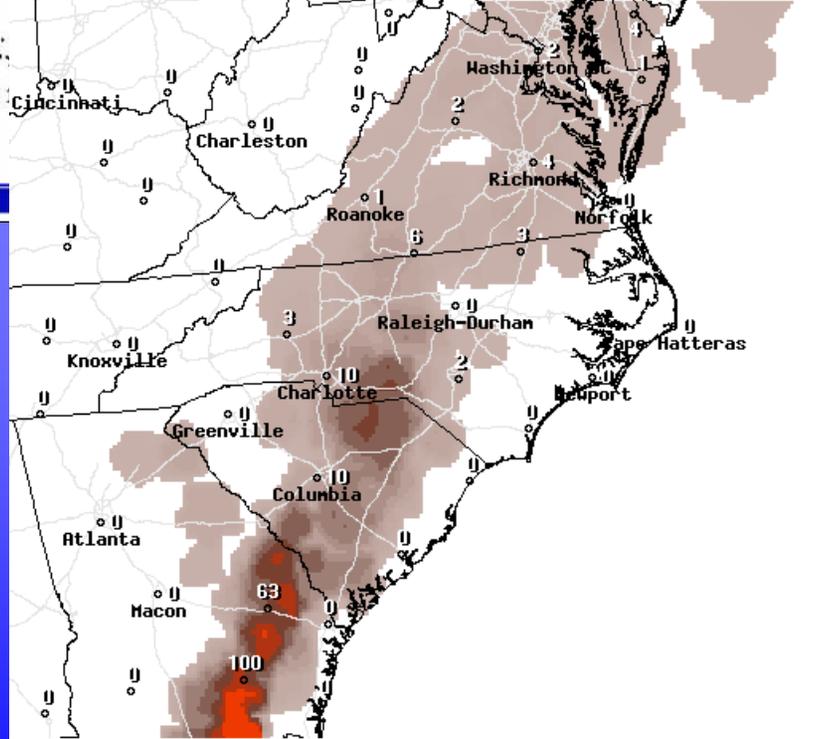
Today	+12Hrs >											
Valid Hour (EST):	-- AM --						-- PM --					
	7	8	9	10	11	12	1	2	3	4	5	6
1Hr Average Ozone Concentration	-	-	-	-	-	-	-	-	-	-	-	-
8Hr Average Ozone Concentration	-	-	-	-	-	-	-	-	-	-	-	-
1Hr Average Surface Smoke	-	-	-	-	-	-	-	-	-	-	-	-
1Hr Average Vertical Smoke Integration	-	-	-	-	-	-	-	-	-	-	-	-

Table MouseOver Effect On



1Hr Surface Smoke (micrograms/m³) Wed Mar 07 2007 (Wed Mar 07 2007 15Z)
 National Digital Guidance Database
 6z model run Graphic created-Mar 07 7:22AM EST

10 20 30 40 50 60 70 80 90 100 110 120 130 140



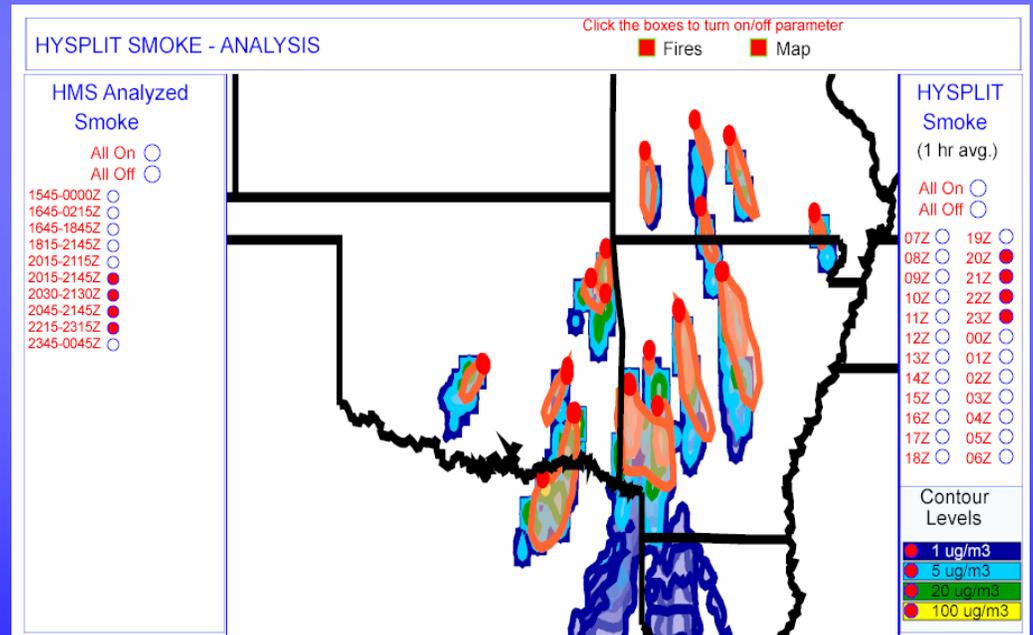
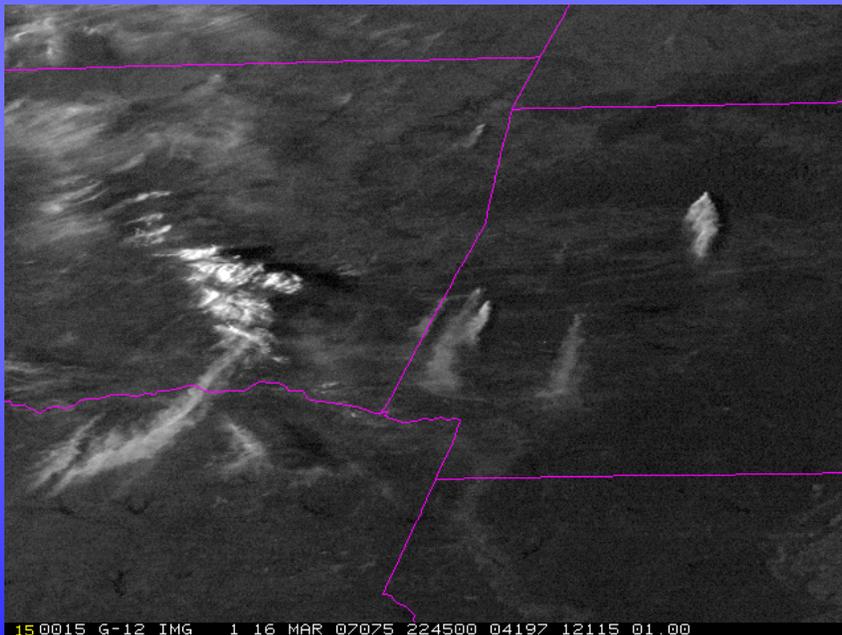
1Hr Surface Smoke (micrograms/m³) Wed May 16 2007 3PM EDT (Wed May 16 2007 19Z)
 National Digital Guidance Database
 6z model run Graphic created-May 16 8:19AM EDT

HYSPLIT is run by NWS at 10Z on the following day using the 06Z NAM run for meteorology.

www.weather.gov/aaq/

VERIFICATION PROCESS

Match analyst drawn plumes with HYSPLIT forecast smoke for same time



HYSPLIT Smoke Analysis Verification for 06/25/2006

< PREVIOUS DAY'S ANALYSIS RETURN NEXT DAY'S ANALYSIS >
TODAY'S STATISTICAL RESULTS

HYSPLIT Smoke Analysis using Scalable Vector Graphic



Click the boxes to turn on/off parameter

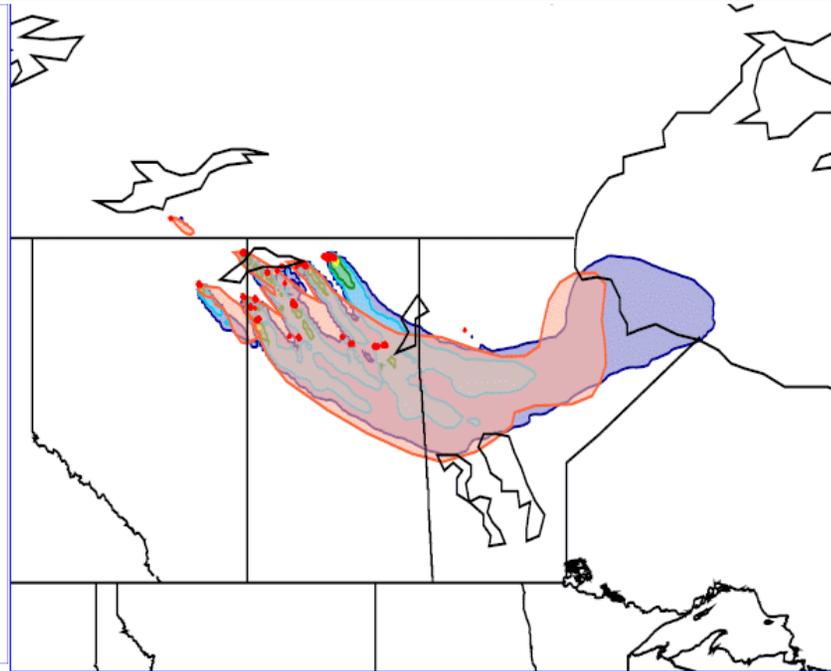
Fires Map

HYSPLIT SMOKE - ANALYSIS

HMS Analyzed Smoke

All On
All Off

- 0015-0115Z
- 0045-0115Z
- 0145-0345Z
- 0230-0330Z
- 1130-2200Z
- 1200-1500Z
- 1230-1330Z
- 1230-1430Z
- 1245-1745Z
- 1400-1500Z
- 1415-0115Z
- 1445-1545Z
- 1700-1800Z
- 1845-1945Z
- 1858-1800Z
- 1858-1858Z
- 1915-0045Z
- 2041-2041Z
- 2041-2222Z
- 2200-2300Z
- 2245-2345Z
- 2300-2330Z
- 2315-0015Z



HYSPLIT Smoke (1 hr avg.)

All On
All Off

- 07Z
- 08Z
- 09Z
- 10Z
- 11Z
- 12Z
- 13Z
- 14Z
- 15Z
- 16Z
- 17Z
- 18Z
- 19Z
- 20Z
- 21Z
- 22Z
- 23Z
- 00Z
- 01Z
- 02Z
- 03Z
- 04Z
- 05Z
- 06Z

Contour Levels

- 1 ug/m3
- 5 ug/m3
- 20 ug/m3
- 100 ug/m3

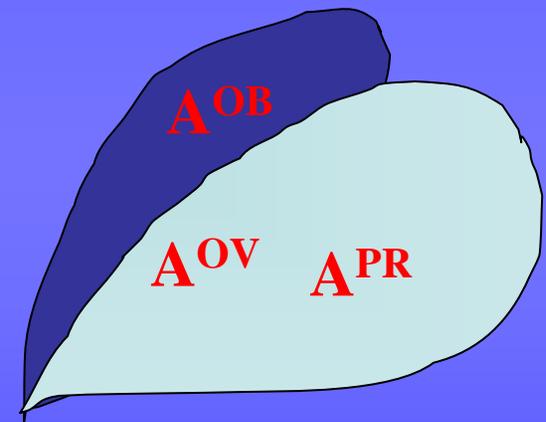
Statistics calculated include:

Figure of Merit in Space (FMS):

$$FMS = (A^{OV}) / (A^{PR} \cup A^{OB})$$

Measure of Effectiveness (MOE):

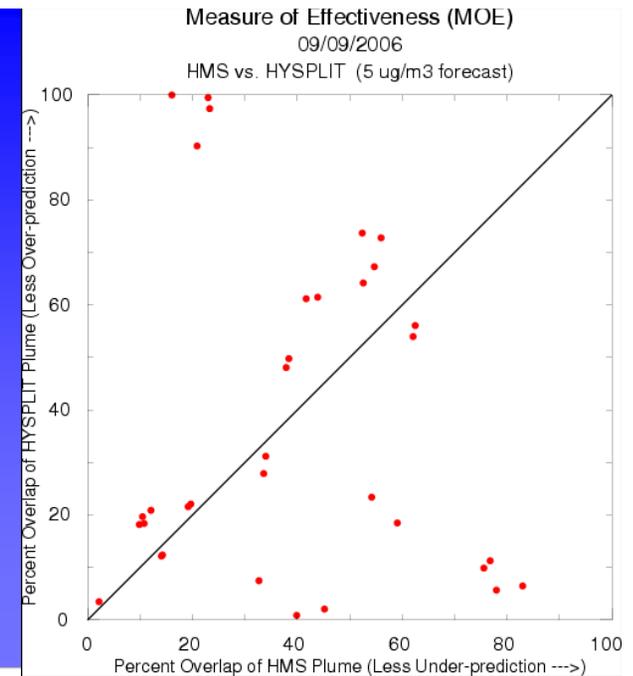
$$MOE = (A^{OV} / A^{OB}, A^{OV} / A^{PR})$$



Results are posted daily to the ARL website:
<http://www.arl.noaa.gov/smoke/verify.html>

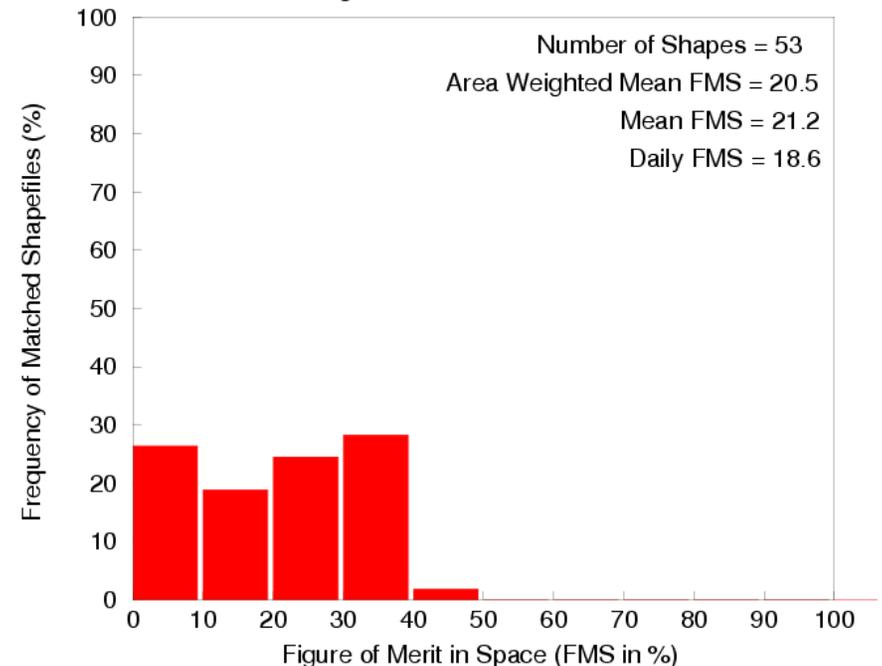
This day dominated by large wildfires in Pacific Northwest and Canada

Points along the line indicate HYSPLIT areal coverage matches HMS area but some displacement has occurred



Smoke Analysis Verification

5 ug/m3 Contour on 09/09/2006

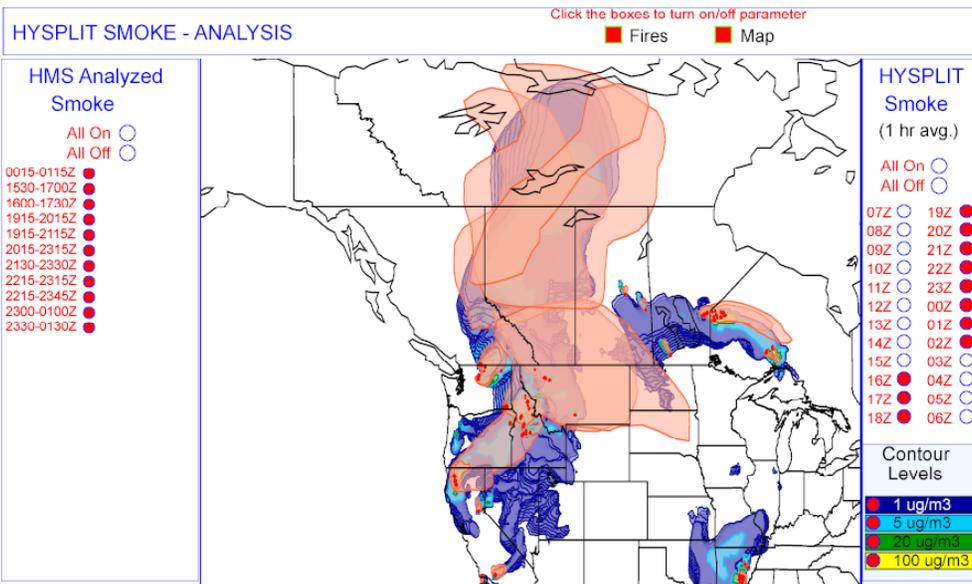


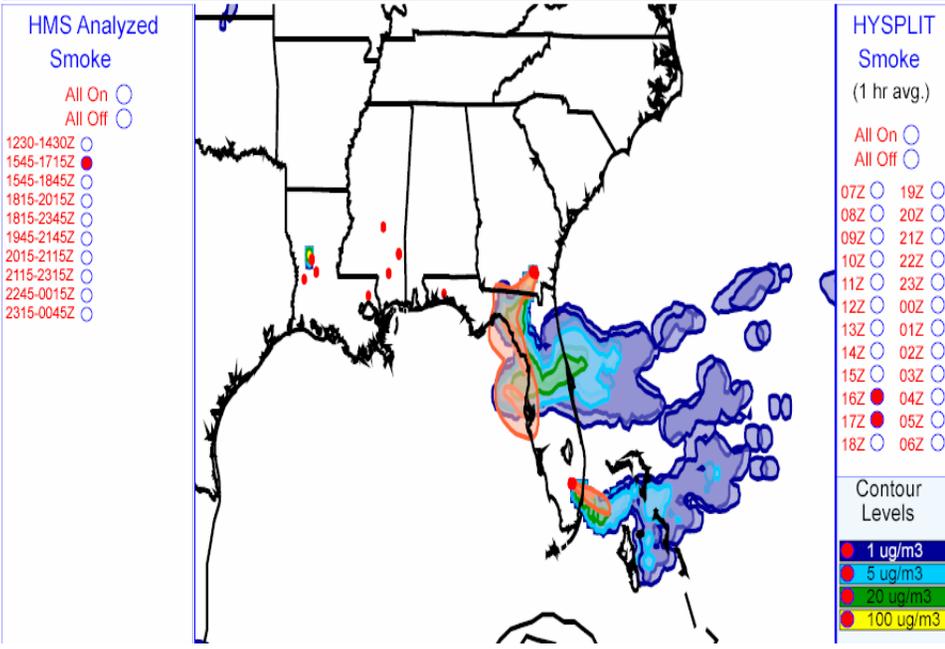
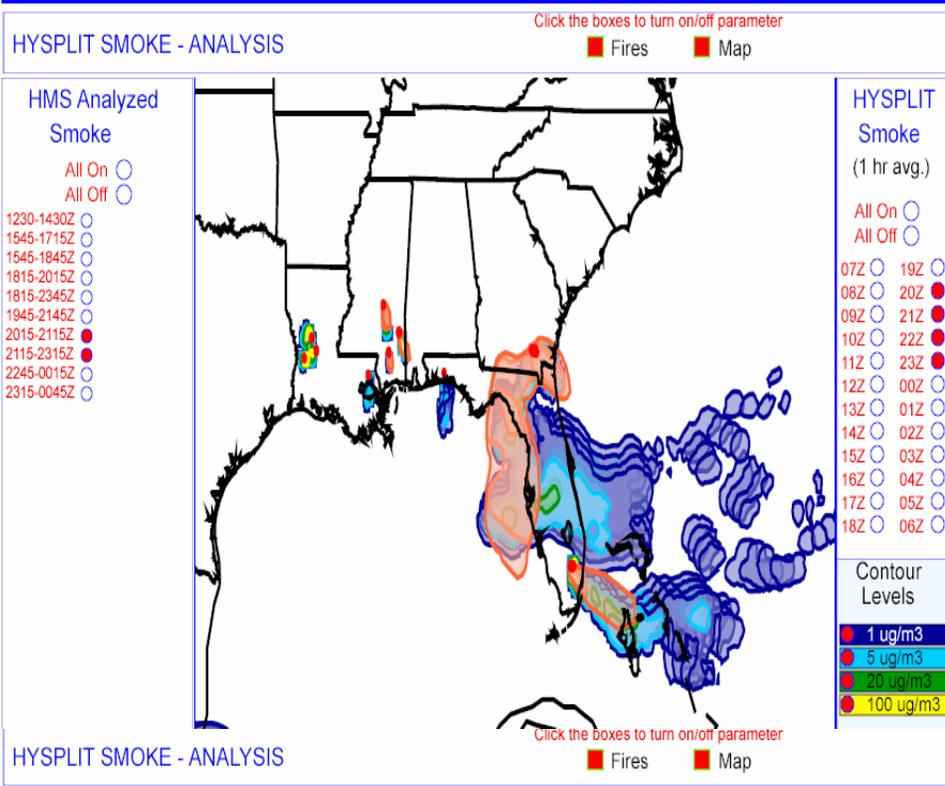
HYSPLIT Smoke Analysis Verification for 09/09/2006

< PREVIOUS DAY'S ANALYSIS RETURN NEXT DAY'S ANALYSIS >
 TODAY'S STATISTICAL RESULTS

HYSPLIT Smoke Analysis using Scalable Vector Graphic

SVG Help





Two separate time periods of HMS analyzed plumes

HYSPLIT smoke from previous day's forecast seen over the Atlantic

HYSPLIT plumes that do not overlap with an HMS plume are not included in the statistics

HYSPLIT SMOKE - ANALYSIS

Click the boxes to turn on/off parameter

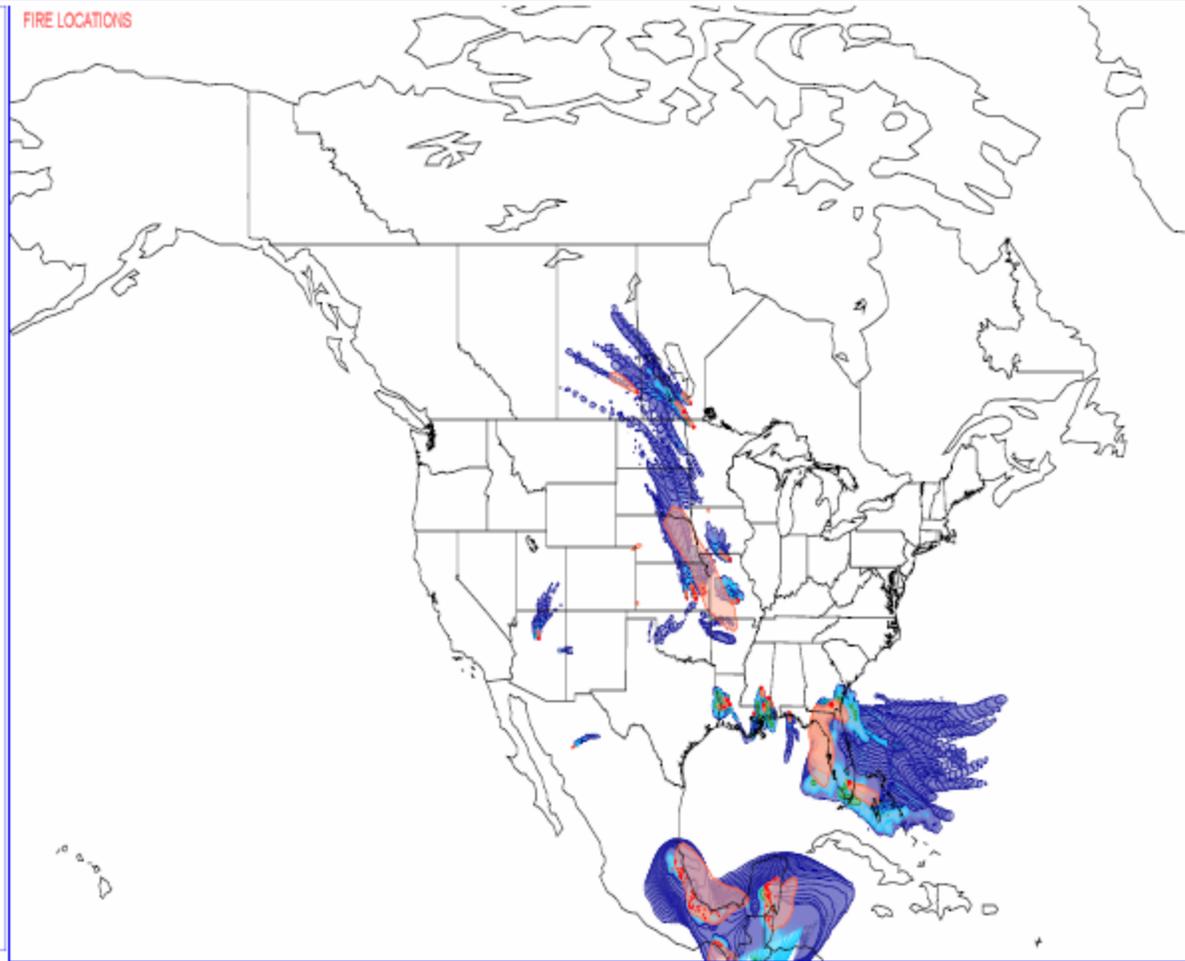
Fires Map

HMS Analyzed Smoke

All On
All Off

- 1230-1430Z
- 1545-1715Z
- 1545-1845Z
- 1815-2015Z
- 1815-2345Z
- 1945-2145Z
- 2015-2115Z
- 2115-2315Z
- 2245-0015Z
- 2315-0045Z

FIRE LOCATIONS



HYSPLIT Smoke

(1 hr avg.)

All On
All Off

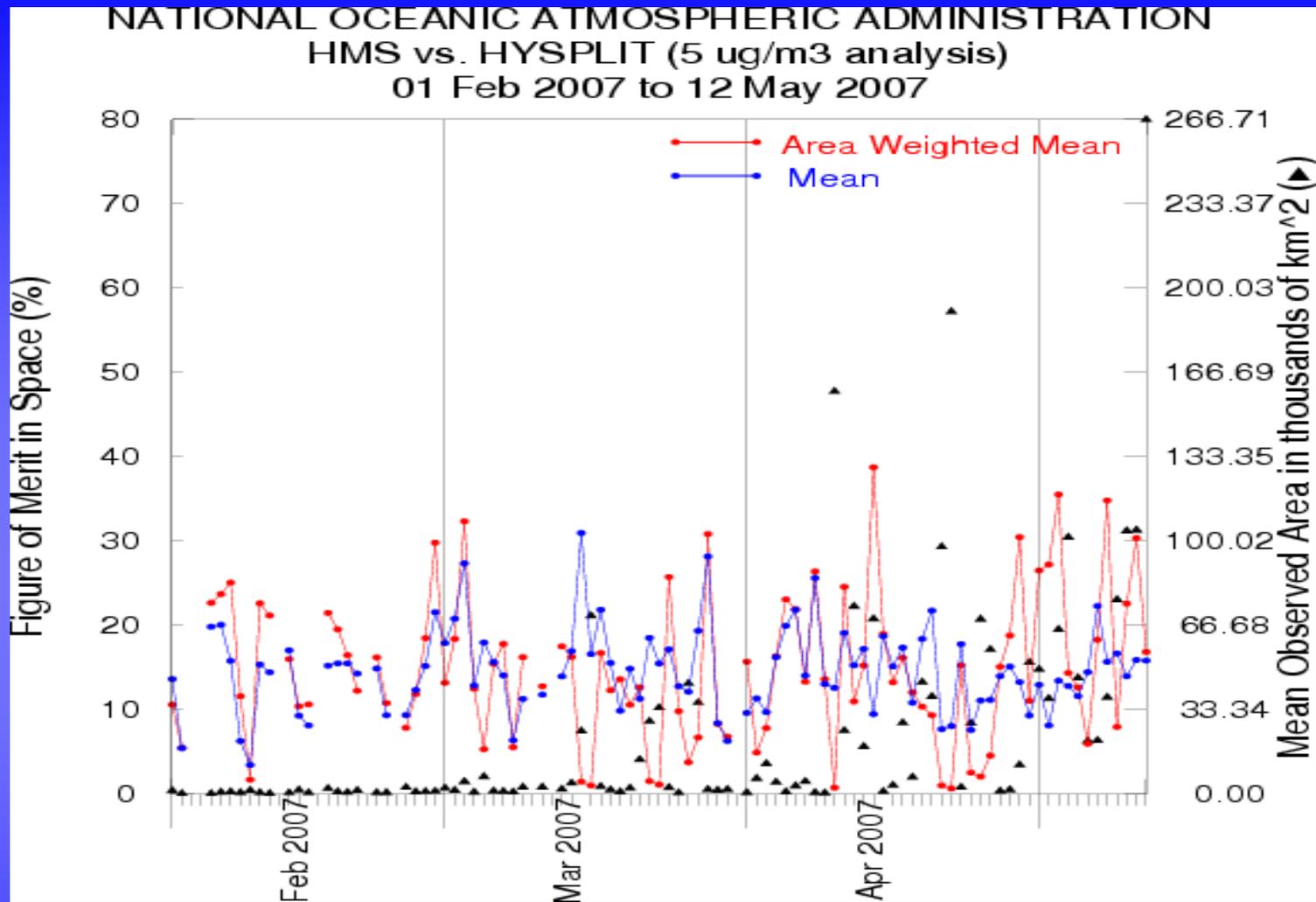
- 07Z 19Z
- 08Z 20Z
- 09Z 21Z
- 10Z 22Z
- 11Z 23Z
- 12Z 00Z
- 13Z 01Z
- 14Z 02Z
- 15Z 03Z
- 16Z 04Z
- 17Z 05Z
- 18Z 06Z

Contour Levels

- 1 ug/m3
- 5 ug/m3
- 20 ug/m3
- 100 ug/m3

19 April 2007

Analysis portion of HYSPLIT run



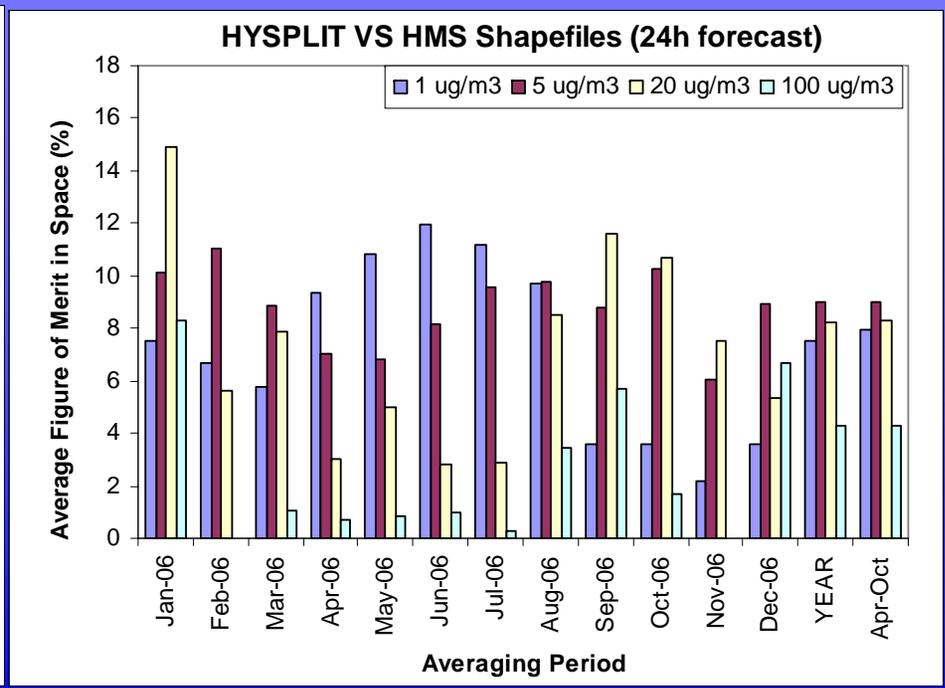
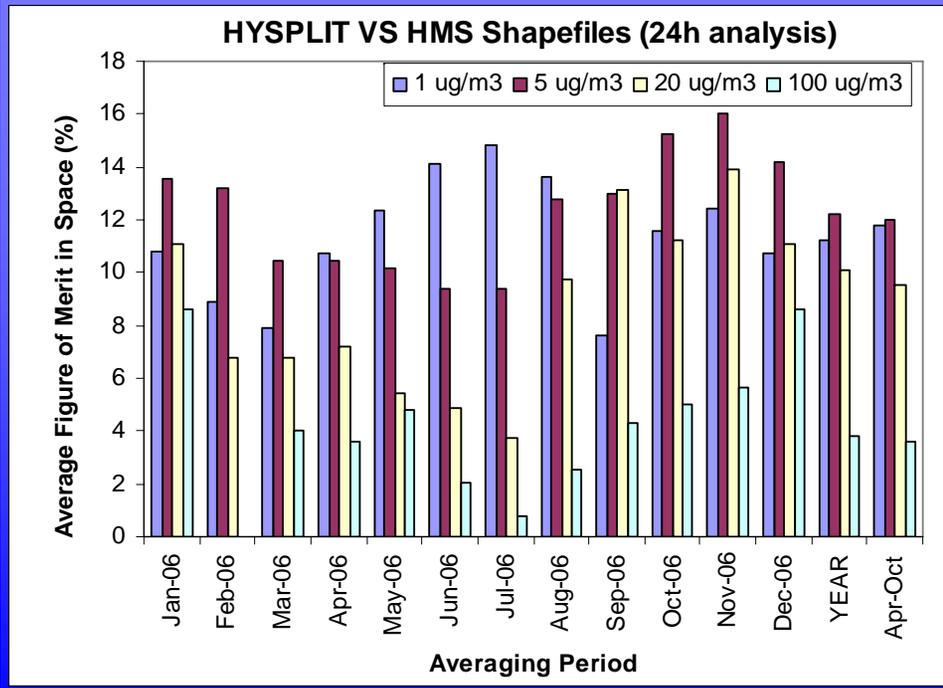
Observed area showed distinct increase around 1 April. This roughly corresponded to increase in observed fires over Central America and the Georgia/Florida fire complexes

Monthly FMS scores for 2006

Improvement in scores for 5 and 20 ug/m³ between July and August correspond to change in treatment of burn rate and emission rate output from BlueSky

Figure 5a. 2006 monthly average Figure of Merit (FMS) scores for the 24 hour analysis.

Figure 5b. 2006 monthly average Figure of Merit (FMS) scores for the 24 hour forecast.





Additional contributors who have made the system possible

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George Stephens

John Simko

Jamie Kibler

Tim Kasheta

Po Li

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CIMMS GOES fire team

Yi Song

Ivan Csiszar

Rob Fennimore

Tad Franson

Jian Zheng

www.ssd.noaa.gov/PS/FIRE/