THE HAZARD MAPPING SYSTEM AND THE TRANSFER OF THIS TECHNOLOGY FOR GLOBAL FIRE AND SMOKE EMISSIONS

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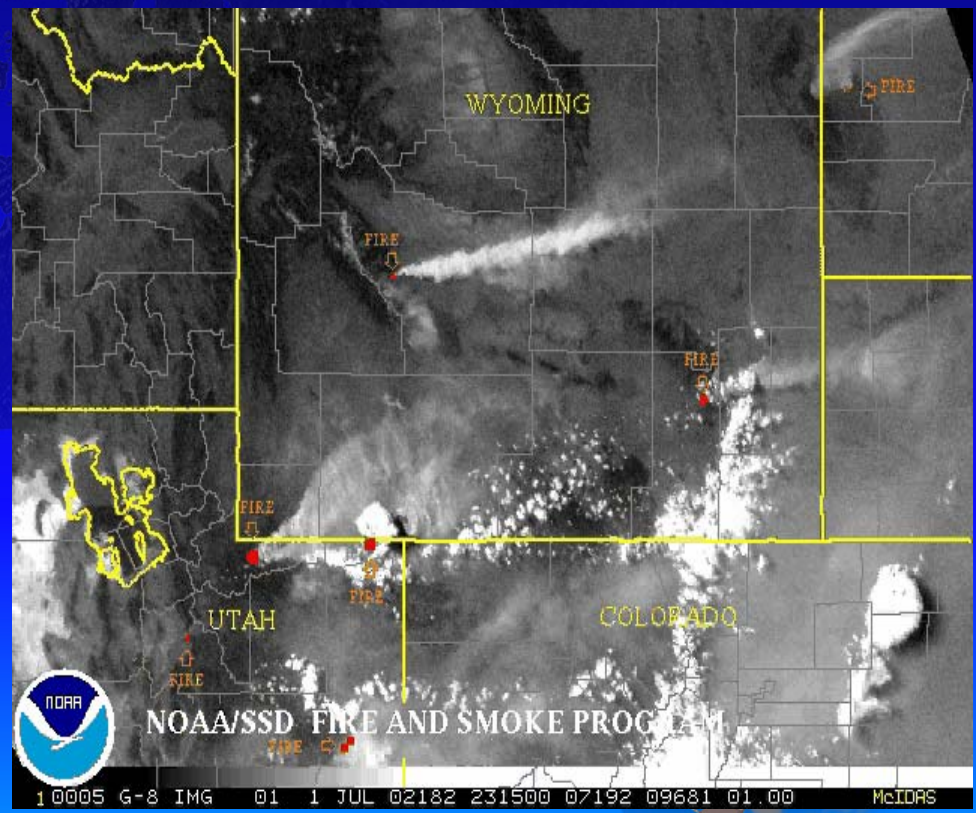
2nd Workshop on Geostationary Fire Monitoring and Applications
December 4-6, 2006, EUMETSAT, Darmstadt, Germany

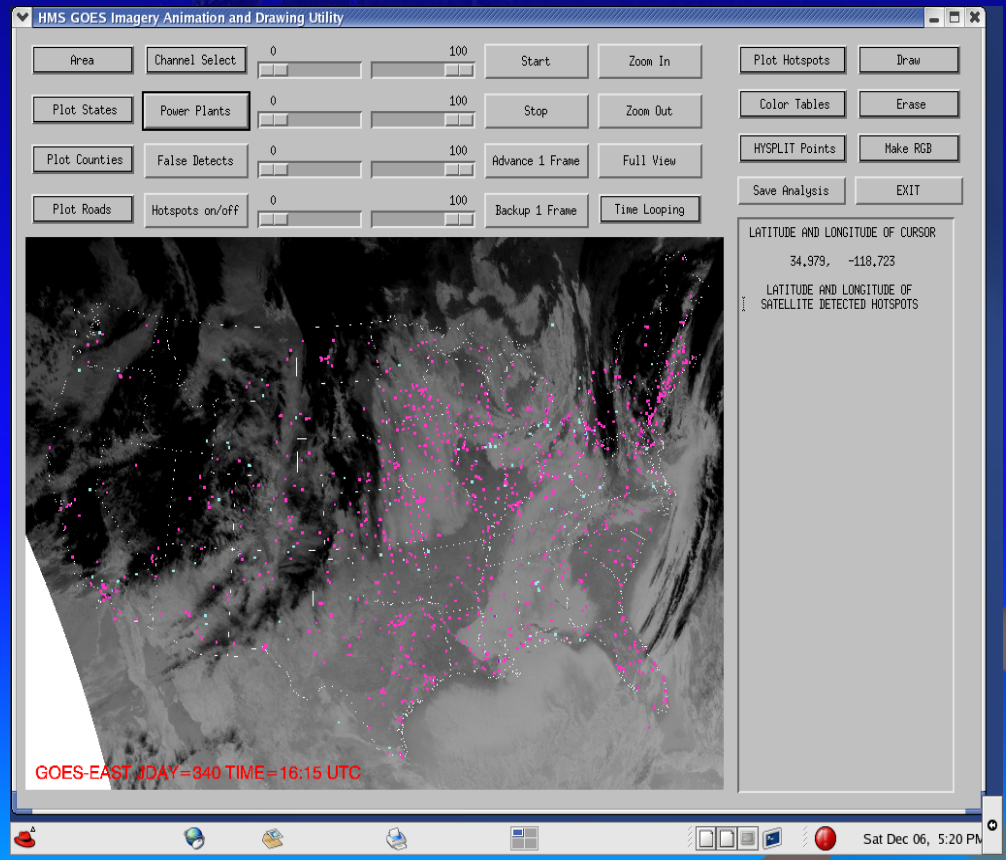
MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

In 1998 NOAA/NESDIS began a fire and smoke analysis as smoke from Mexico began moving into the southern US and affecting health, transportation and other forms of industry. The analysis at the time was done in the format of individual sectors.



MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

- **In July 2002 the fire and smoke analysis began on the Hazard Mapping System (HMS) for the continental US and eventually Alaska, Hawaii, Canada and Mexico/Central America.**



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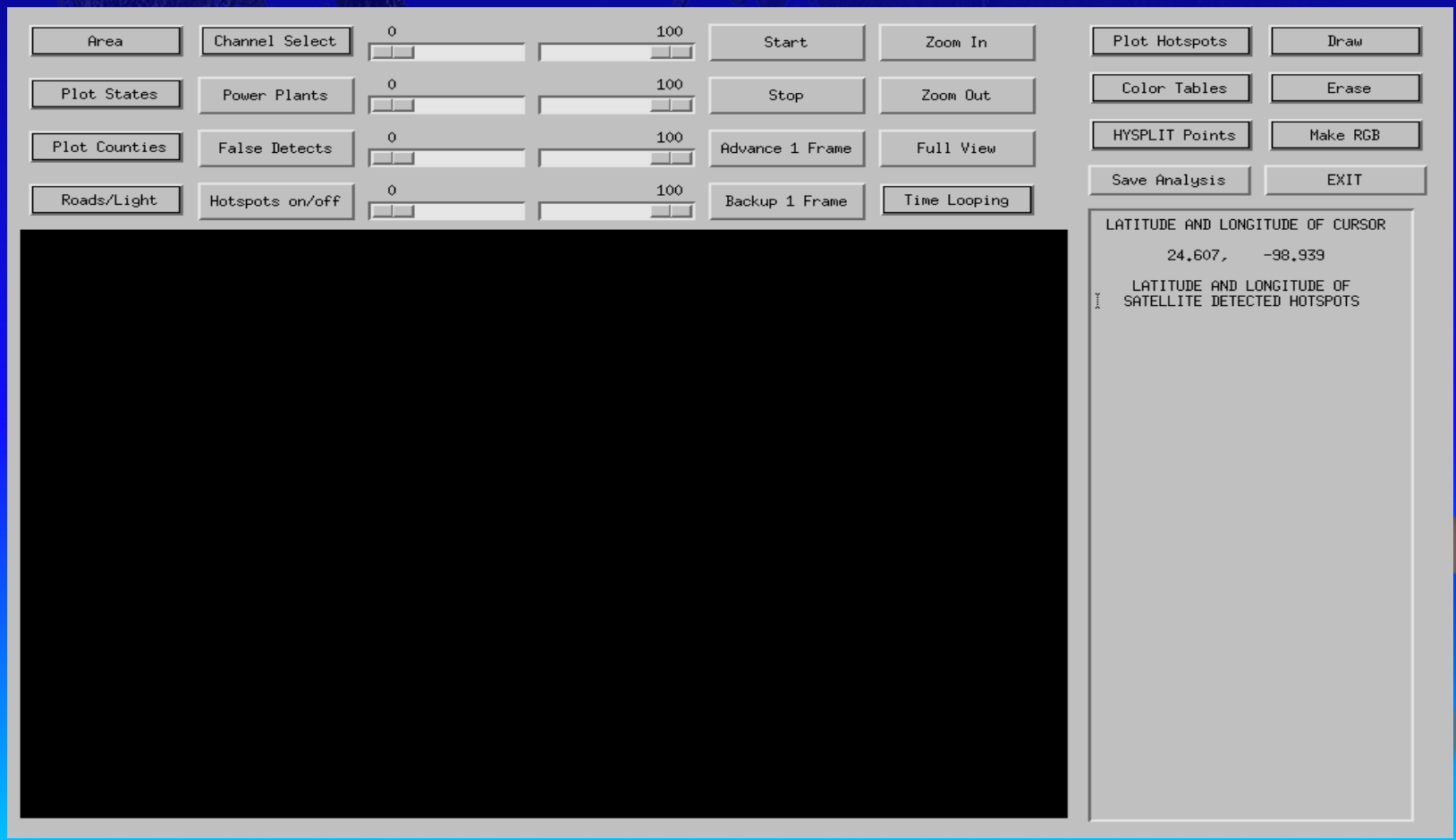
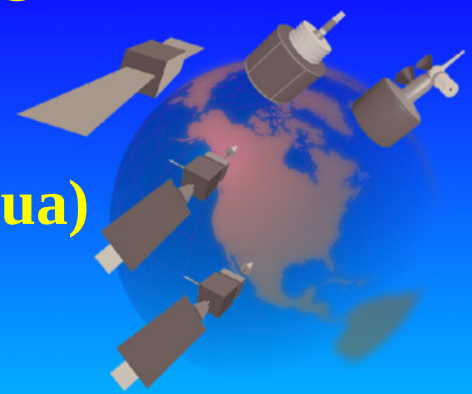
The HMS GUI



MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

AUTOMATED FIRE DETECTION ALGORITHMS USED IN THE HMS

- **Wildfire – Automated Biomass Burning Algorithm (WF-ABBA) for GOES**
- **Fire Identification, Mapping and Monitoring Algorithm (FIMMA) for NOAA AVHRR**
- **MODIS MOD14 for MODIS (Terra and Aqua)**



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SATELLITES CURRENTLY USED FOR FIRE AND SMOKE DETECTION

- GOES 12 and GOES 11
- NOAA 15, 17 and 18
- MODIS AQUA AND TERRA
- Future: OMI and METOP

Over 100 looks per day in areas of GOES-East and GOES-West overlap.

Two looks per satellite per day with Polar spacecraft in mid latitudes – more at high latitudes

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

THE FIRE AND SMOKE ANALYST

THEIR JOB

- Quality checks the fire points produced by the ABBA, FIMMA and MODIS algorithms by looking at the associated satellite data.
- Draws in the smoke produced by the fires. The analyst can identify the smoke as light, moderate or thick with an assigned numerical value for each plume.
- Provides locations of significant smoke producing fires as input to the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model which provides a 48 hour forecast of the smoke.

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

WHY DO WE NEED INPUT FROM FIRE AND SMOKE ANALYST AND ARE NOT THE ALGORITHS GOOD ENOUGH?

1. The reflectivity from the edge of cloud bands can be mistaken for fires by the algorithms.
2. Sun glint off water surfaces at high sun angles can generate false detects by the algorithm.
3. Urban Heat Islands and certain land types can cause the algorithm to identify false detects as fires.
4. The algorithms do not pick up all fires due to a number of reasons.
   - A. Fire does not burn hot enough or fire duration is too short
   - B. Screens are inserted into the algorithm to eliminate false detects, but sometimes they actually eliminate real fires.
   - C. Canopy issues – fires in a heavily forested area.
   - D. Many more.....

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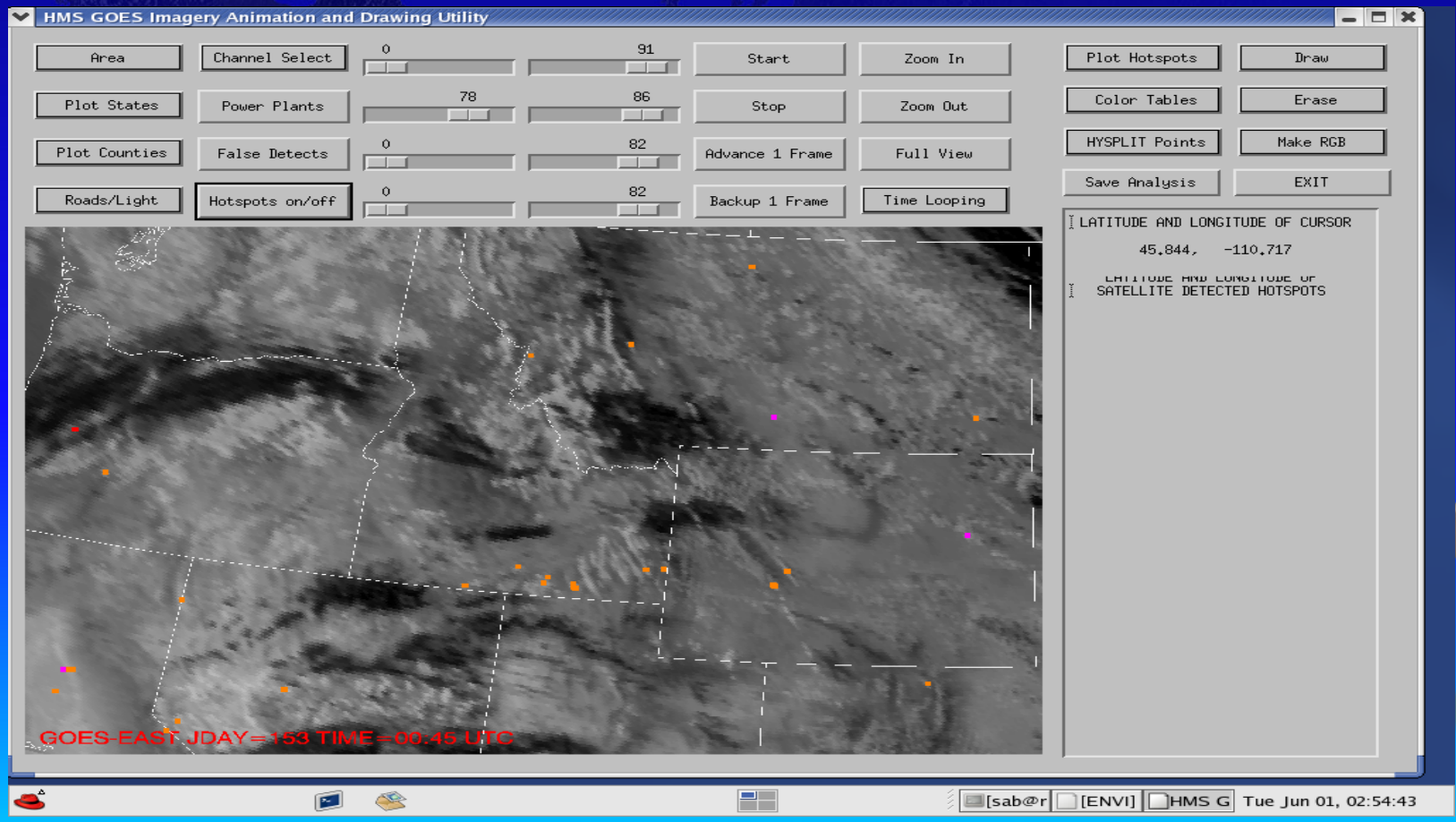
HIGHLY REFLECTIVE CLOUDS IDENTIFIED AS FIRES



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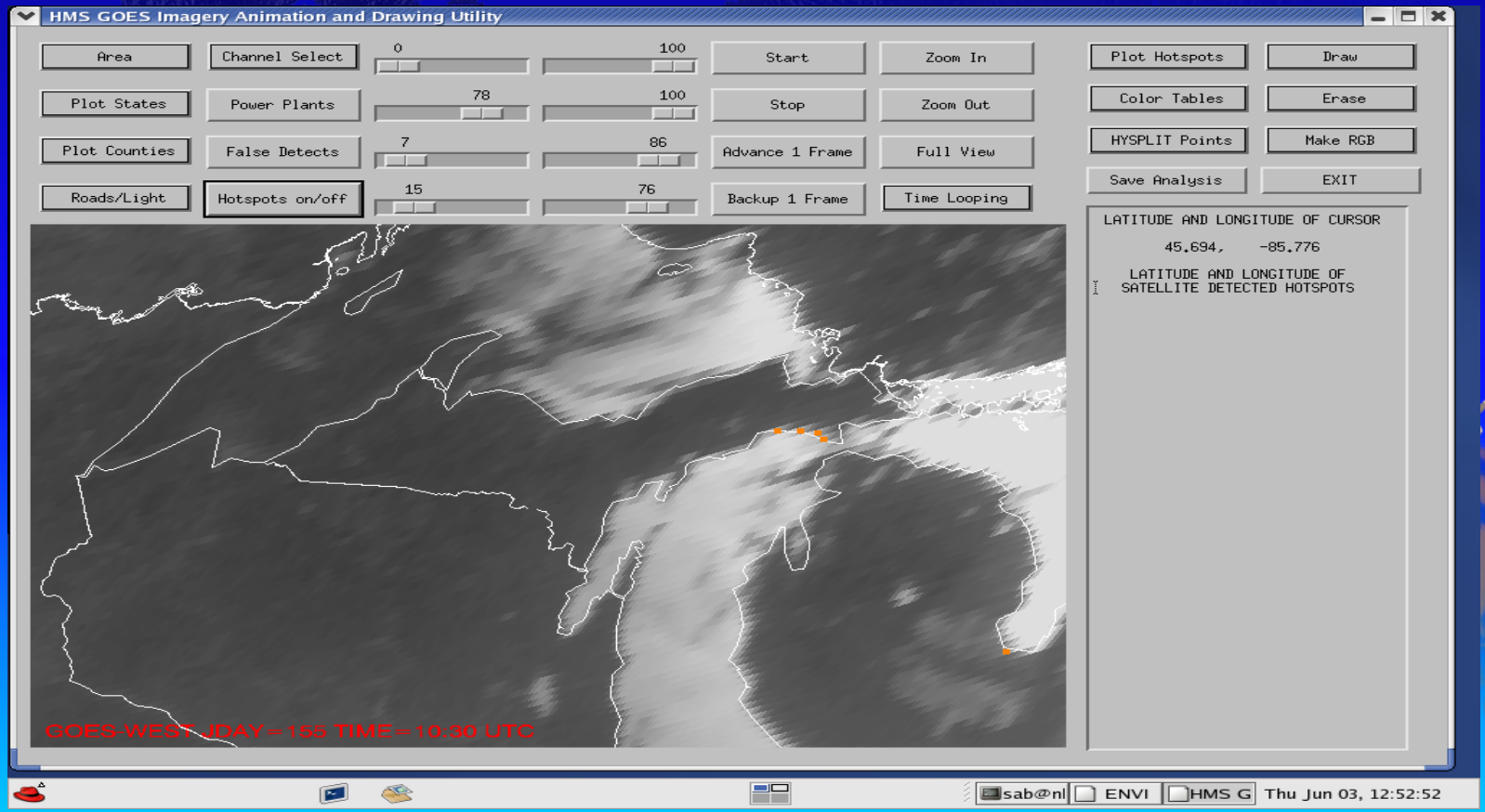
SUN GLINT OFF WATER SURFACES AT HIGH SUN ANGLES



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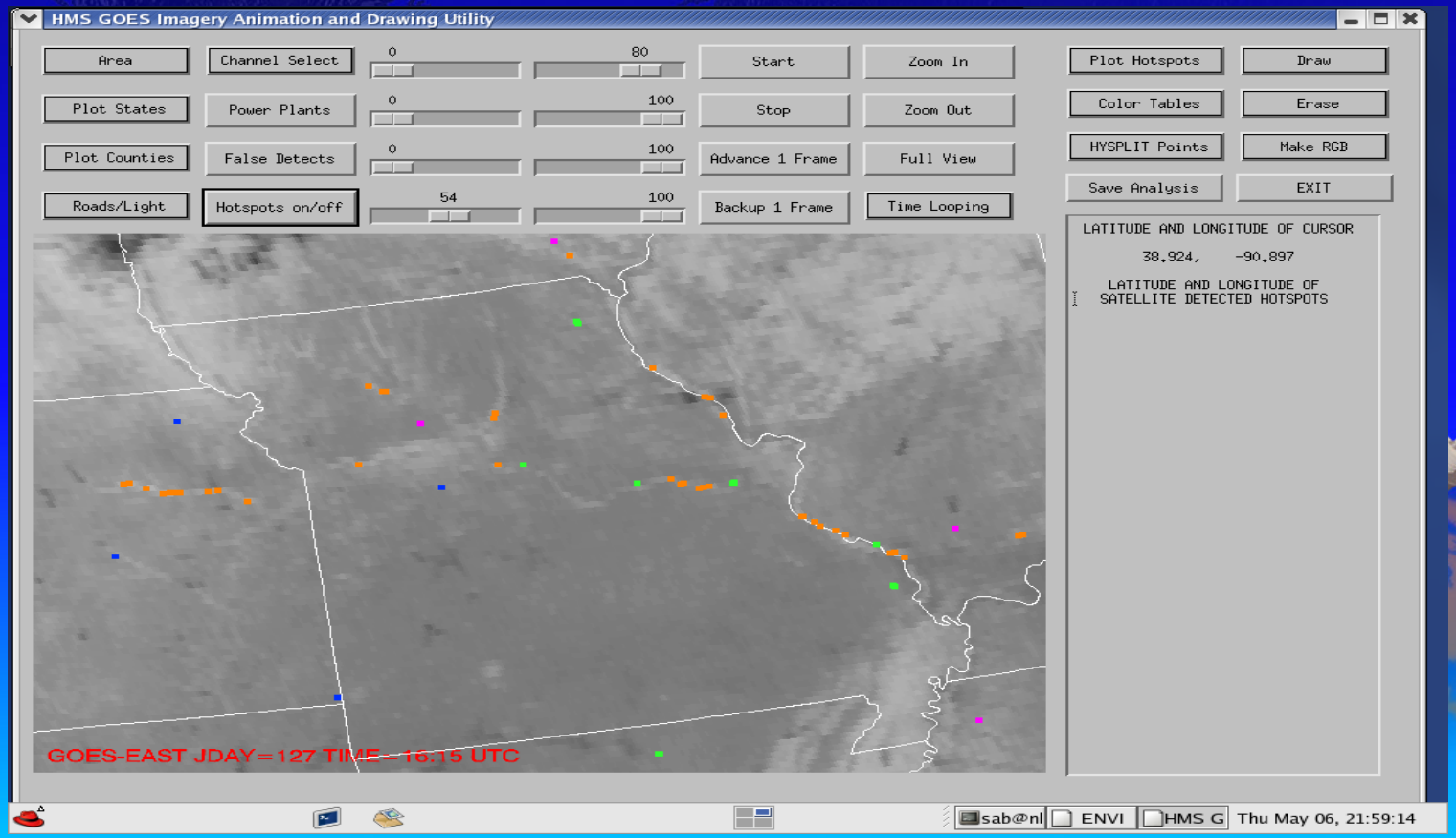
URBAN HEAT ISLANDS AND LAND TYPES CAN CAUSE FALSE DETECTS



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SHORT DURATION AGRICULTURAL/PRESCRIBED

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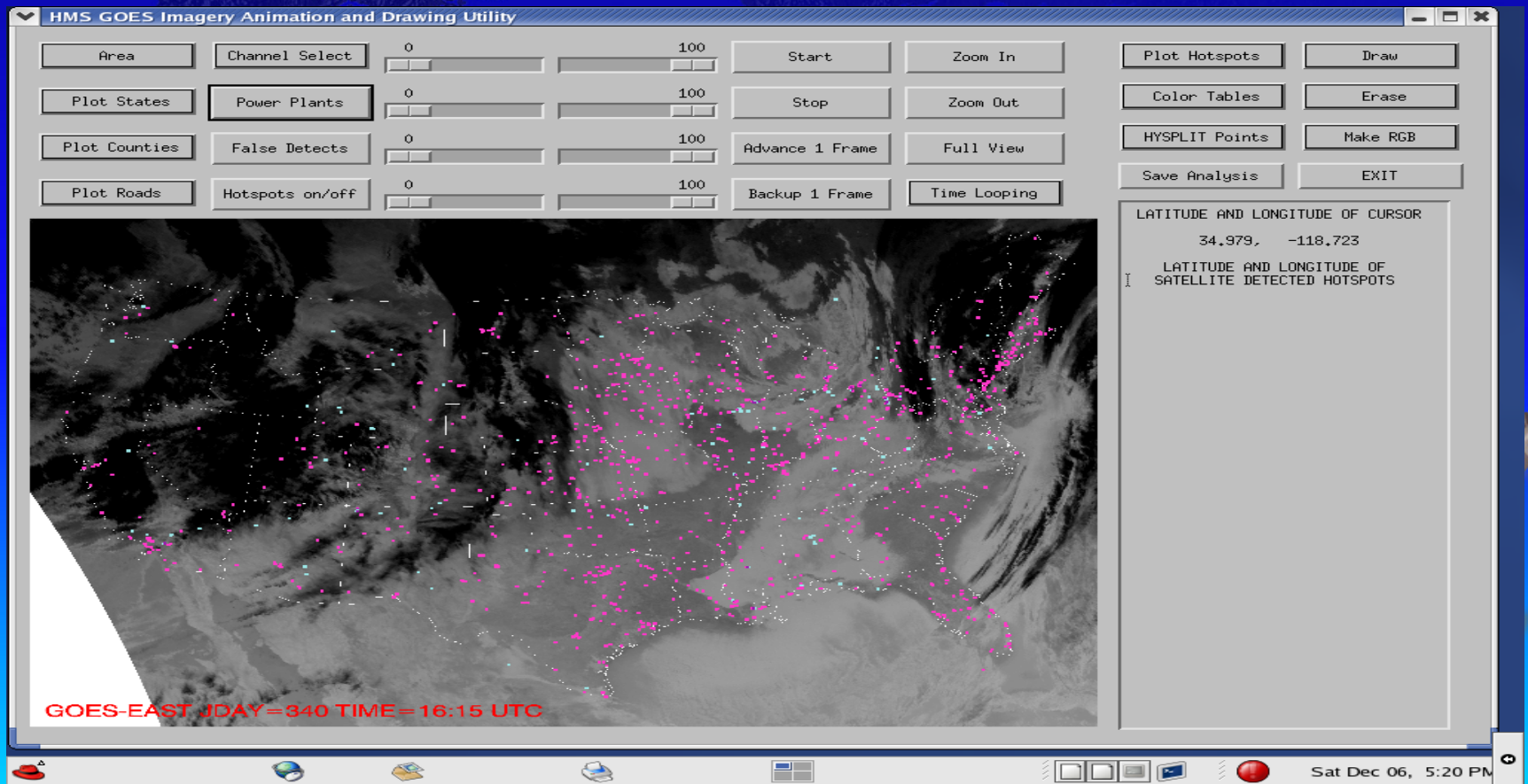
HMS GUI WITH POWER PLANTS AND KNOW FALSE ALARM LOCATIONS



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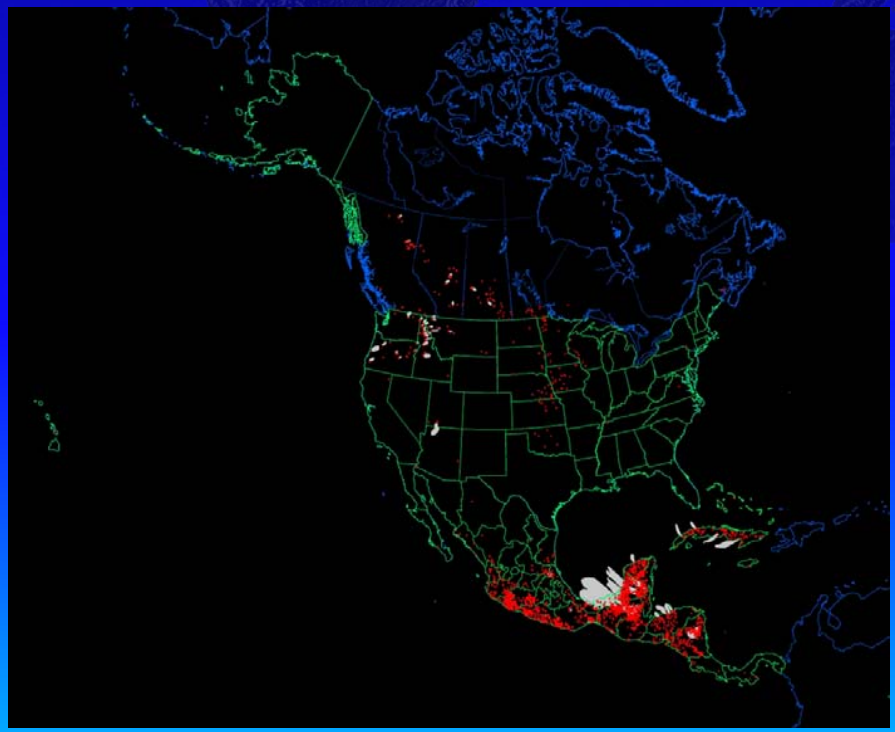
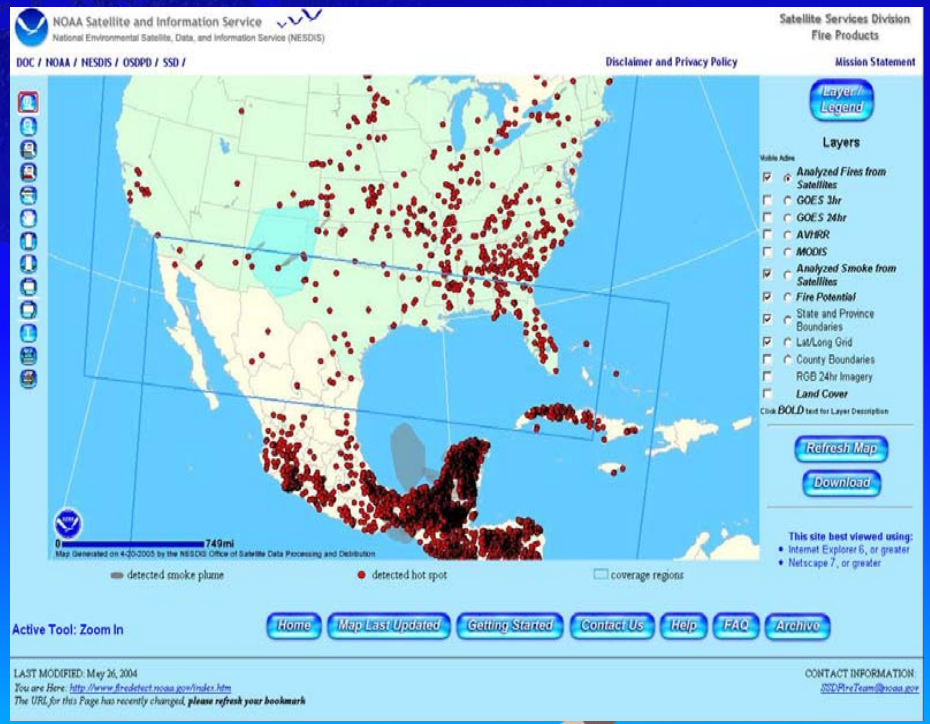
HMS GRAPHICAL OUTPUT IN A STATIC JPG AND GIS





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What is done with the smoke after analyzing it.

1. The analyst provides input to the HYSPLIT in the following ways:

   A. Identifies the duration of the smoke being produced by the fire.

   B. Number of HYSPLIT points determined by the amount of smoke and/or areal extent of the fire

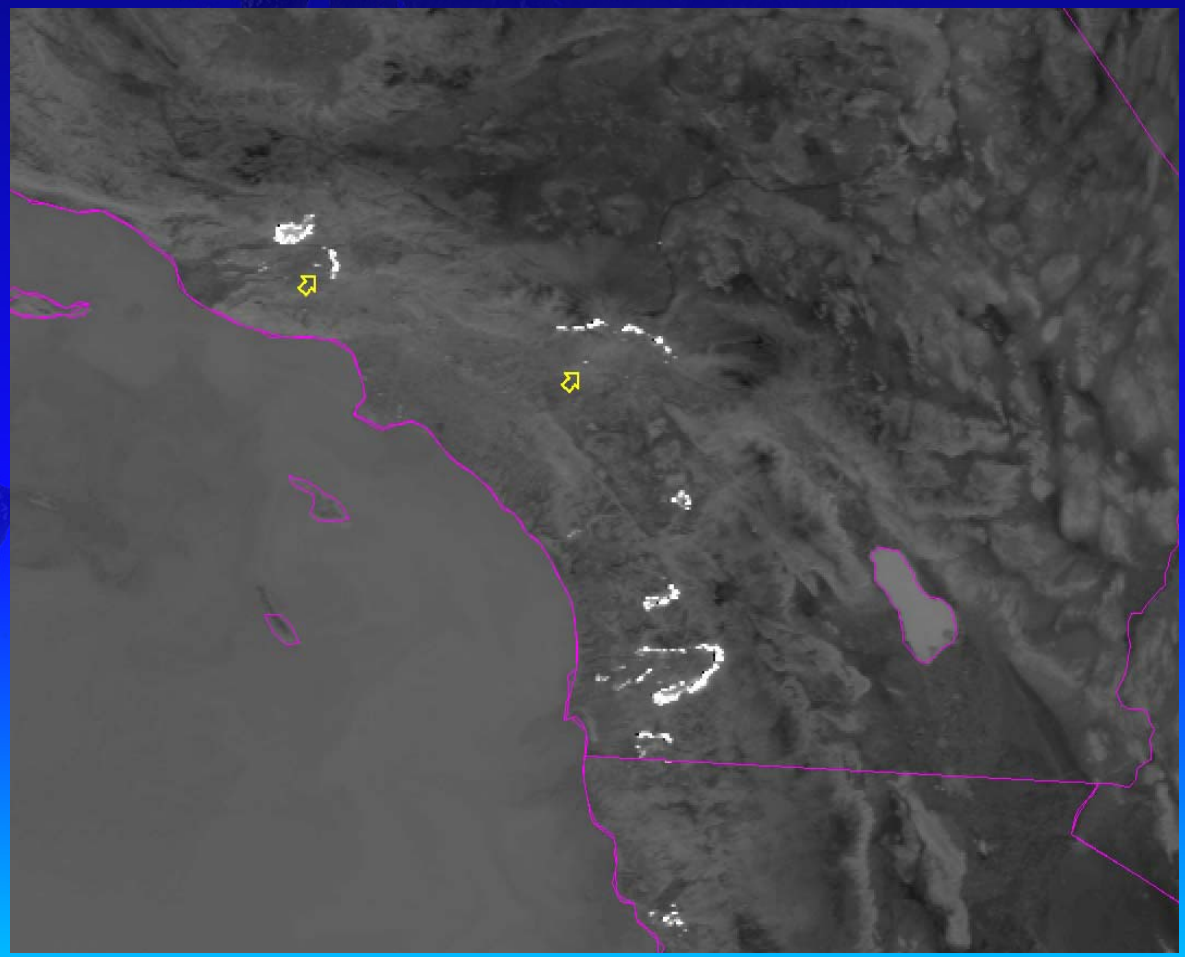
   C. Each Point represents 1 square km.

2. Text product describing smoke and blowing dust. The analyst will describe the location of the fire, how thick the smoke is and where the smoke is moving by mentioning states, regions counties, roads, national forest, and etc.

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Arrows pointing to single pixel (~1km^2) hotspots.

Each of the large fires would be represented by 20-30 or more points as input to an emission model



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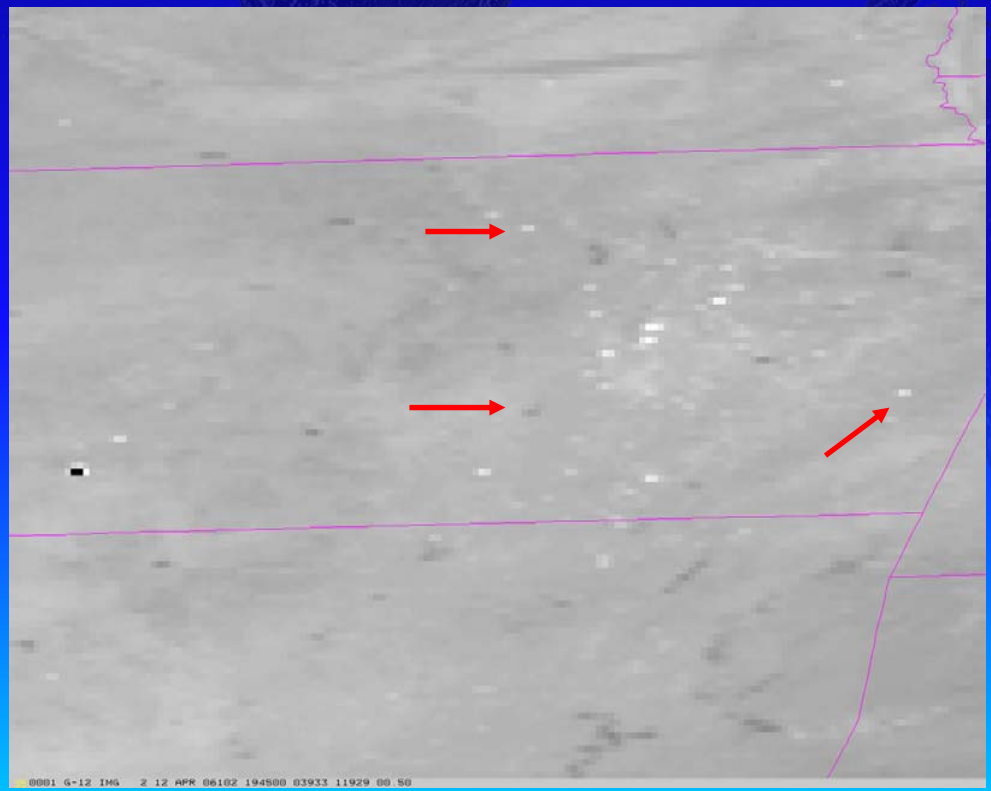
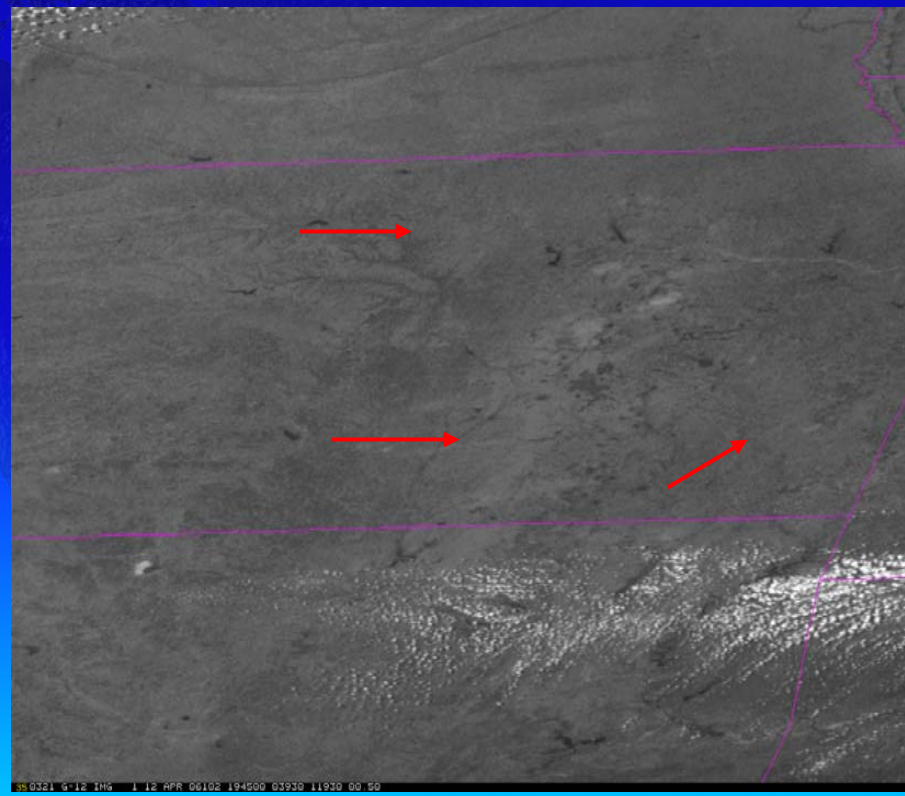
Analyst can determine the duration of the smoke being produced by the fire



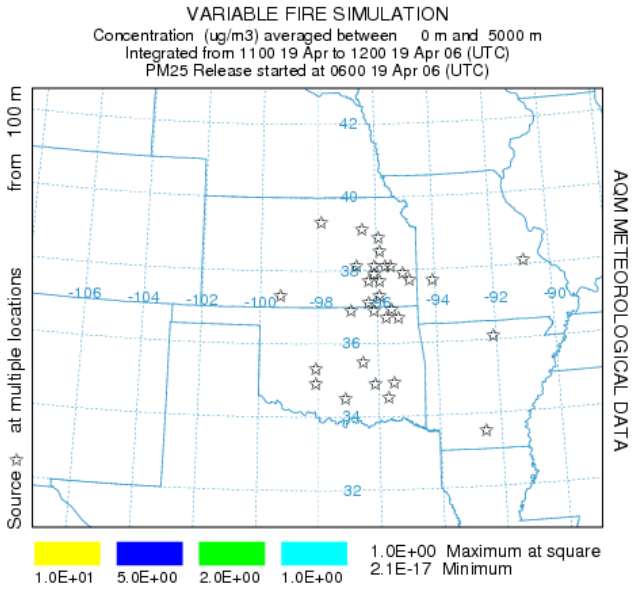


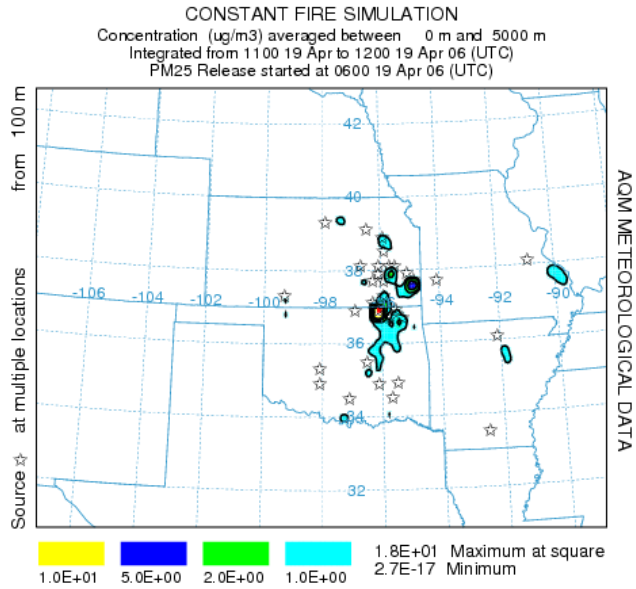
MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Recent Changes to the HYSPLIT INPUT

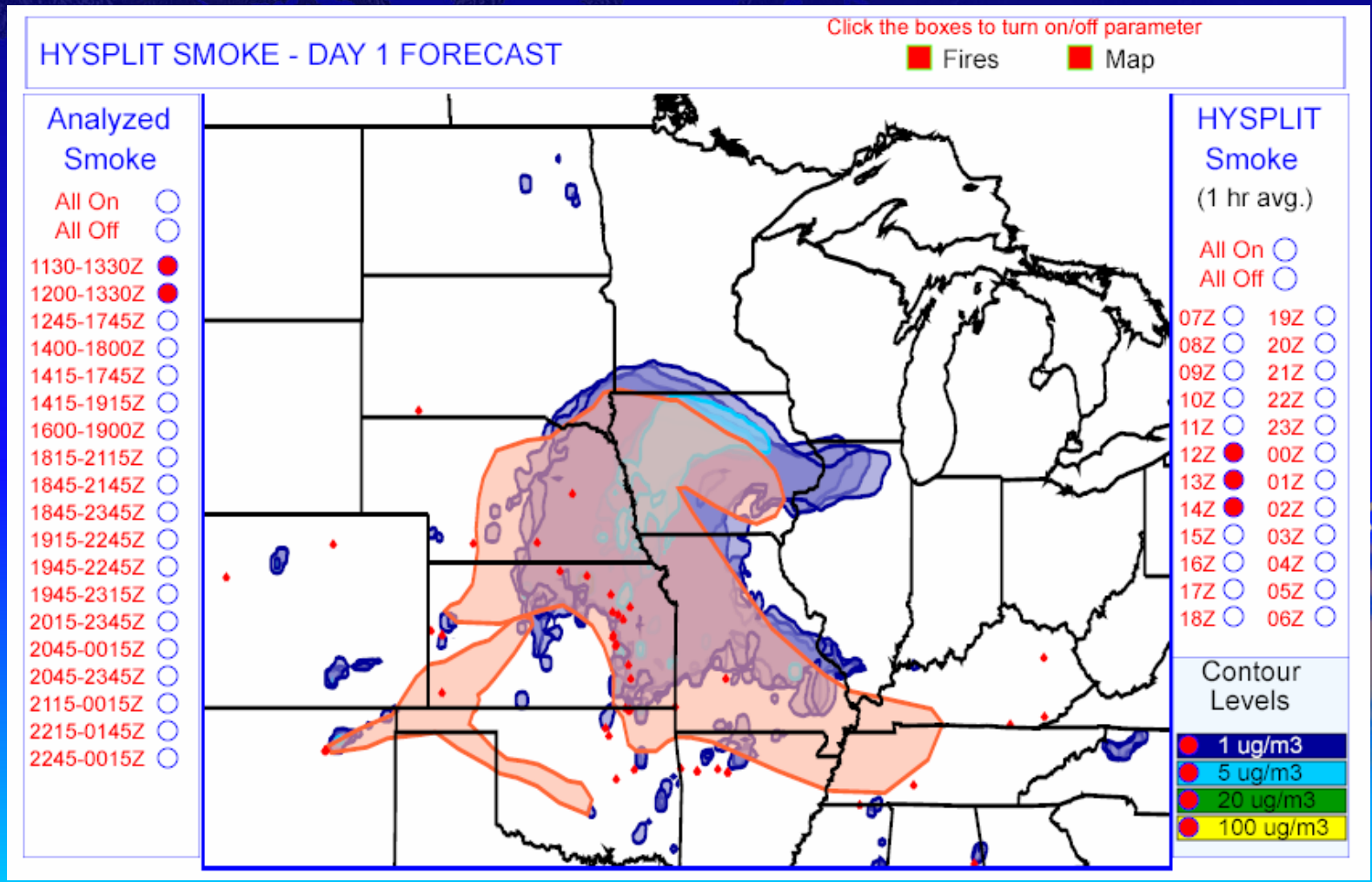
1. **HYSPLIT switched from using constant emission rate for all input locations to using BlueSky framework in 2005 BlueSky emissions are variable and dependent on land use/vegetation type, fuel loading, moisture, consumption, etc.**
2. **In May 2006 analyst began supplying start/end times for smoke emitting fires.**
   This allows for specification of short duration agricultural and prescribed burns as well as replicating the diurnal variations observed in wildfires (seen in previous slides).

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM





MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM



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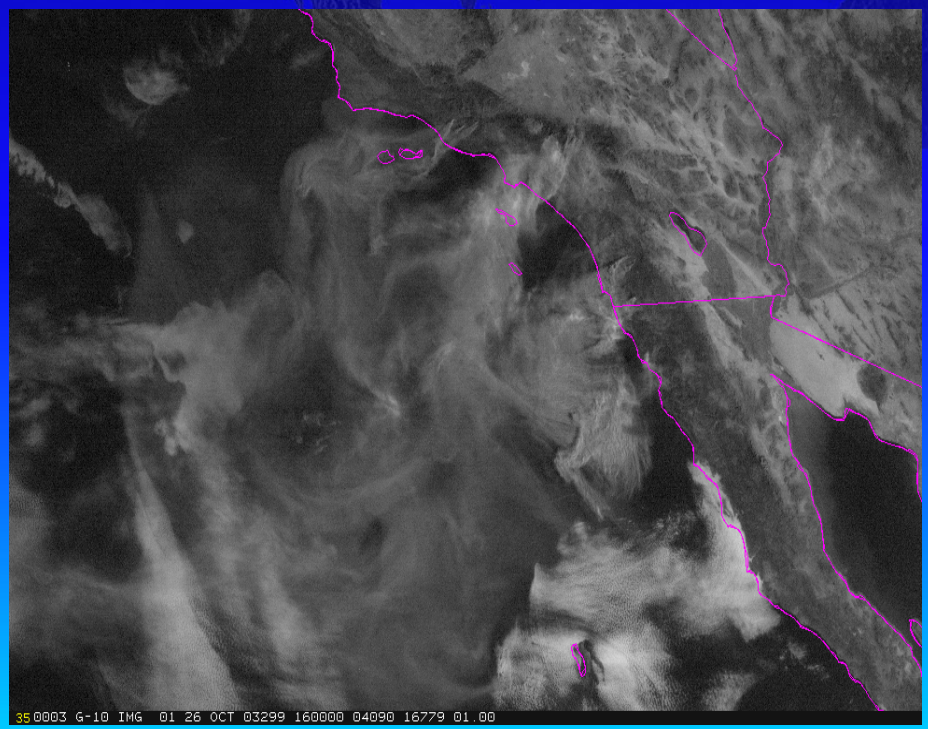
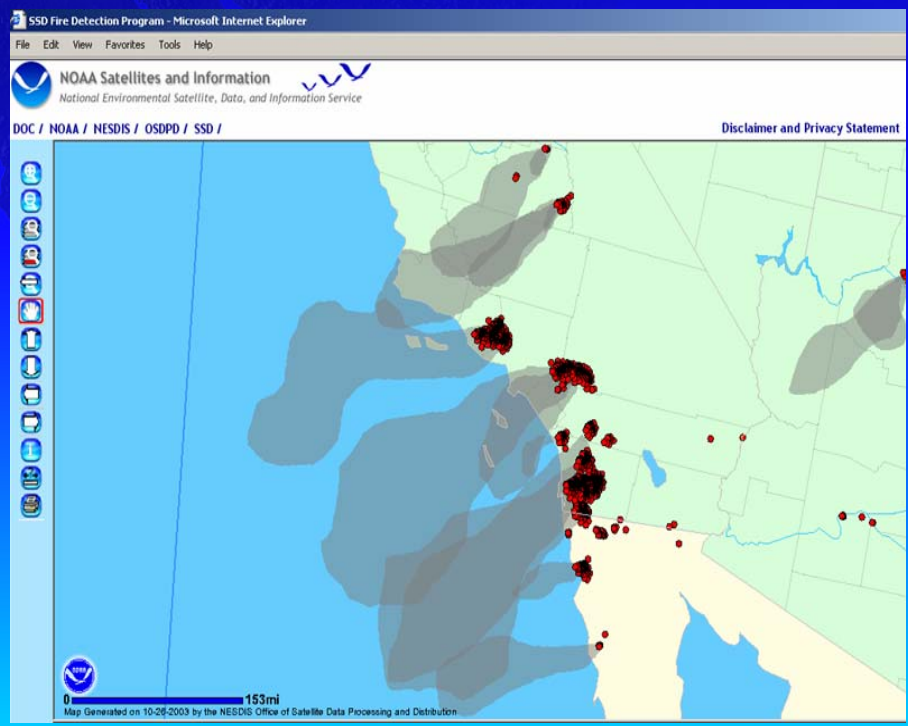
Individual GIS smoke plume shapefiles are tagged with observation start/end times





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SMOKE TEXT PRODUCT

Tuesday October 24, 2006 DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 0130Z October 25, 2006

California: A wildfire burning in the Sequoia National Park (Tulare county) is producing an area of moderately dense smoke moving south across southeastern California. In the Lassen National Park (Tehama county), a fire is emitting an area of moderately dense smoke moving east SE into Lassen and Plumas counties. Oregon: Multiple fires burning across Klamath counties are producing areas of moderately dense smoke moving east SE. The two fires in the northern part of the county are burning in the Winema National Forest. Another fire in Curry county is emitting moderately dense smoke moving south SW into the Pacific. In Josephine county a fire is emitting a smoke plume moving south SW into northwestern California before reaching the Pacific Coast.

North Dakota/Saskatchewan/Manitoba/Northern Plains: Hundreds of most likely agricultural fires are burning across southern Saskatchewan/Manitoba and North Dakota. There are some fires in the surrounding states. The numerous fires are producing an area of thin smoke across eastern North Dakota and southwest Manitoba and southeast Saskatchewan. There are so many fires trying to find the point source of the smoke is very difficult.

J Kibler

Unless otherwise indicated:

Areas of smoke are analyzed using GOES-EAST and GOES-WEST Visible satellite imagery.
Only a general description of areas of smoke or significant smoke plumes will be analyzed.
A quantitative assessment of the density/amount of particulate or the vertical distribution is not included.
Widespread cloudiness may prevent the detection of smoke even from significant fires.

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Currently we are just drawing smoke outlines of smoke extent

Very soon analysts will begin drawing contours of smoke concentrations.

Contours will be largely influenced by the GOES Aerosol and Smoke Product (GASP)

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Properties of GASP:

Produced ½ hourly from GOES EAST/WEST

Fully automated

Utilizes GOES visible band brightness values

Aerosol Optical Depth (AOD) is converted to concentration using a mass extinction coefficient of 7.9 +/- 4.5 m2/g

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Limitations of GASP (and analyst drawn contours):

There is no vertical structure

Due to dependence on visible imagery, only available during daylight

Clouds hinder detection

GASP does not distinguish between aerosol types – analysts attempt to

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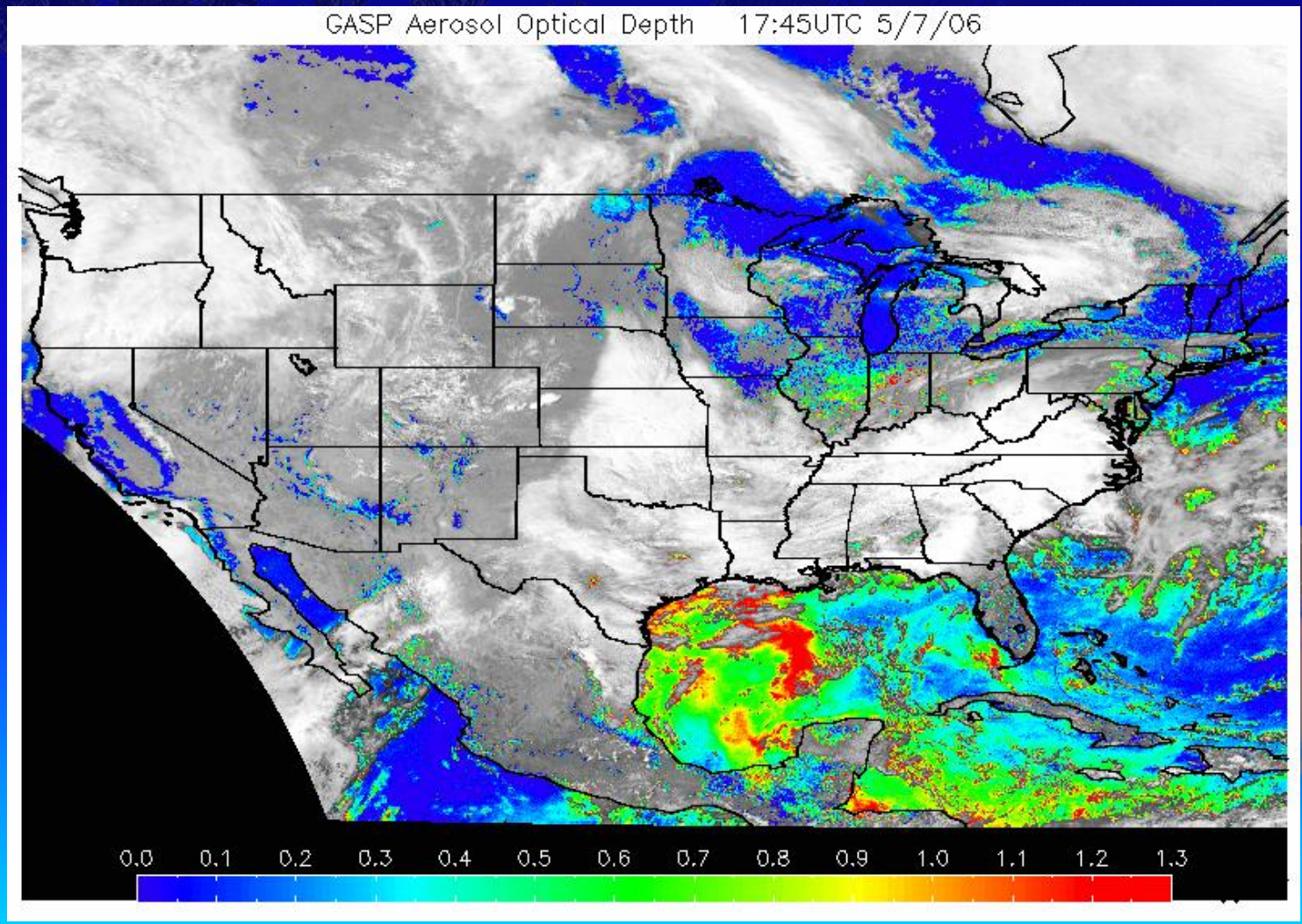

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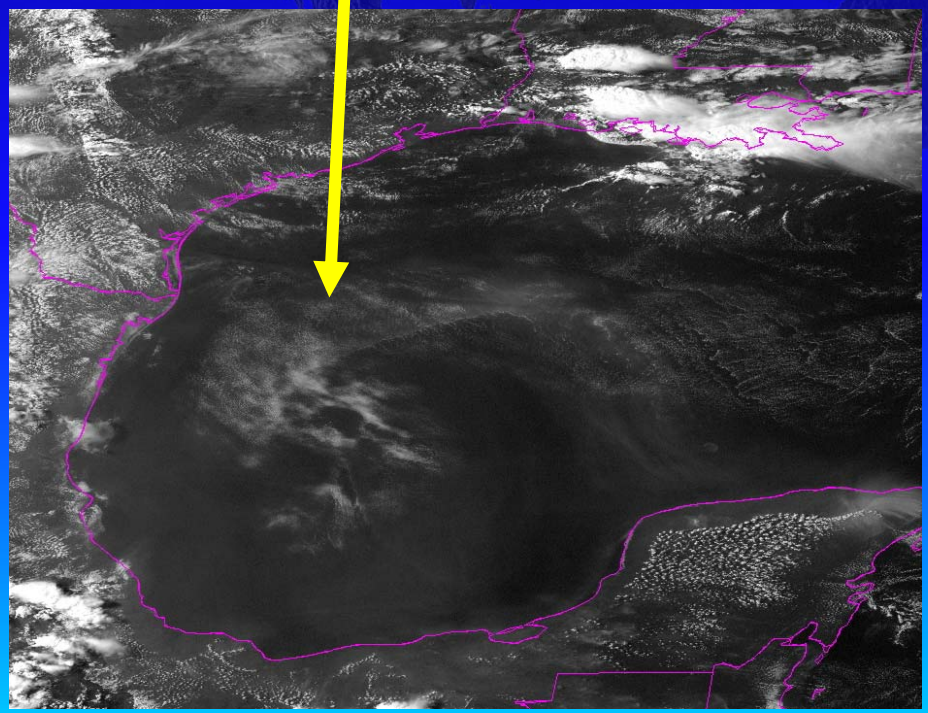
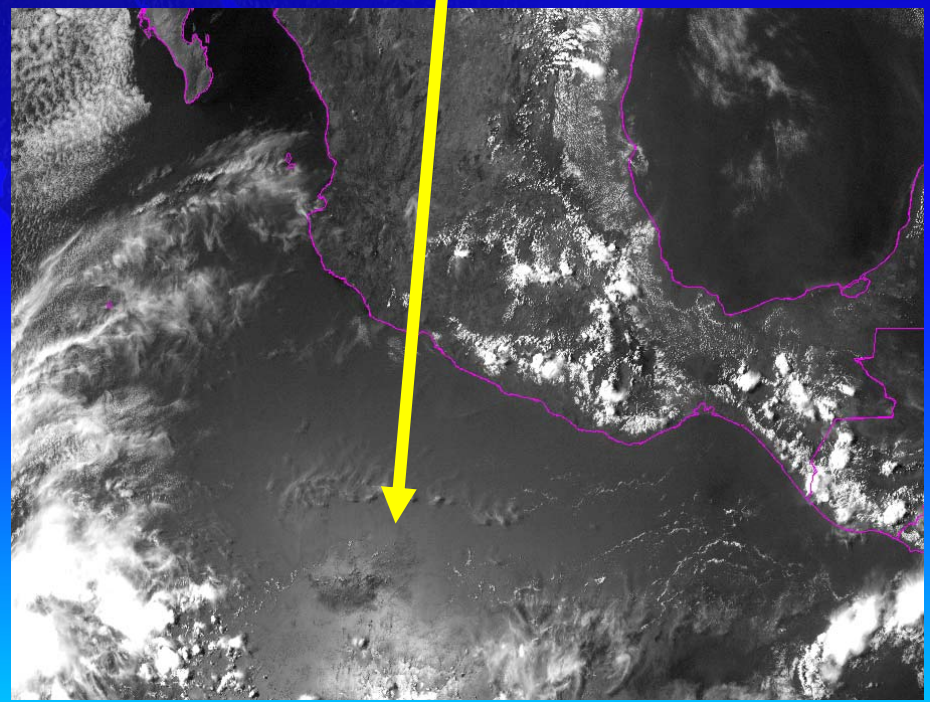
Clouds and sun glint are difficult for GASP to resolve

Clouds mixed with smoke



Sun glint



MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Long range transport of smoke does not adhere to political or geographic boundaries

HMS analysis includes Central America during Spring and Alaska/Canada from late Spring into the Fall during each region's peak burn season

Responsibility for Central American analysis was transferred to the Mexican National Weather Service in Spring 2006

By mid to late 2007 the goal is to have a HMS installed for the Thailand region in the detection of fires and associated smoke.

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Reasons for the Technology Transfer of the HMS to Mexico and Thailand

- Global Air Quality Forecast/Initiatives
- To be used as a tool to combat illegal burning in Central America and Thailand.
- To alert emergency crews of the presence of wildfires across Mexico.
- To have a full integrated North American fire and smoke product.
- Each office produces an analysis for the region they are most familiar with

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

WHAT TOOK PLACE IN THE TRANSFER OF THE HMS TO MEXICO/CENTRAL AMERICA

- In 2004 and 2005 the Partners of the Americas, through the State Department funded The American Fellows Program. This allowed analyst from Mexico and Guatemala to be trained on the HMS and provide analysis for Central America during the Spring fire season in 2004/2005.
- In February – April 2006 the HMS was installed in Mexico in the Servicio Meteorolgoical Nacional (SMN) environment. The ability to run the HYSPLIT to track smoke emissions was acquired. The analysis from Mexico is transferred and merged with that from NESDIS to produce a coherent analysis for North America.
- Future: Provide the framework for the continuation of the program, possibly through a Memorandum of Agreement (MOA) or Memorandum of Understanding (MOU)
- Updates and modifications of the HMS in Mexico

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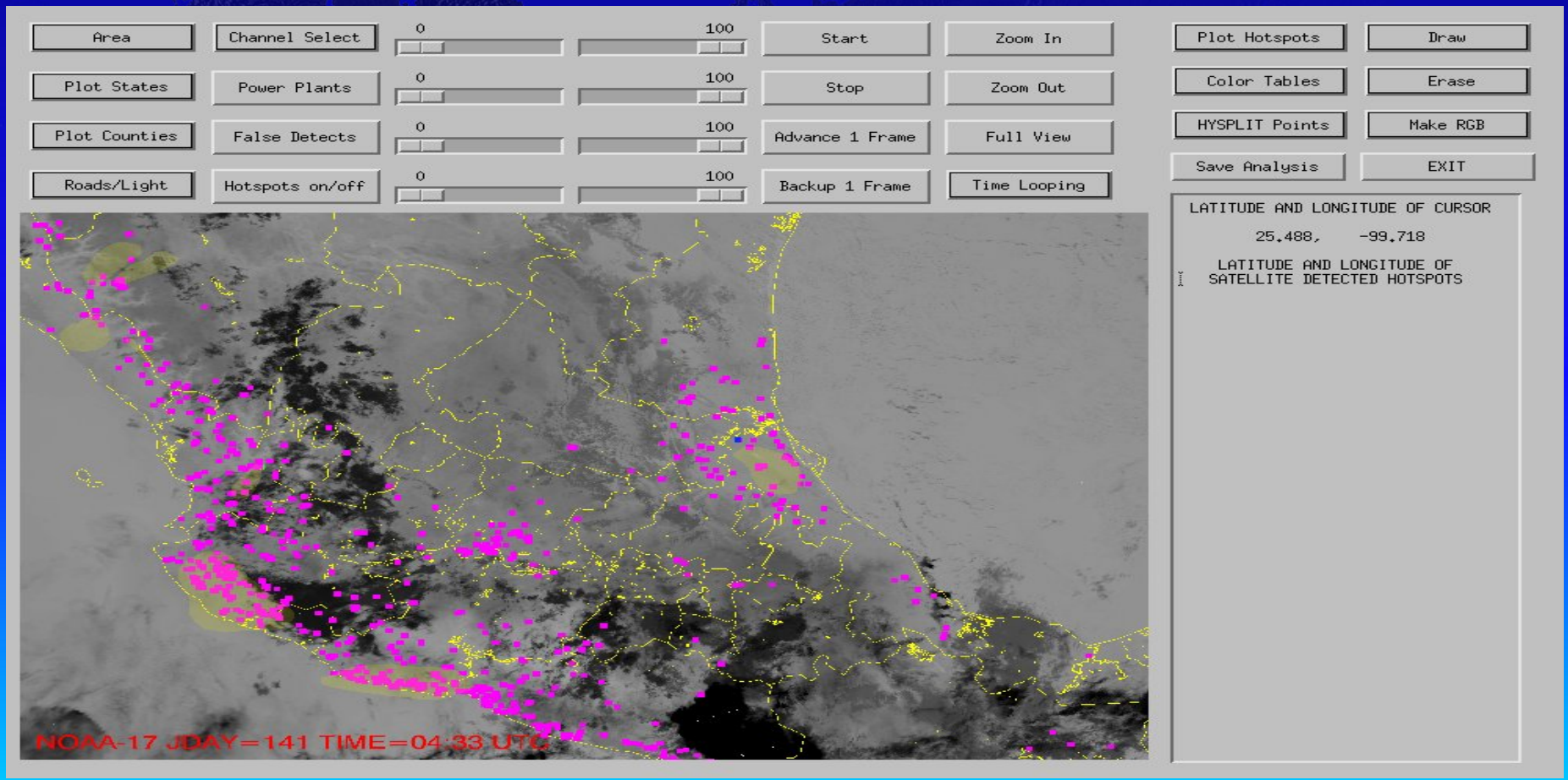
CENTRAL AMERICA HMS GUI



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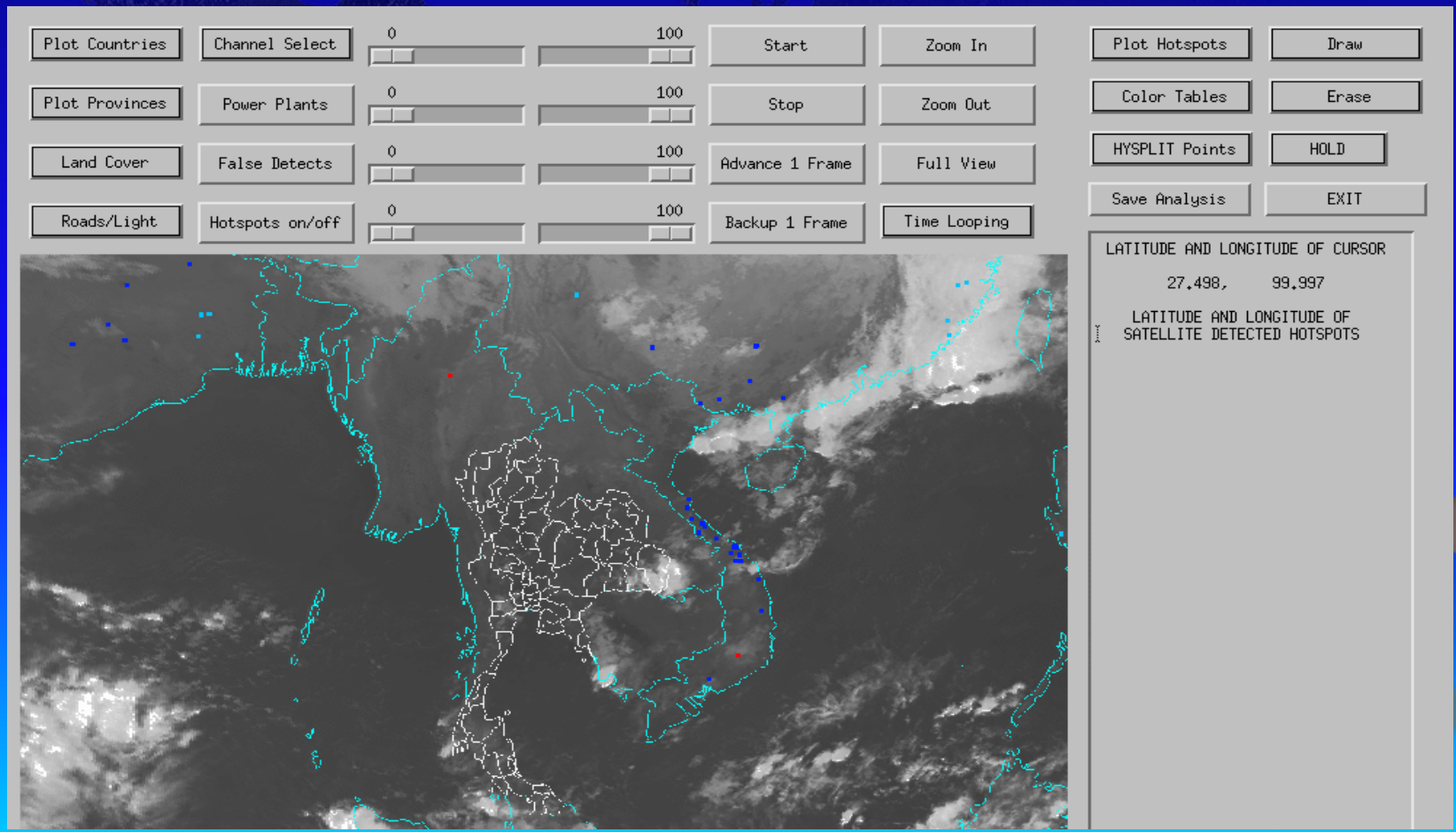
THAILAND HMS GUI: MID/LATE 2007



MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

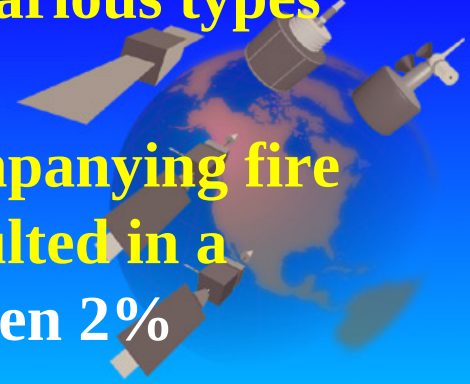
Validation of the HMS

- Primary objective was to verify manual and automated fire points from the MODIS TERRA satellite and near simultaneous GOES images.
- Validation used high resolution imagery from the Advance Spaceborne Thermal emission and Reflection Radiometer (ASTER)
- Due to the availability of ASTER data, study limited to mid to late morning observation hours near center of MODIS images suborbital track.
- AVHRR sensor and MODIS AQUA not included in the study due to the above limitation.

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Results of the MODIS Validation

- Among the 659 MODIS automated detections obtained, ASTER did not detect 28 of them, an indication of a commission error.
- The ASTER scenes verified 9 of the MODIS pixels were adjacent to a ASTER pixel showing an active fire.
- 8 pixels were found to be associated with various types of industrial plants.
- The remaining 11 pixels without an accompanying fire or heat source to explain the detection resulted in a reasonably low commission error of less then 2%



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Results of the GOES Validation

- Among the 103 GOES automated detections obtained, ASTER did not detect 19 of them, an indication of a commission error.
- Visual inspection of the location of the fires confirmed only two pixels as true commission errors.
- Of the remaining 17 detections, 16 pixels were found to have active ASTER fire pixels in the immediate vicinity of the GOES pixel and 1 within two GOES pixels.
- The result was a commission rate of less low commission error of less than 2%.....similar to MODIS

Validation Conclusion

The automated fire products derived from MODIS (MOD14) and GOES (ABBA) are performing reasonably well for the region and time of day studied. Commission errors were relatively small for both products (less than 2%)

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

- **All products available on the Web at:**

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

- **Includes links to**

  archived products
  automated fire algorithms
  GIS page
  HYSPLIT smoke forecasts
  near real time imagery
  GASP imagery
  manual quality controlled analysis

MONITORING FIRE AND SMOKE EMISSIONS WITH THE HAZARD MAPPING SYSTEM

Additional contributors who have made the system possible

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George Stephens
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