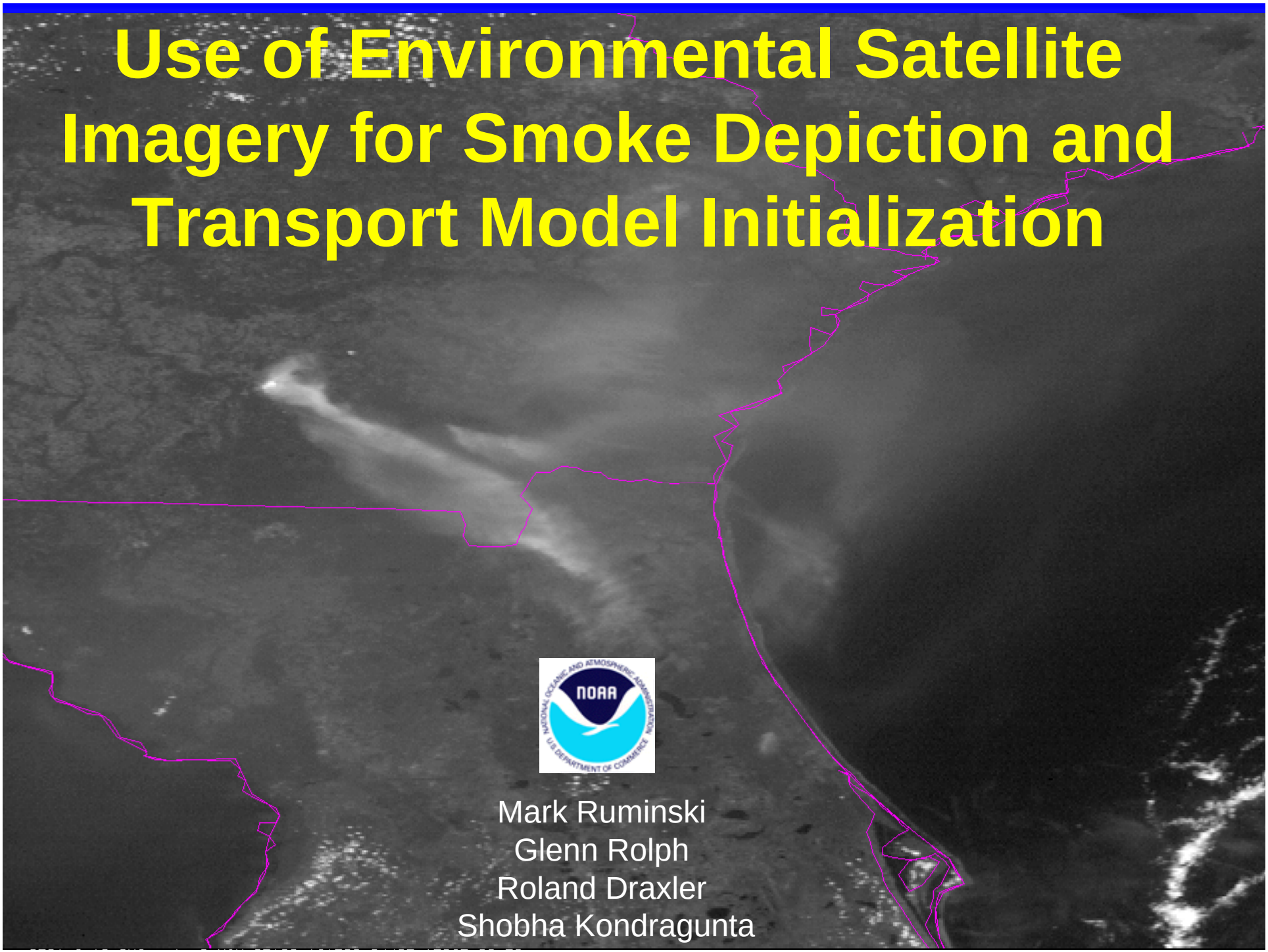
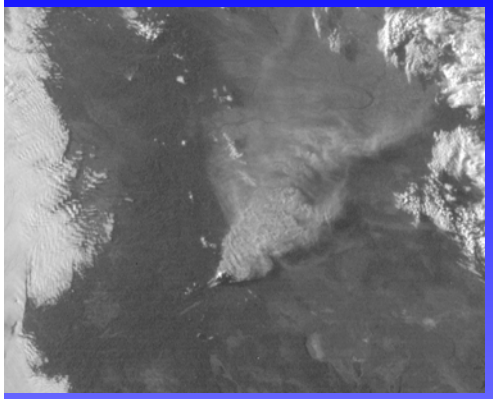
Use of Environmental Satellite Imagery for Smoke Depiction and Transport Model Initialization

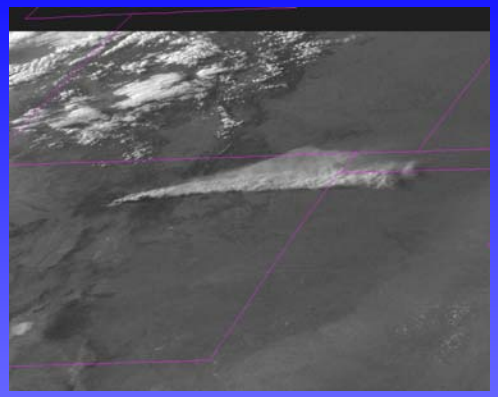


Mark Ruminski
Glenn Rolph
Roland Draxler
Shobha Kondragunta

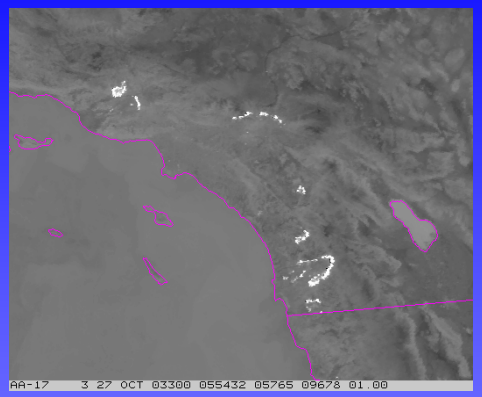
- HAZARD MAPPING SYSTEM OVERVIEW
- SMOKE DETECTION
- SMOKE CONCENTRATION
- INPUT TO HYSPLIT FOR SMOKE TRANSPORT AND DISPERSION
- HYSPLIT VALIDATION



GOES-WEST



GOES-EAST

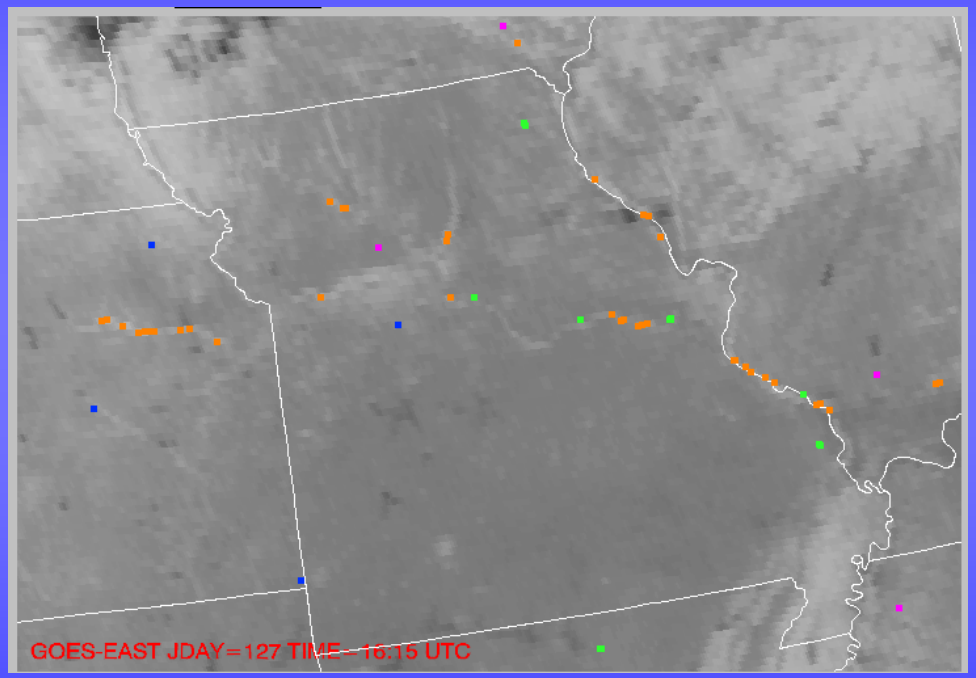


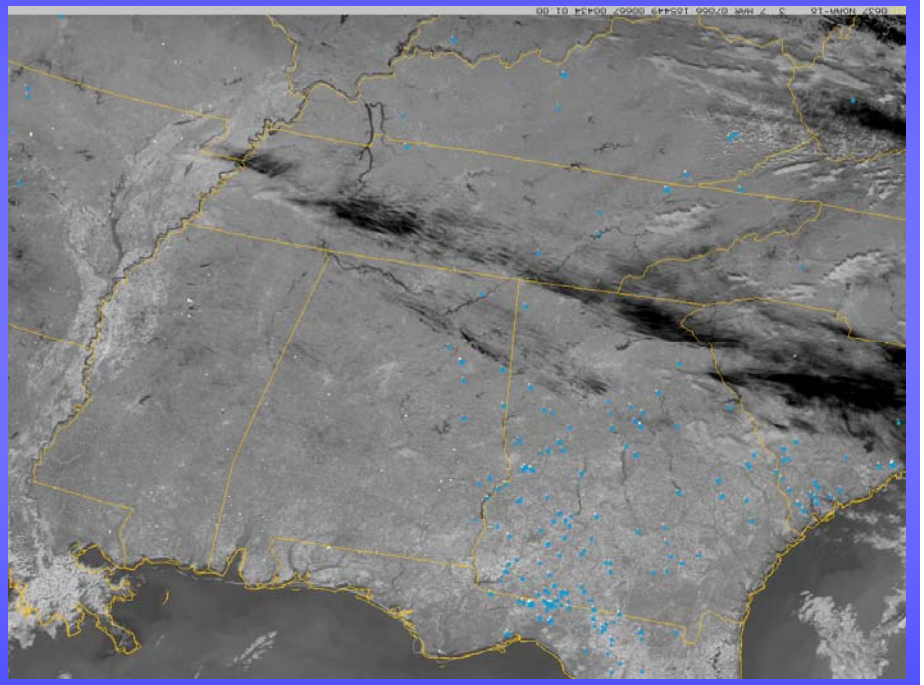
NOAA-AVHRR

MODIS

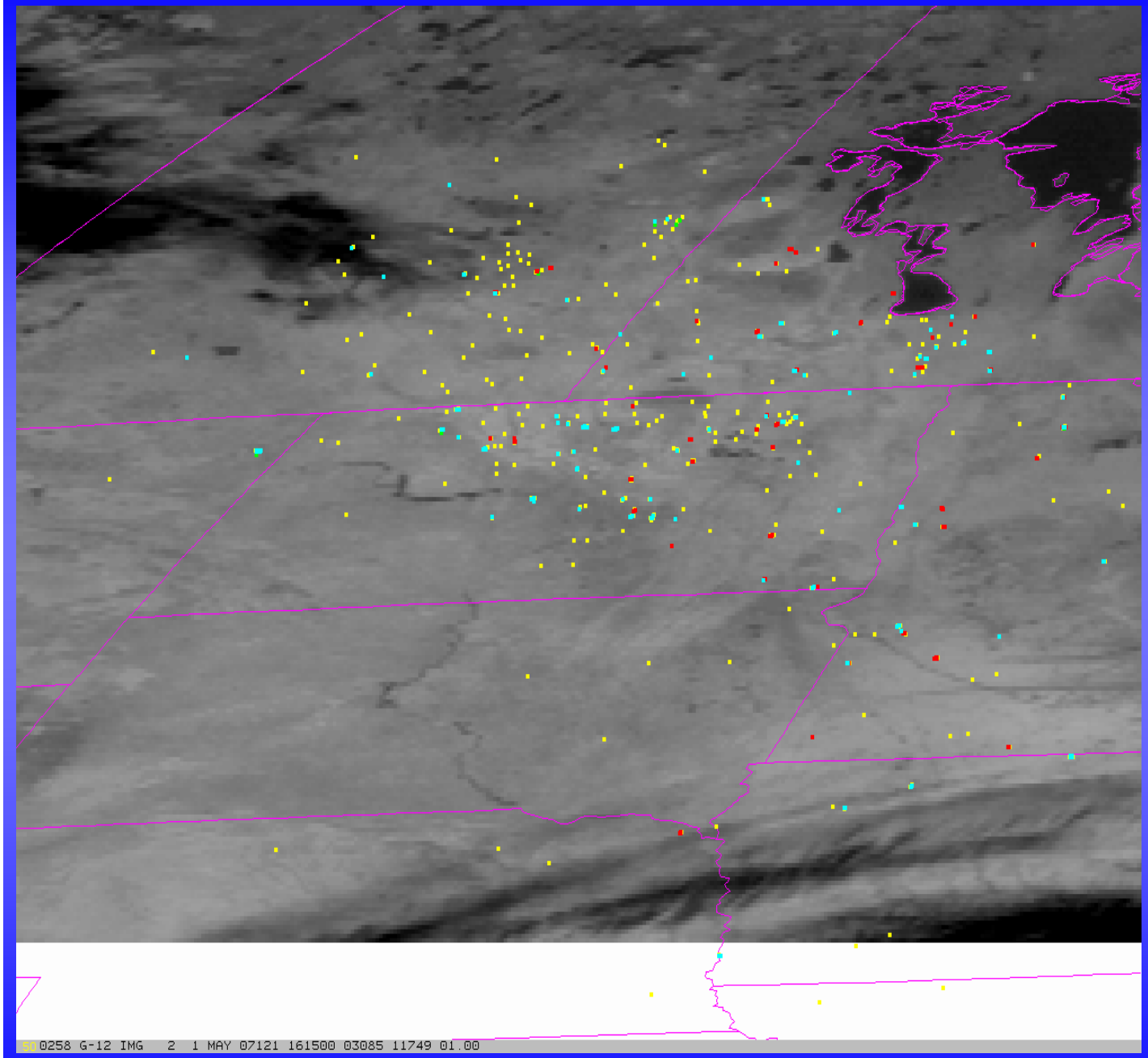
- HMS Incorporates 7 satellites – 2 geostationary and 5 polar orbiting
- Over 100 looks per day in areas of overlap
- POES spacecraft provide 2 orbits/day in mid latitudes, more frequent over Alaska/Canada
- Analysis performed year-round for contiguous US and Hawaii, seasonally for Central America, Alaska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

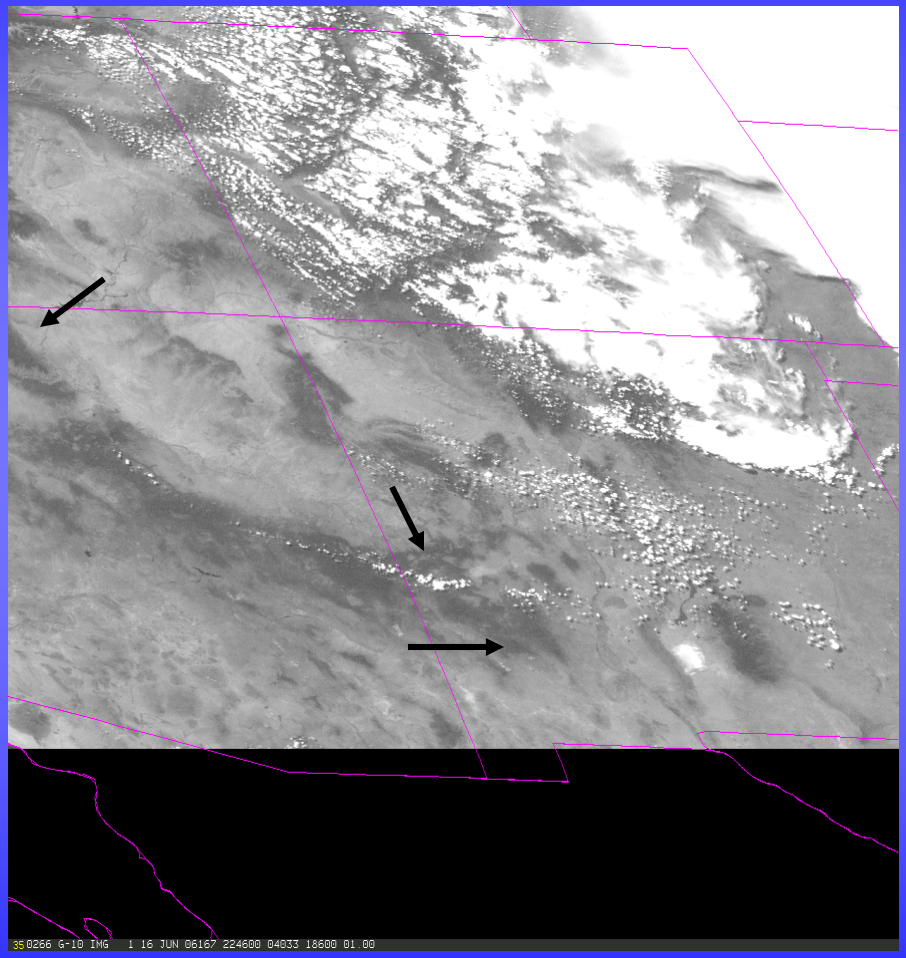
WF-ABBA

Smoke Analysis consists of:

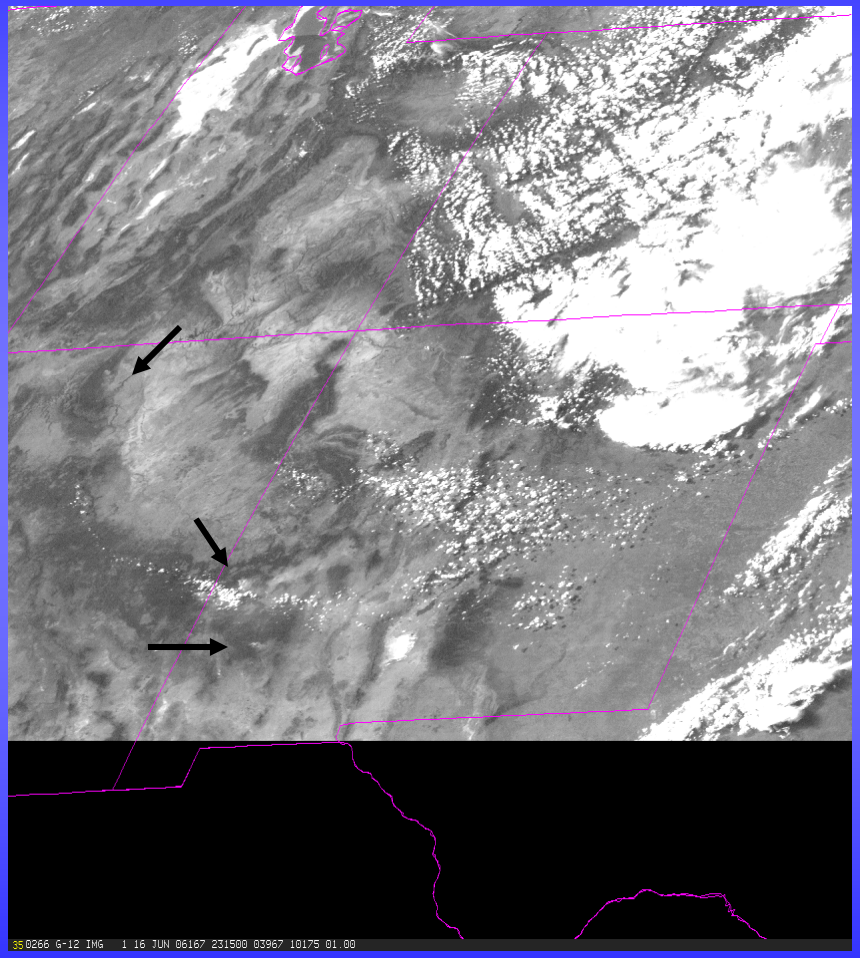
- Graphic of smoke extent and density
- Input to HYSPLIT dispersion and transport model which is used in NWS AQ forecast. Smoke emissions generated by BlueSky
- Text product describing smoke and blowing dust

SMOKE DETECTION USING VISIBLE BAND IMAGERY:

Sun/Satellite Viewing Geometry Makes the Difference

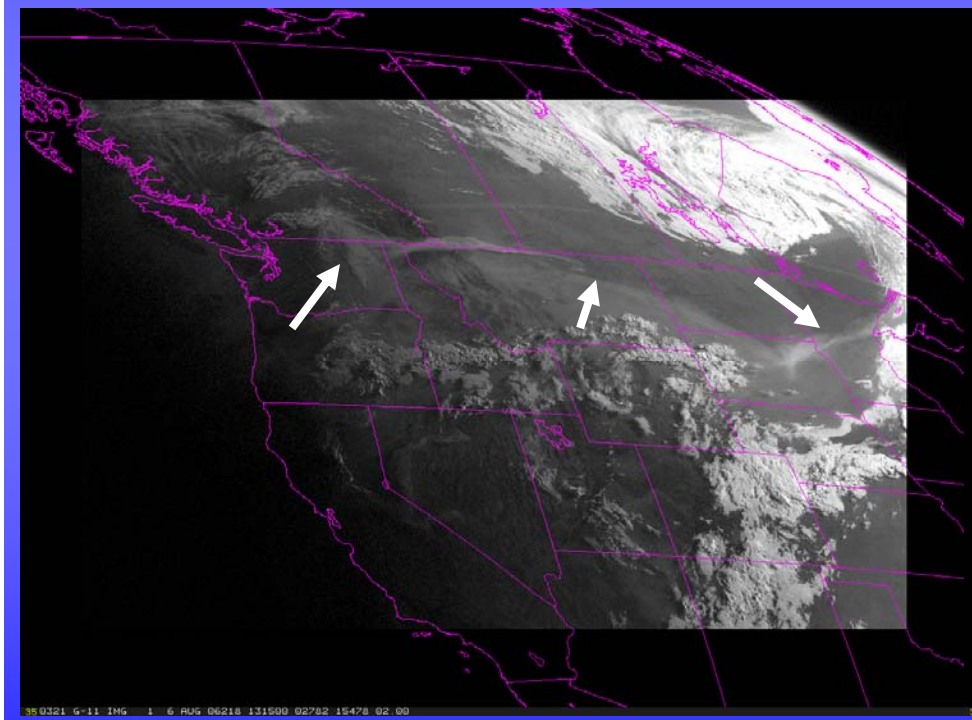


EVENING VIEW FROM GOES-WEST
16 JUNE 2006

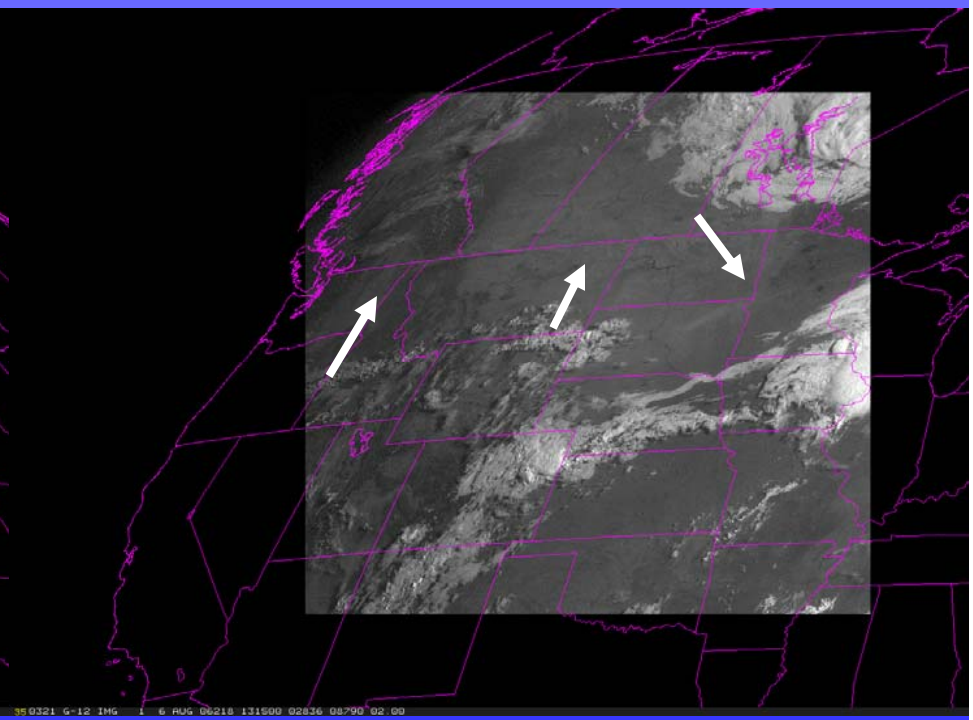


EVENING VIEW FROM GOES-EAST
16 JUNE 2006

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



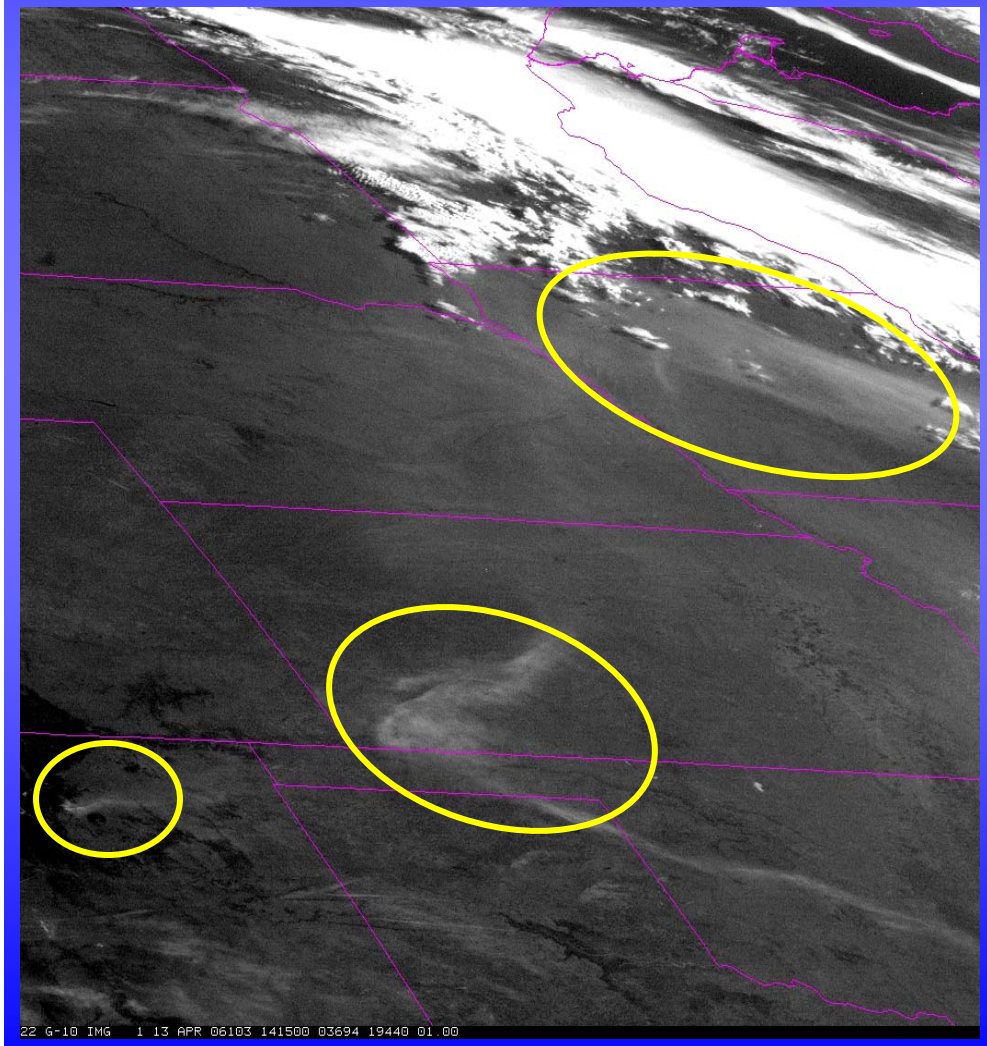
MORNING VIEW FROM GOES-WEST
06 AUGUST 2006



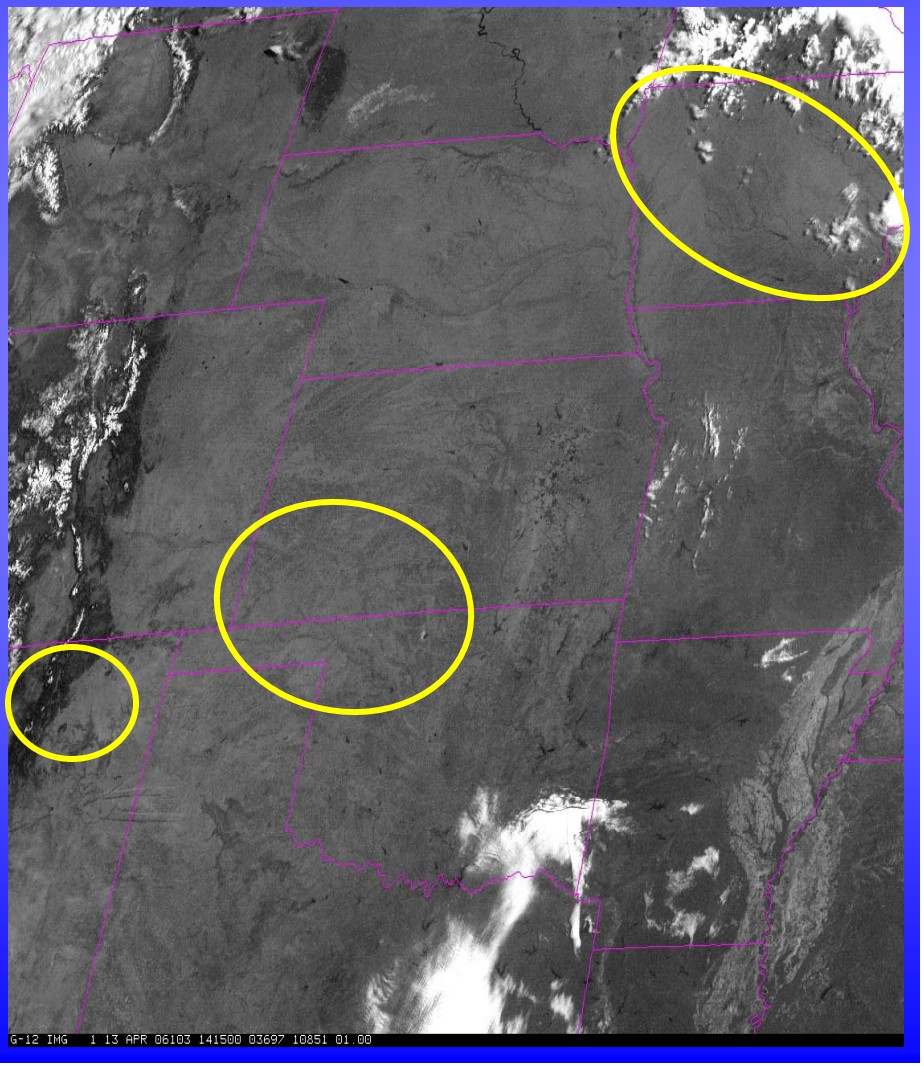
MORNING VIEW FROM GOES-EAST
06 AUGUST 2006

13 APRIL 2006 1415Z

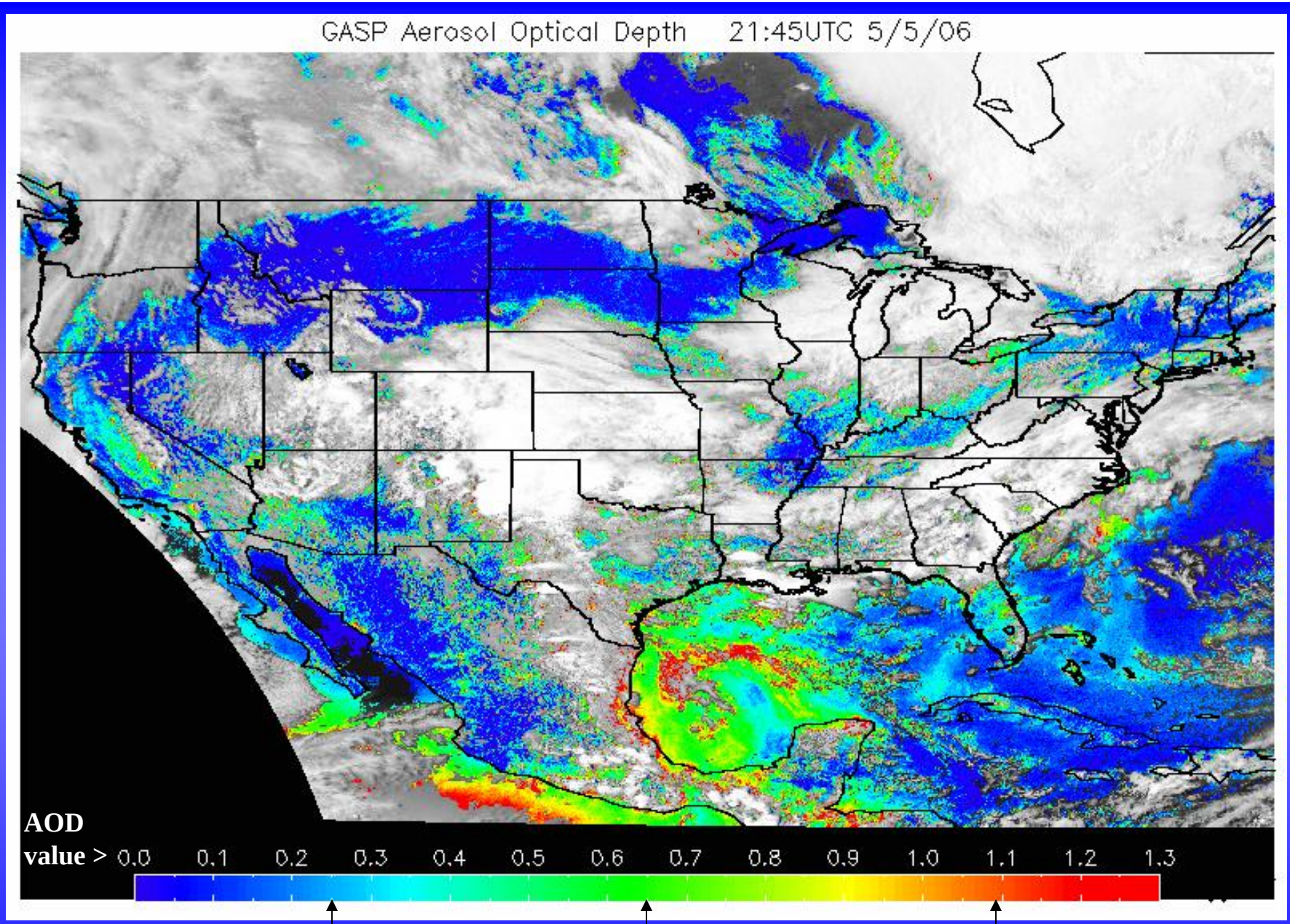
GOES-WEST



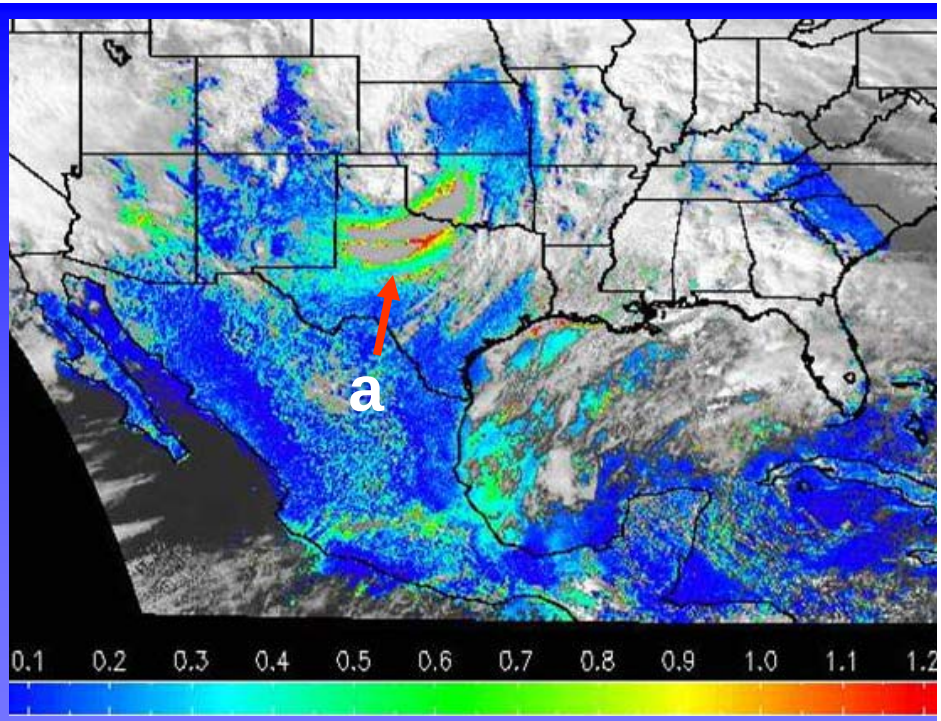
GOES-EAST

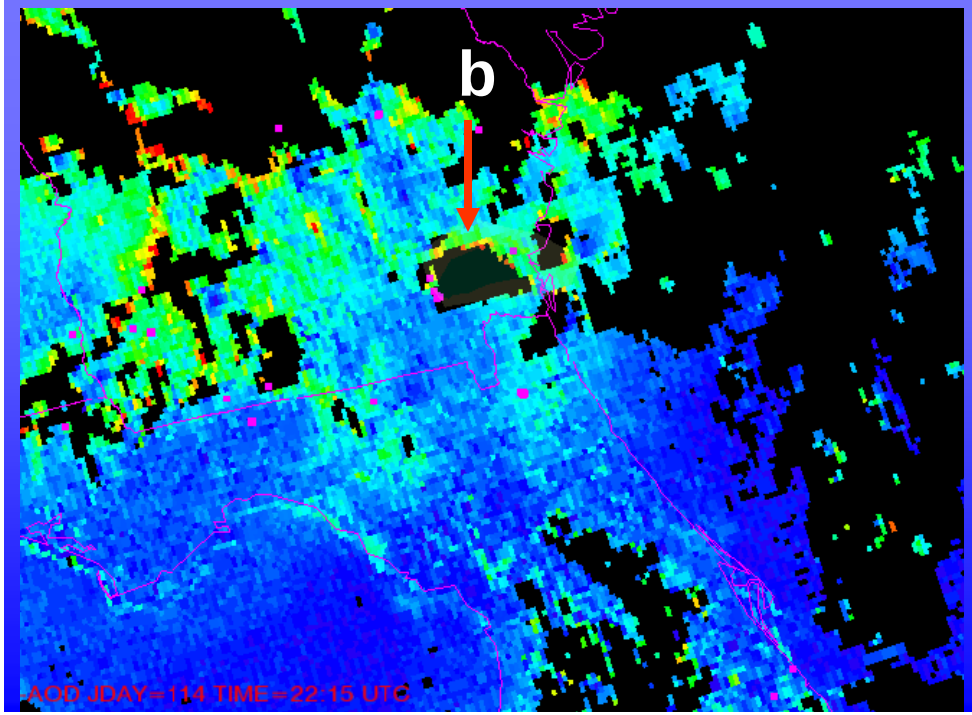


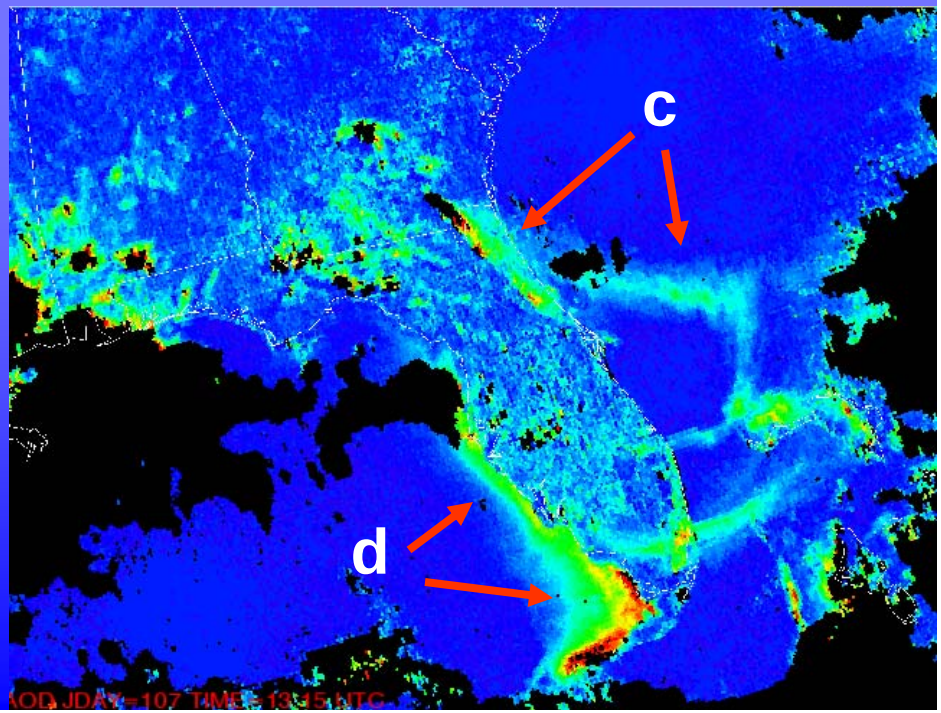
- **Specification of smoke concentration began November 2006**
- **Determination of smoke concentration values are aided by the GOES Aerosol and Smoke Product (GASP)**
- **Values assigned are 5, 16 or 27 µg/m^3 for light, medium and thick smoke**
- **The value represents the mid-point in a range of values**

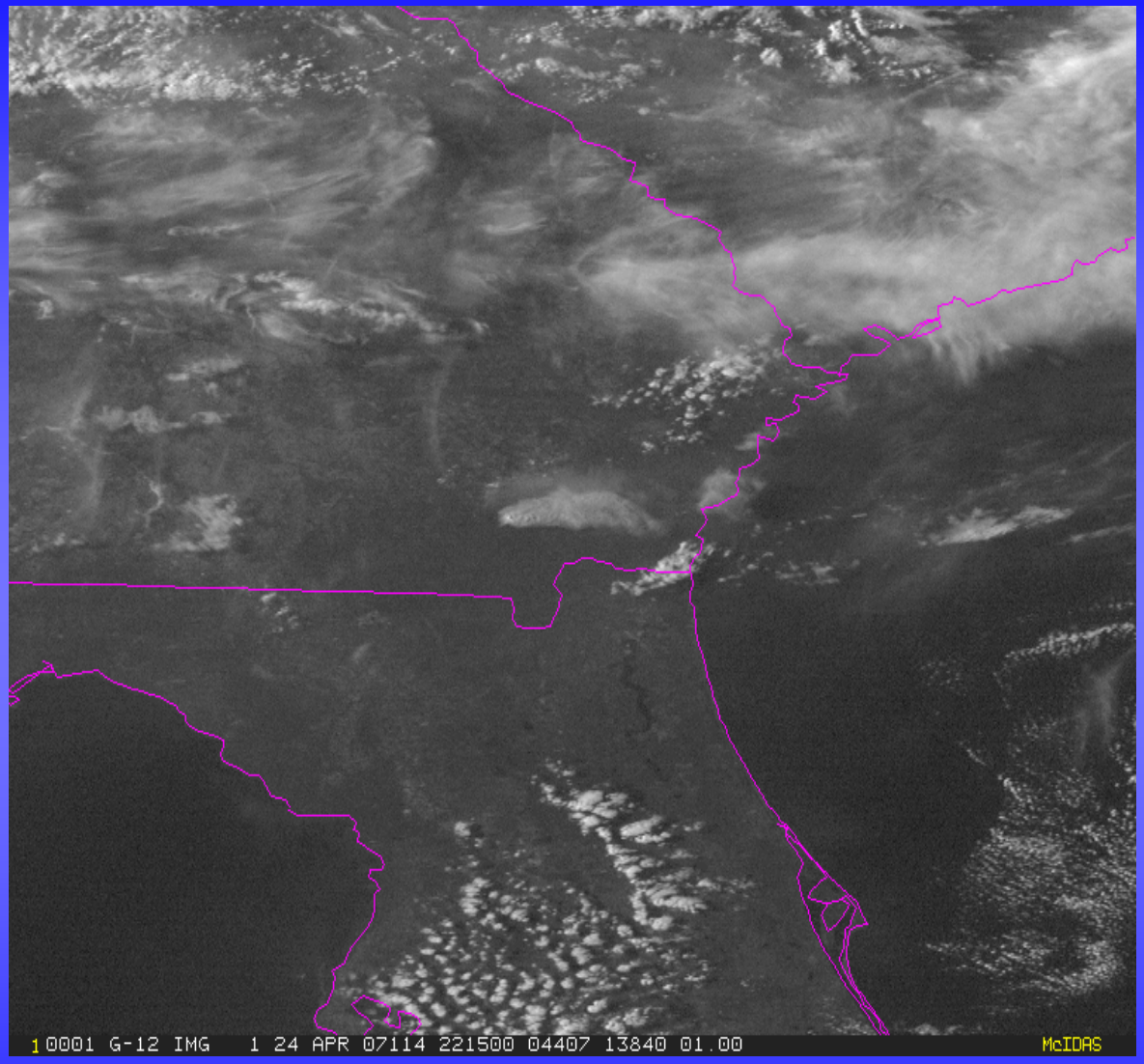

GASP Aerosol Optical Depth 21:45UTC 5/5/06
AOD
value > 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3
5
16
27
Smoke concentration value (µg/m3)

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





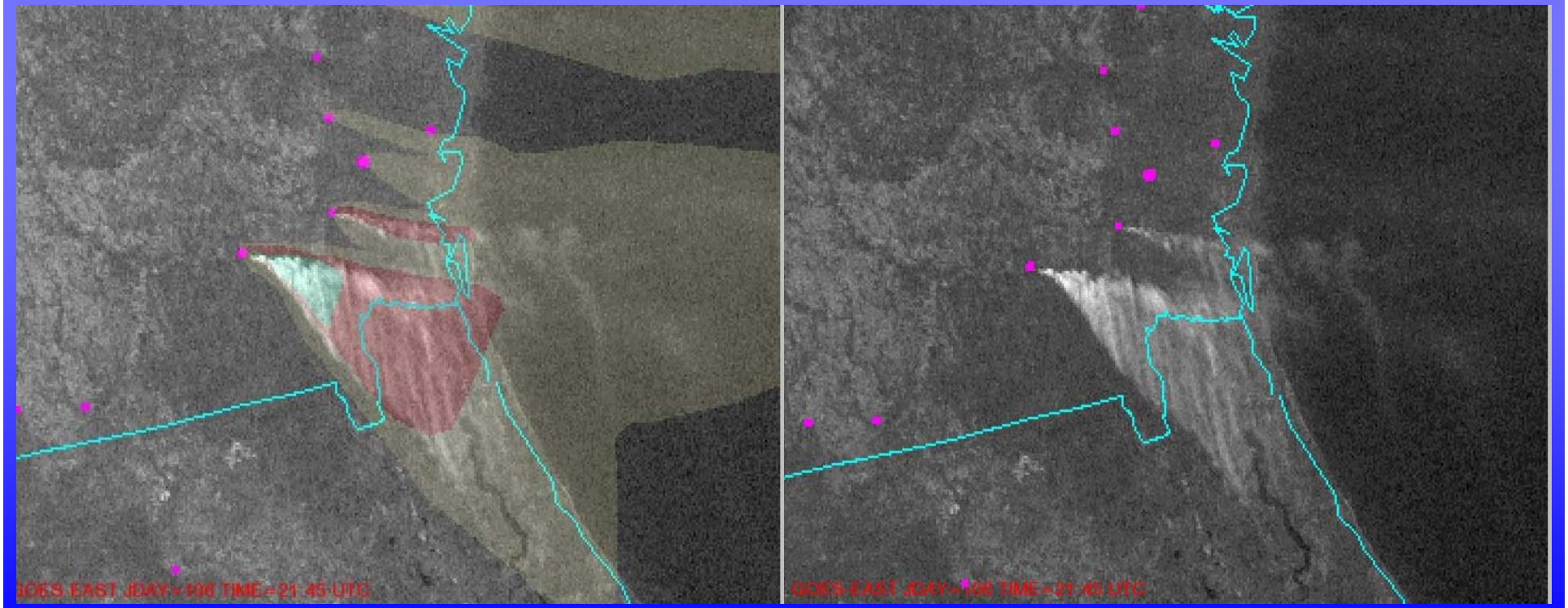




GOES-12 IMAGE AT SAME TIME AS GASP IMAGE IN (b) IN PREVIOUS SLIDE

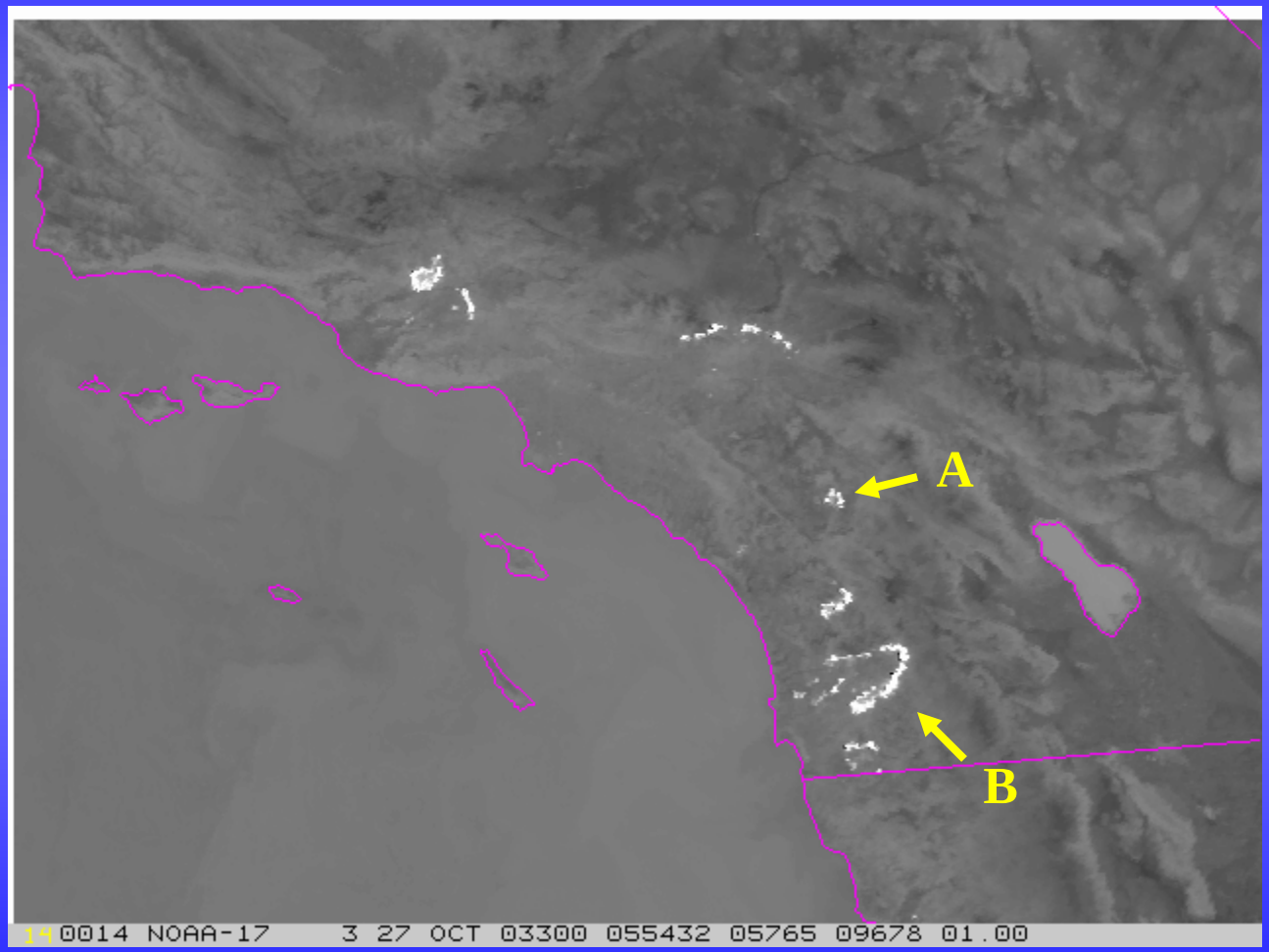
GOES-12 VISIBLE IMAGE
16 April 2007 2145Z

- represents analyzed fire location



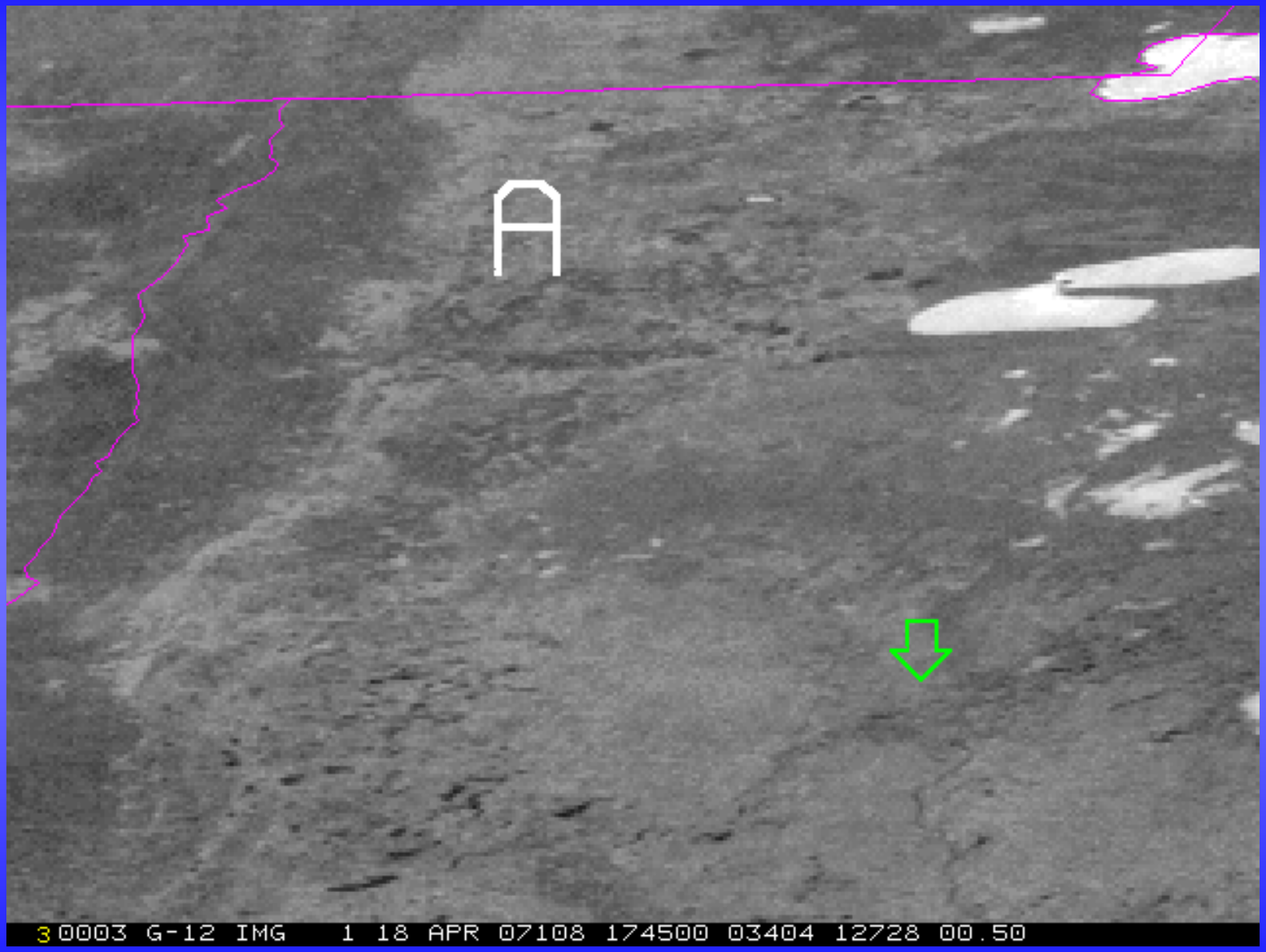
Analyst input to the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) Model which is used in the National Weather Service (NWS) Air Quality Forecast:

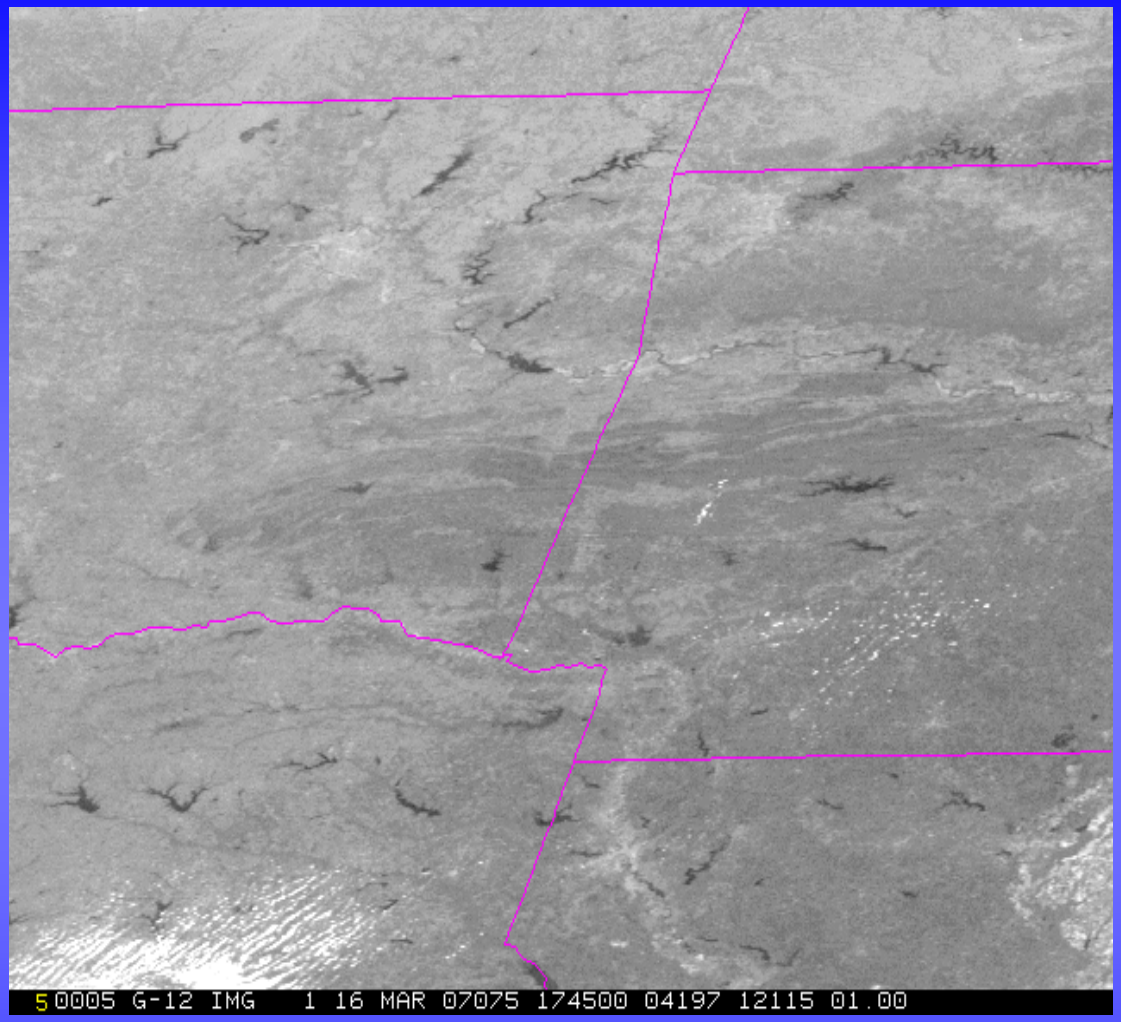
- **Locations of smoke emitting fires**
- **Each point represents 1 square km**
- **Start time and duration of smoke emissions**



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)**


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



Note the differences in the smoke plumes:

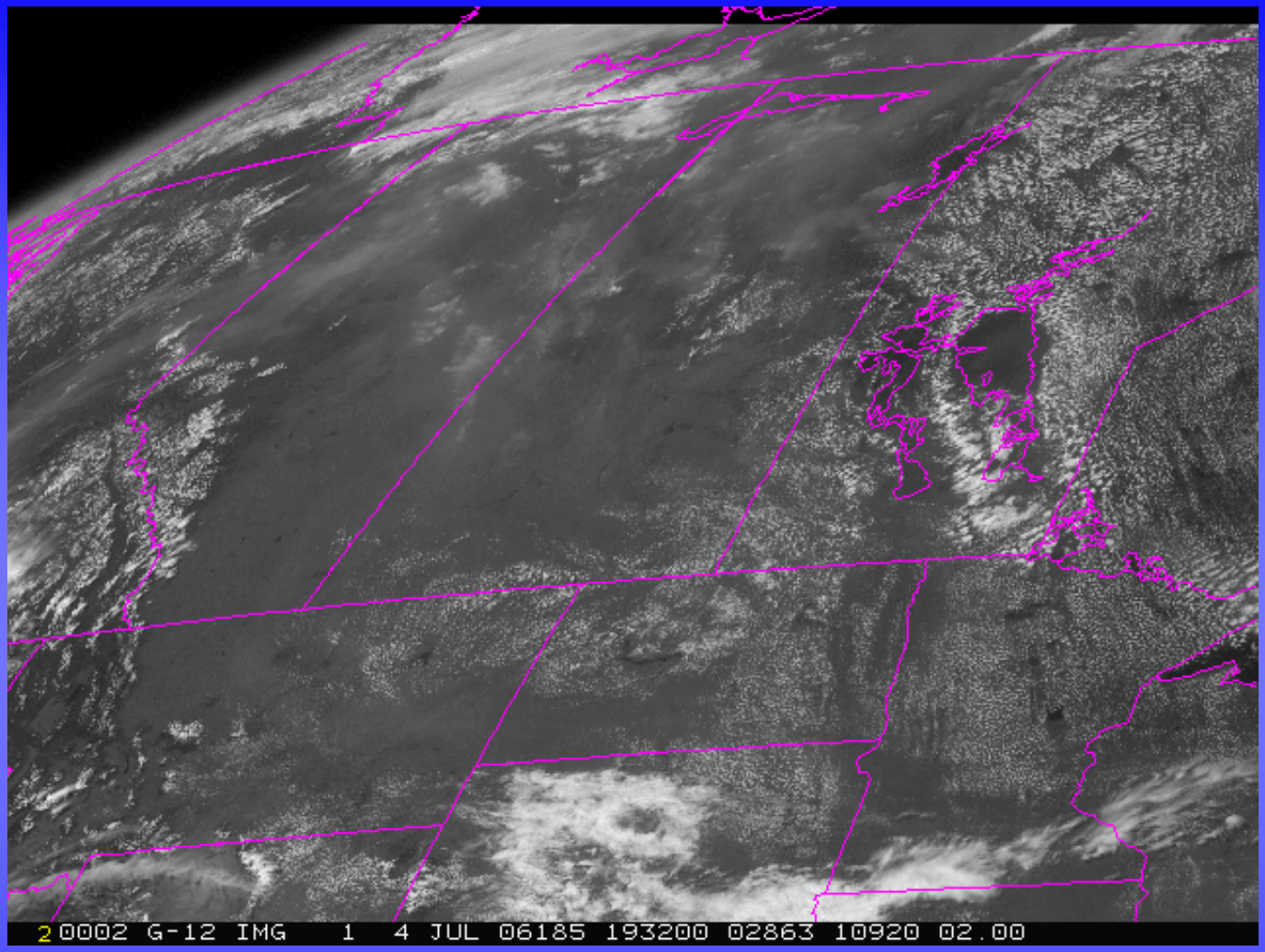
Start times

Smoke density

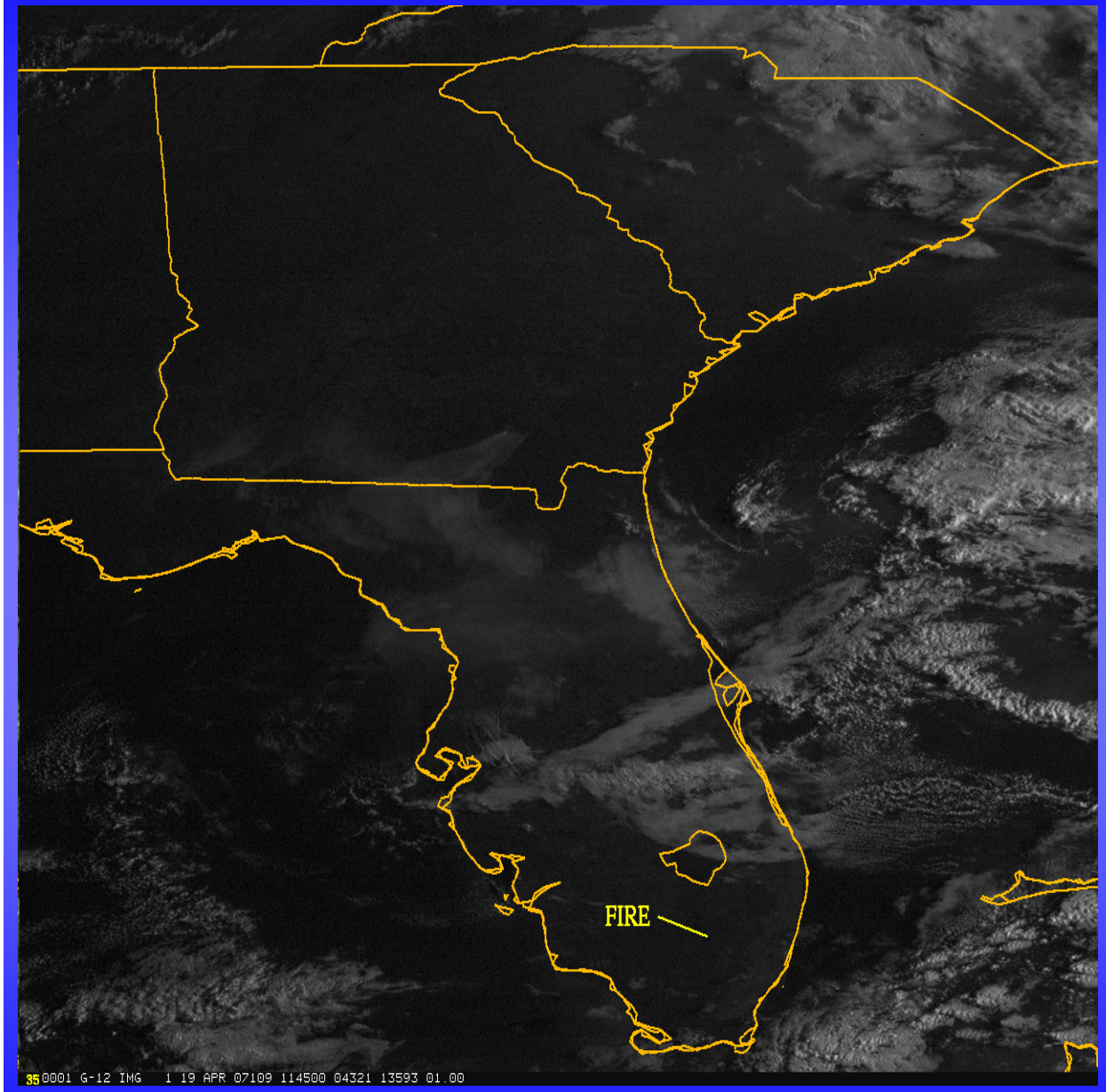
Amount of smoke

Dynamics within plume

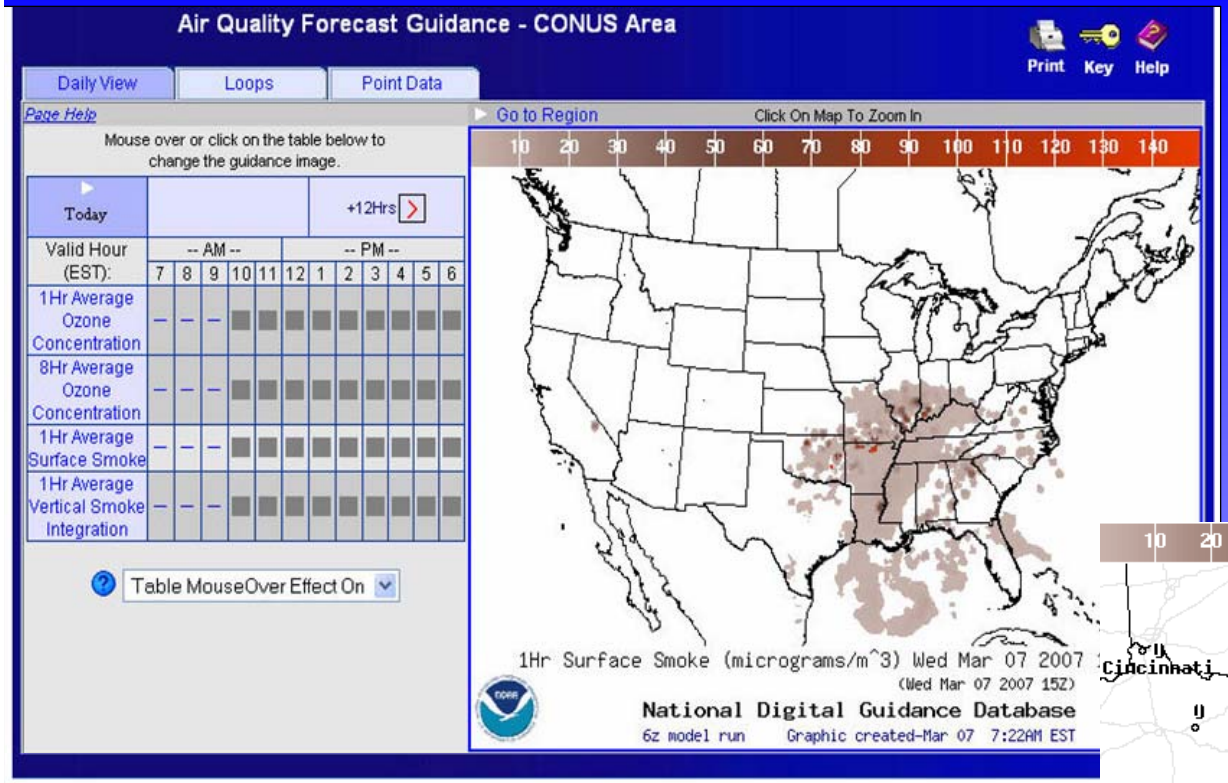
Are these wildfires or prescribe burns?

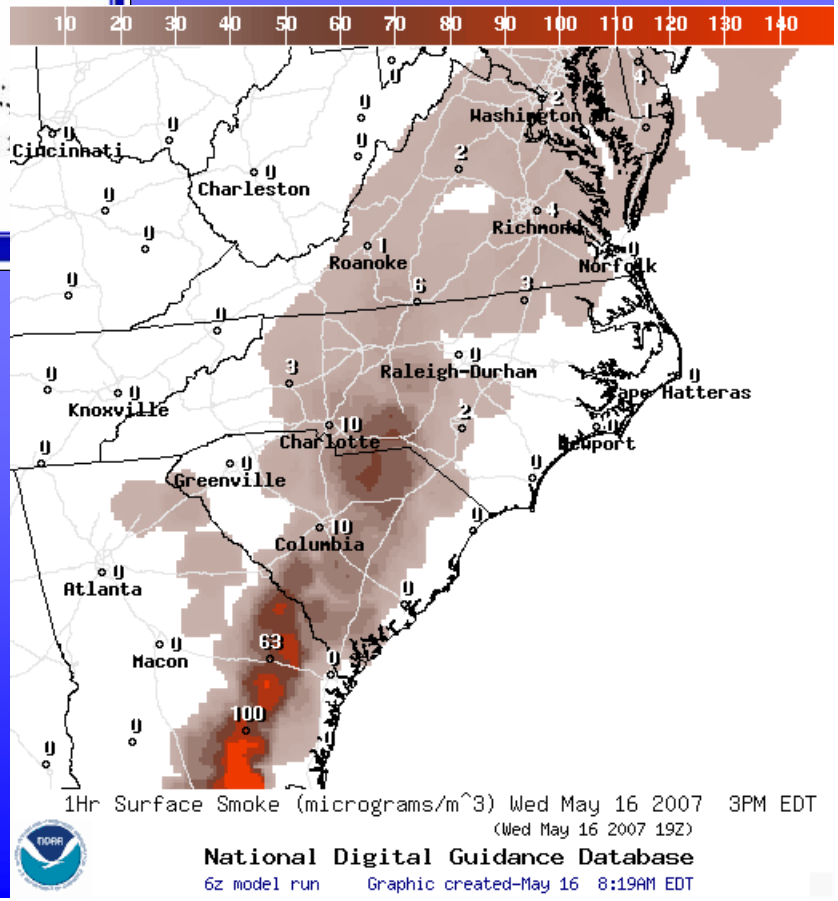


Treated as wildfires burning continuously



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



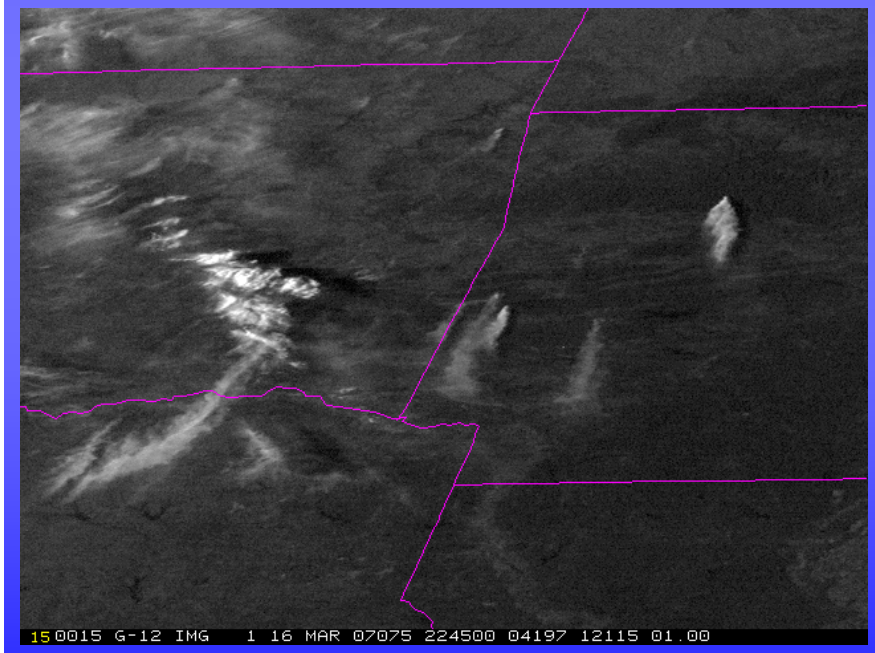


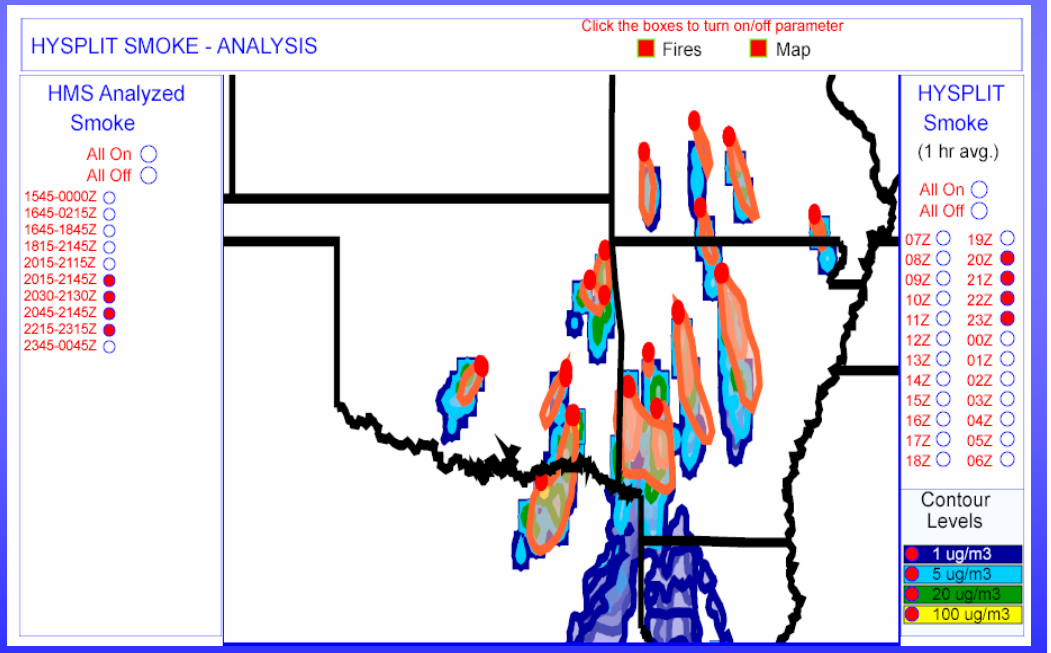
HYSPLIT is run by NWS at 10Z on the following day using the 06Z NAM run for meteorology.

www.weather.gov/aq/

VERIFICATION PROCESS

Match analyst drawn plumes with HYSPLIT forecast smoke for same time





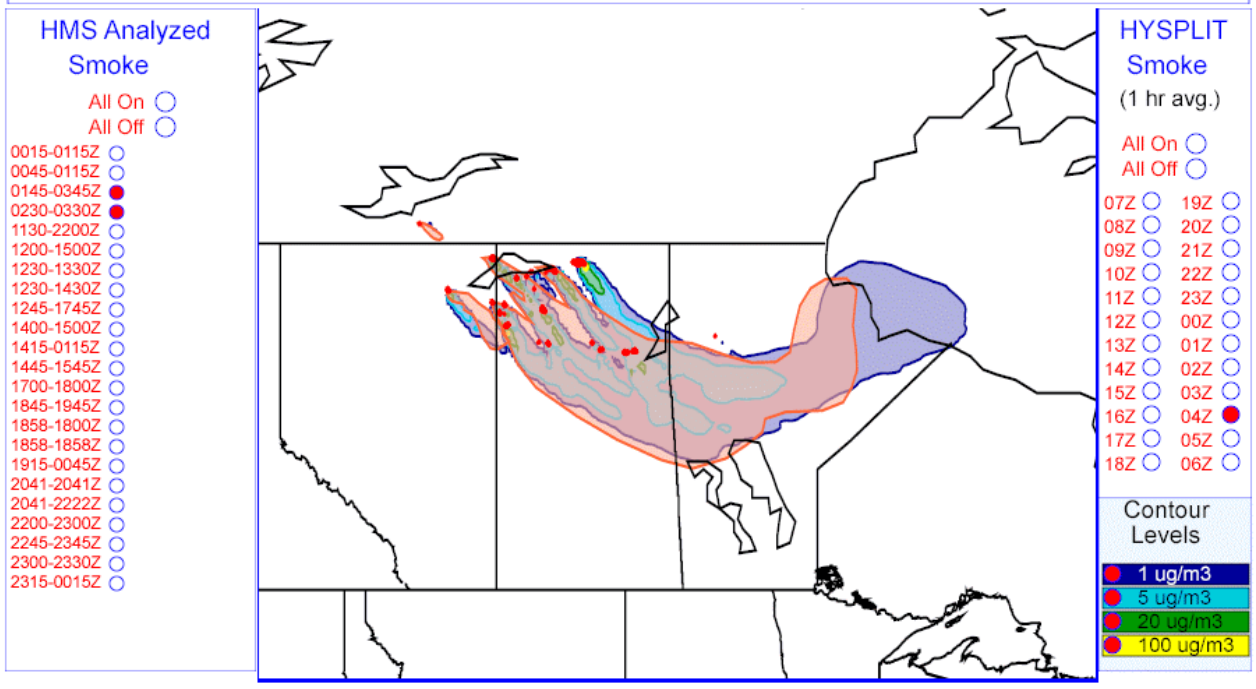
HYSPLIT Smoke Analysis Verification for 06/25/2006

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

HYSPLIT Smoke Analysis using Scalable Vector Graphic SVG Help Download Adobe SVG Viewer

HYSPLIT SMOKE - ANALYSIS

Click the boxes to turn on/off parameter
Fires Map



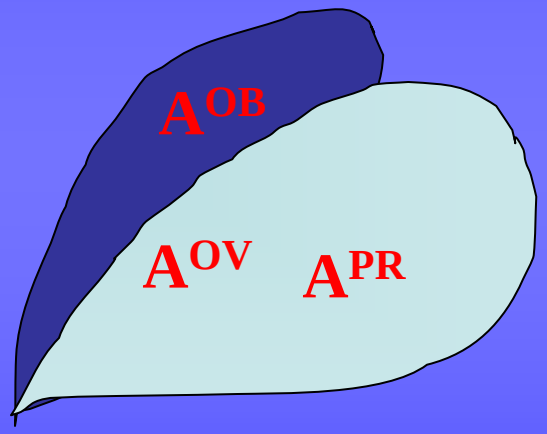
Statistics calculated include:

Figure of Merit in Space (FMS):

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

Measure of Effectiveness (MOE):

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

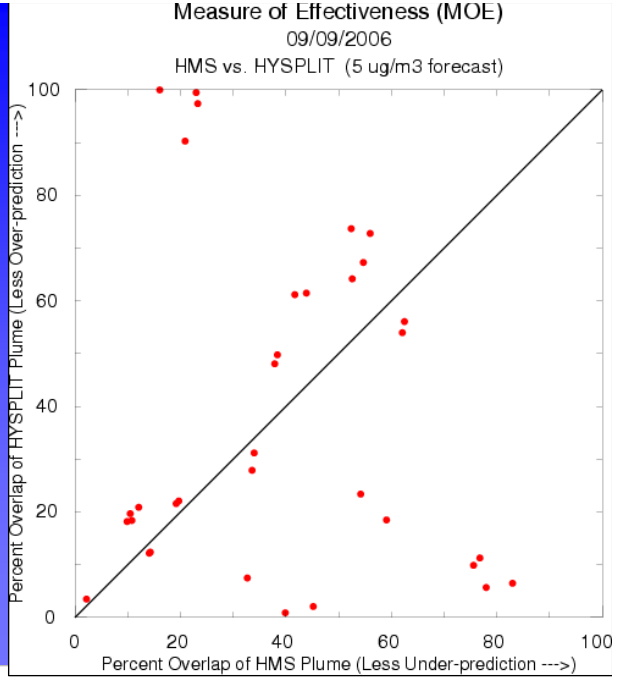


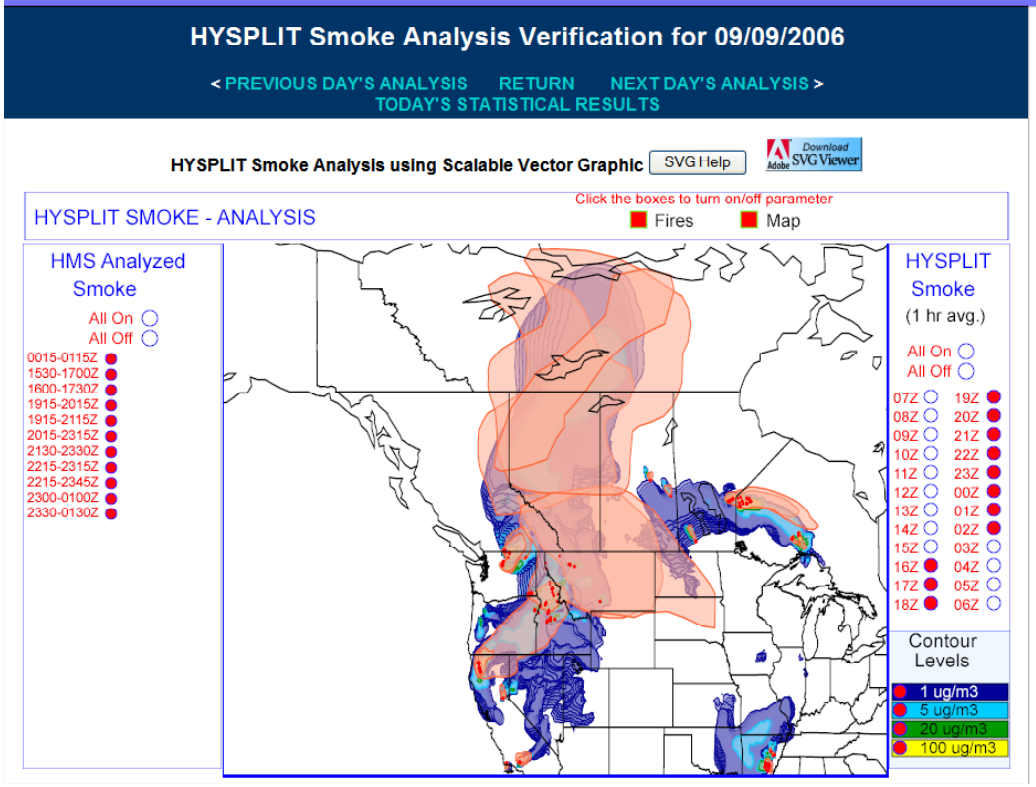
Results are posted daily to the ARL website:

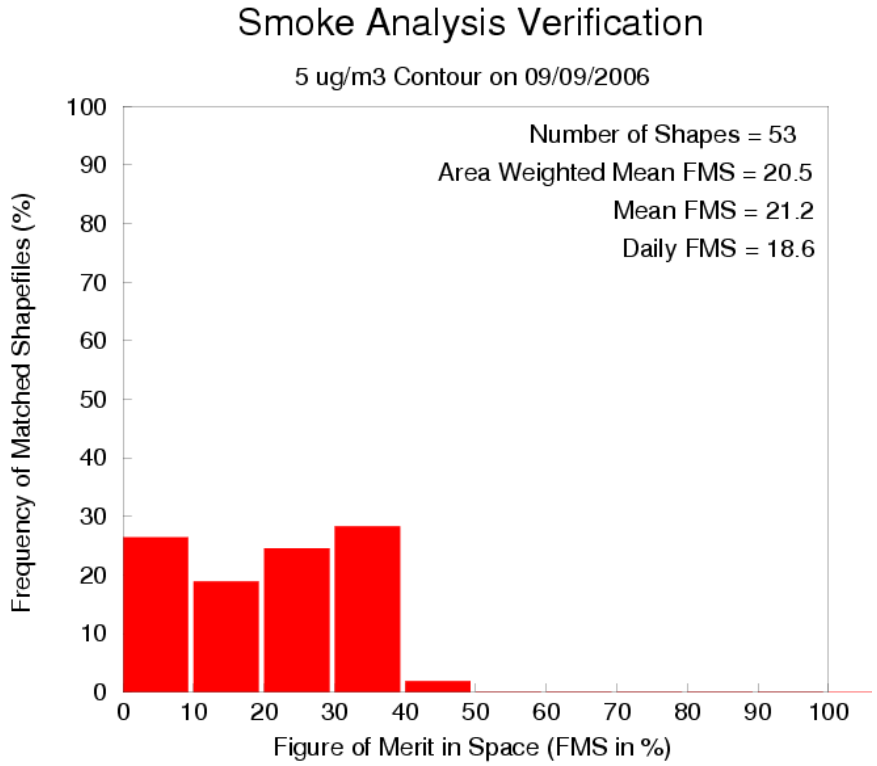
http://www.arl.noaa.gov/smoke/verify.html

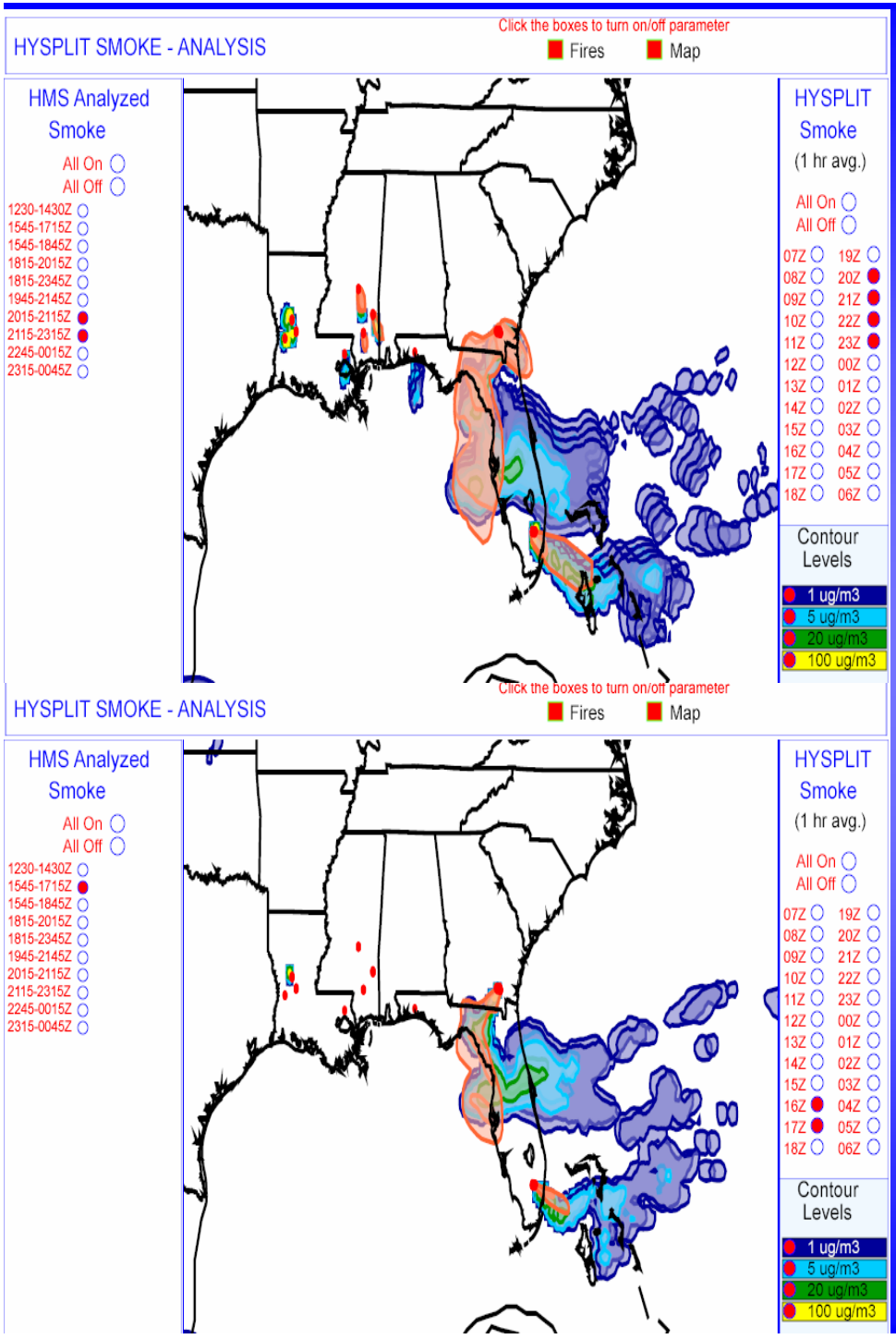
This day dominated by large wildfires in Pacific Northwest and Canada

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

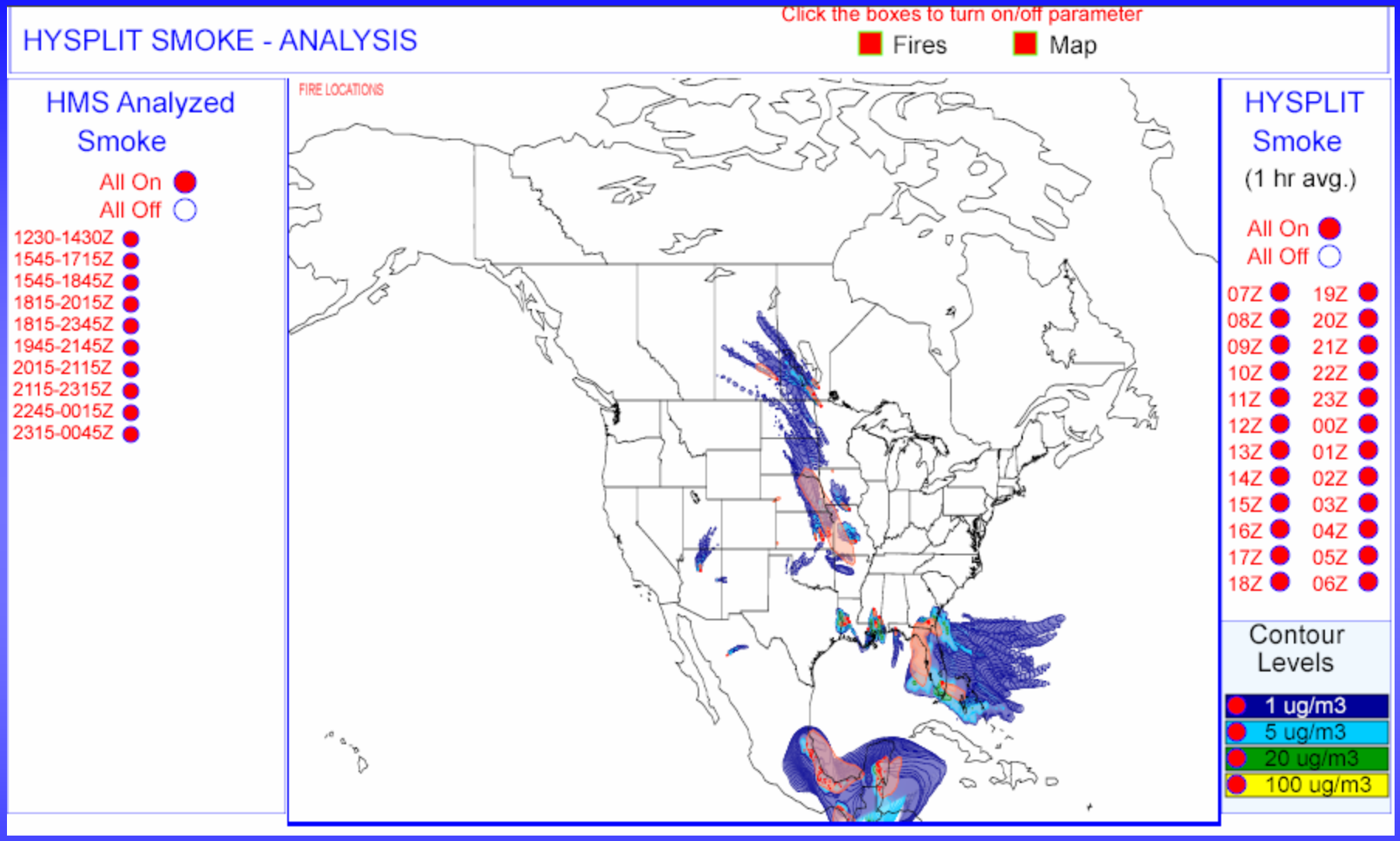






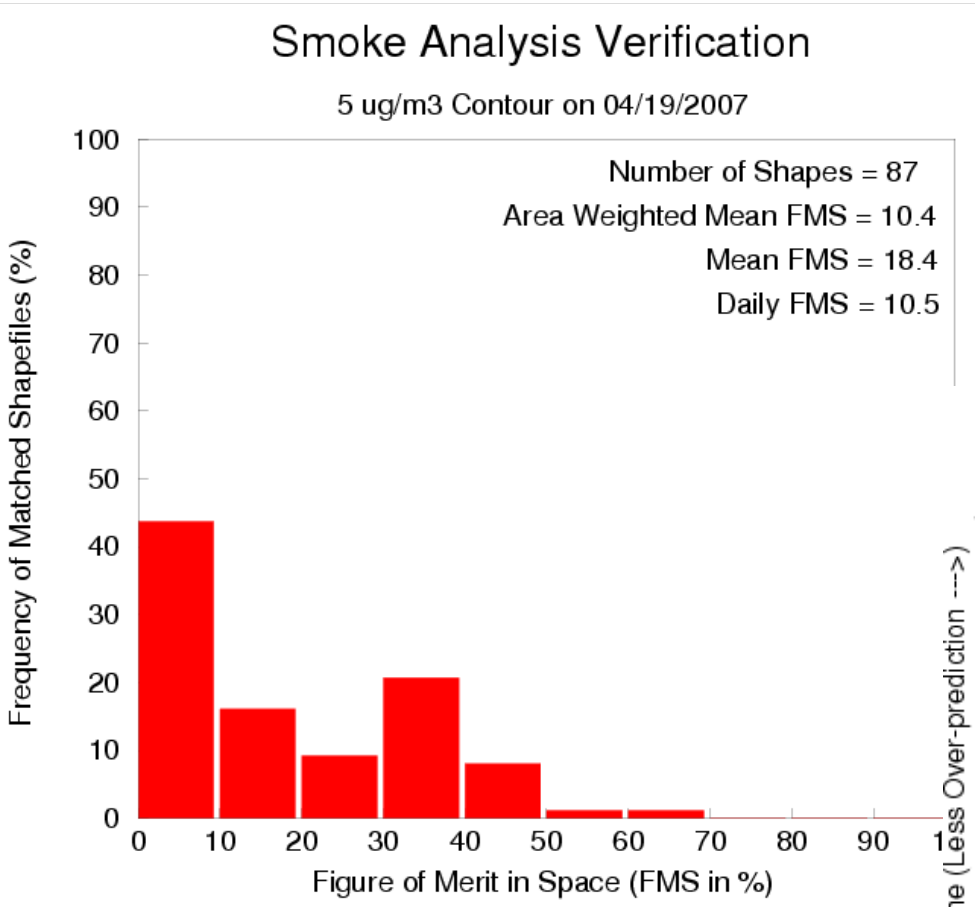


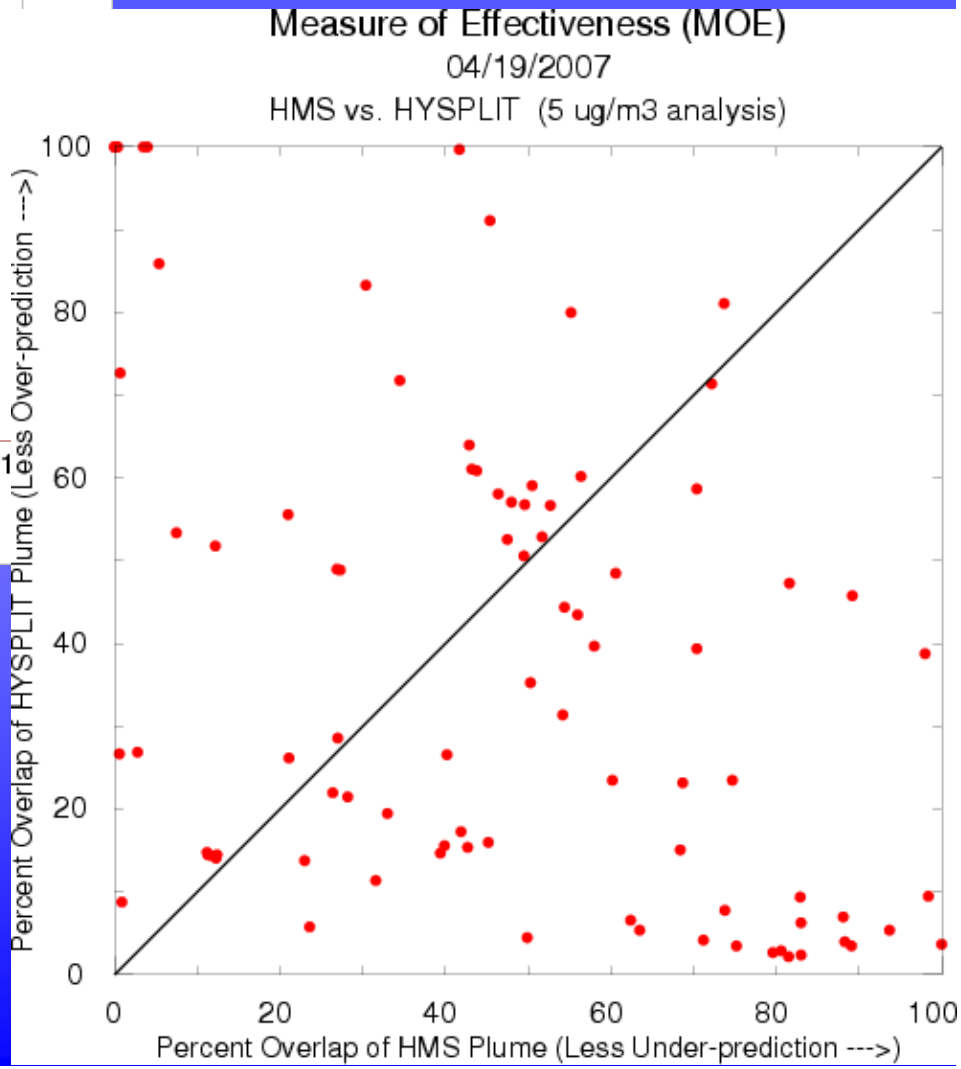
- **Two separate time periods of HMS analyzed plumes**
- **HYSPLIT smoke from previous day's forecast seen over the Atlantic**
- **HYSPLIT plumes that do not overlap with an HMS plume are not included in the statistics**



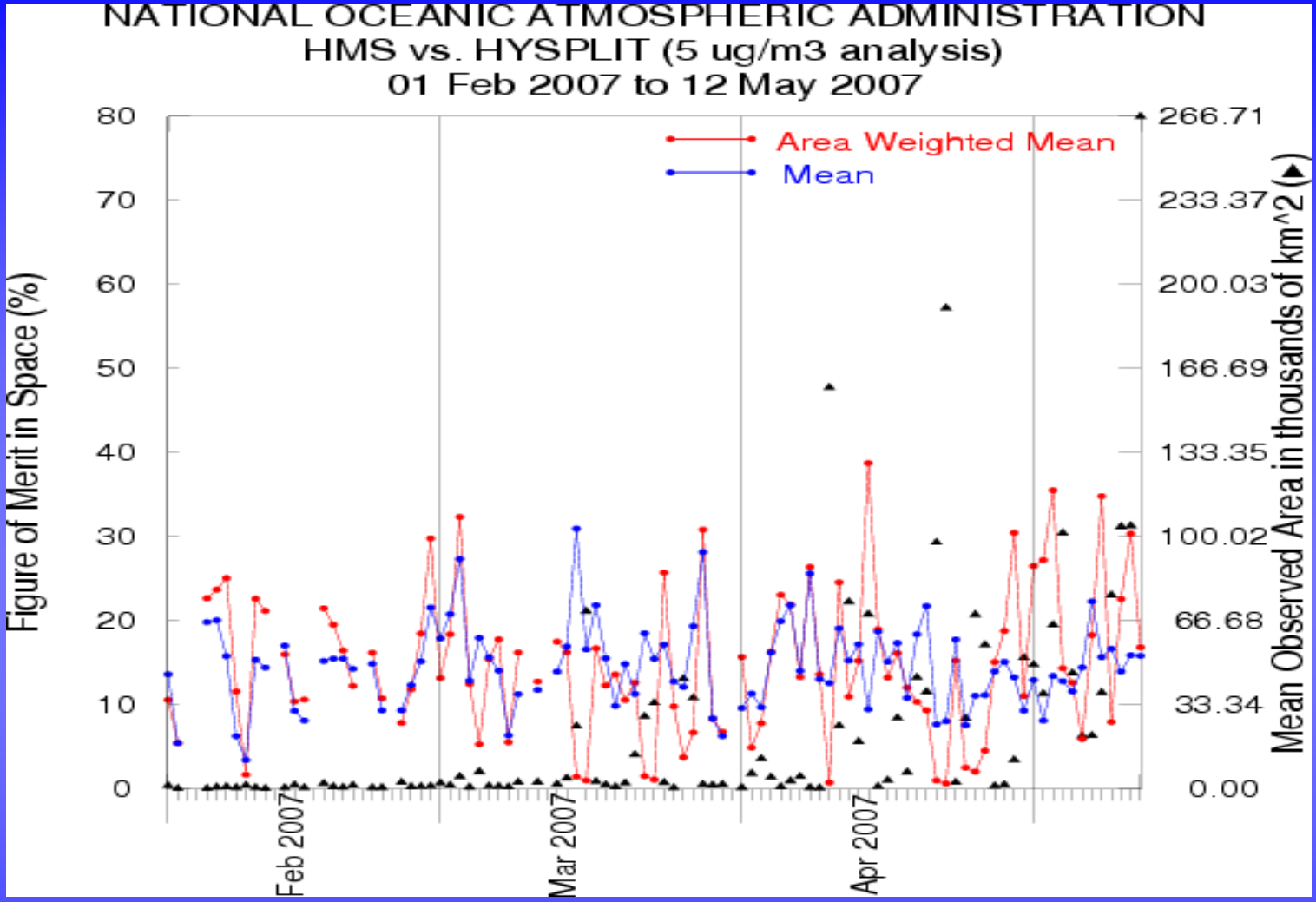
19 April 2007

Analysis portion of HYSPLIT run





These statistics are for 5 ug/m3 HYSPLIT values



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.

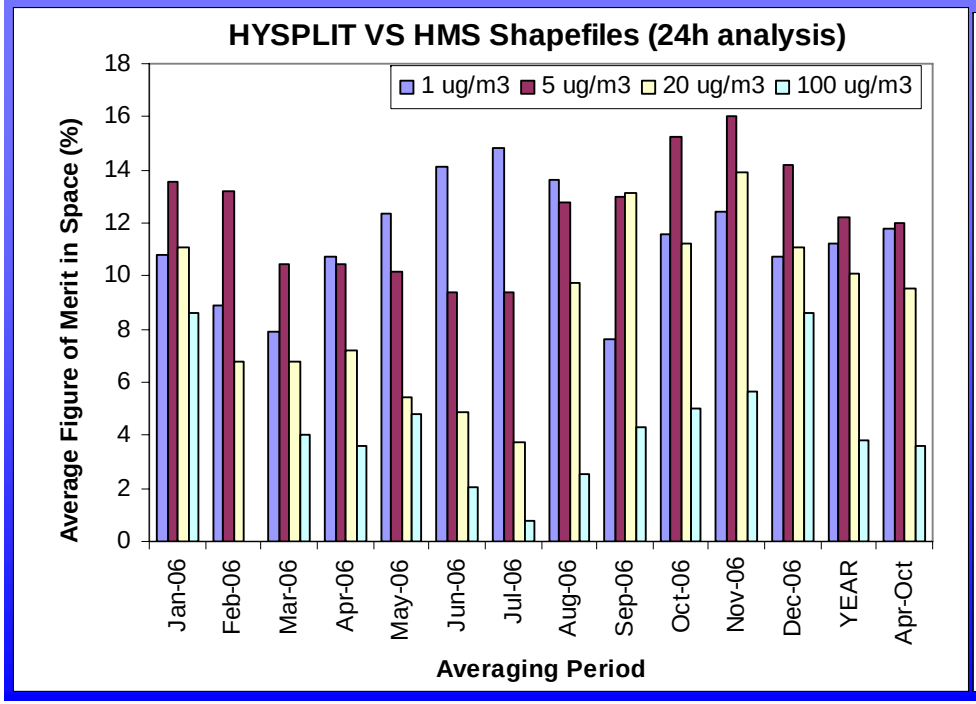
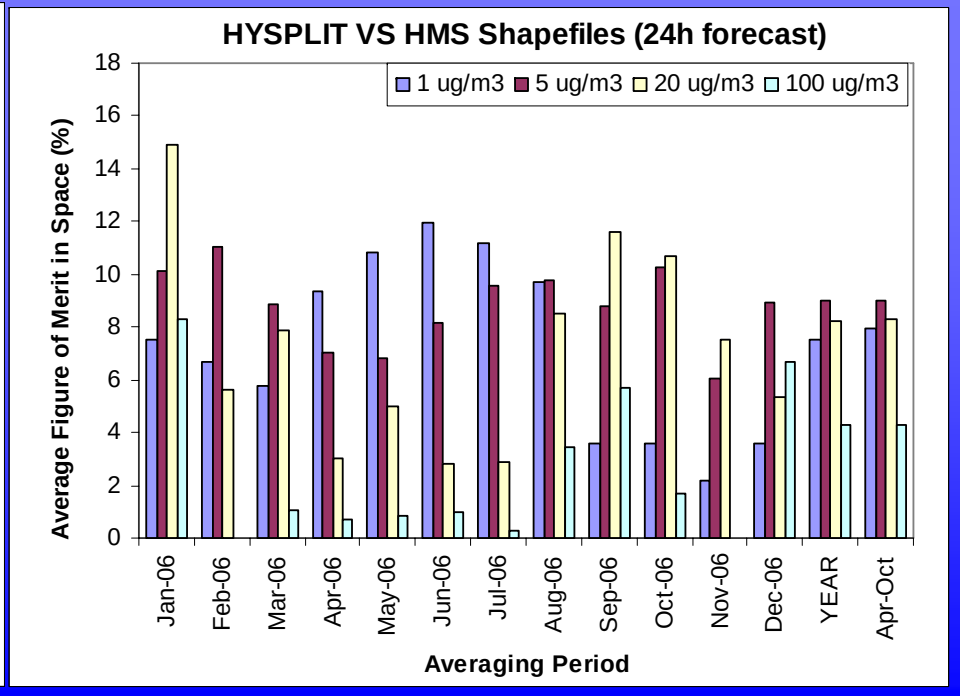


Figure 5b. 2006 monthly average Figure of Merit (FMS) scores for the 24 hour forecast.



Additional contributors who have made the system possible

Donna Mcnamara
George Stephens
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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/