# Experimental Smoke Forecast Tool

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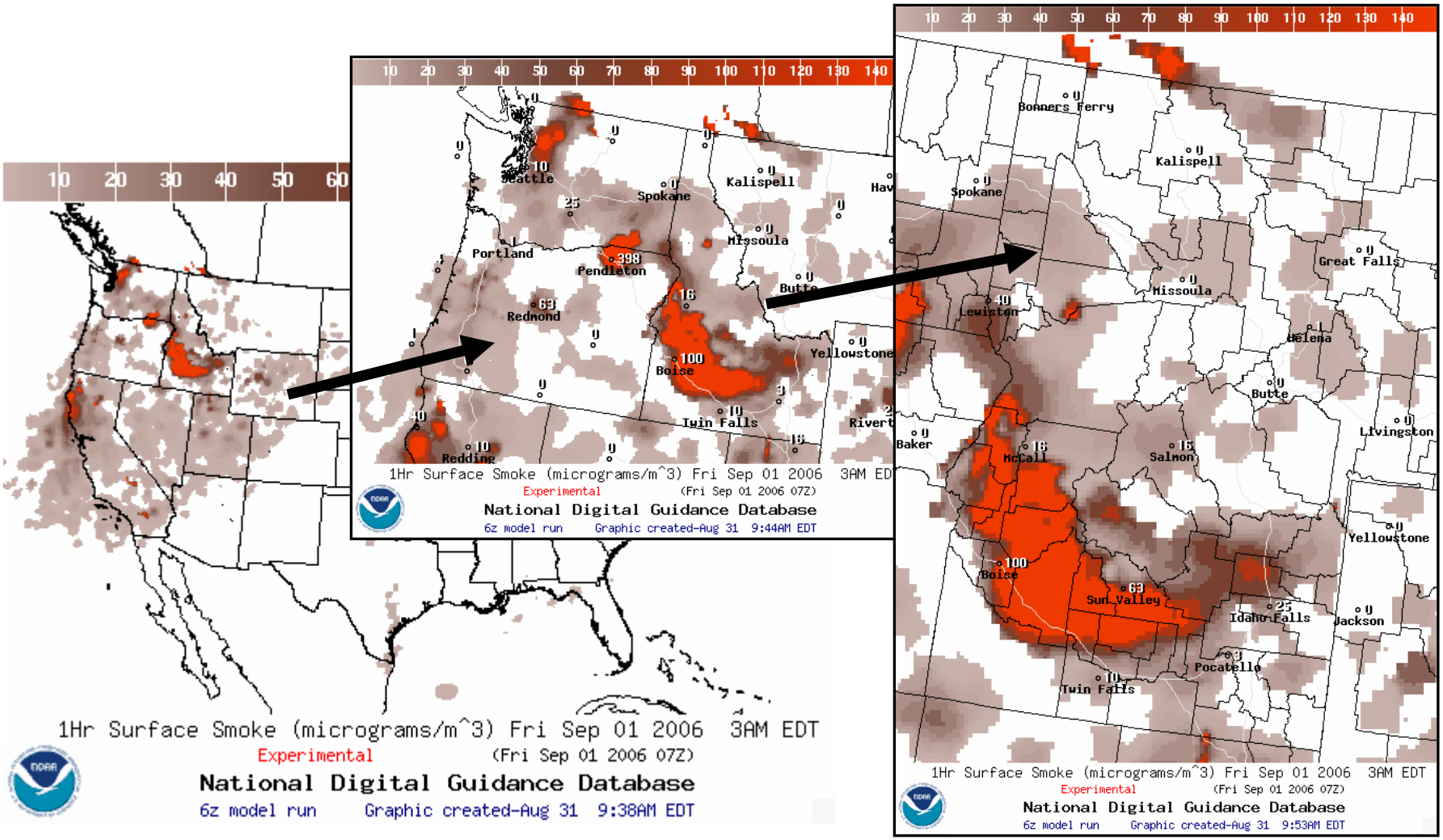
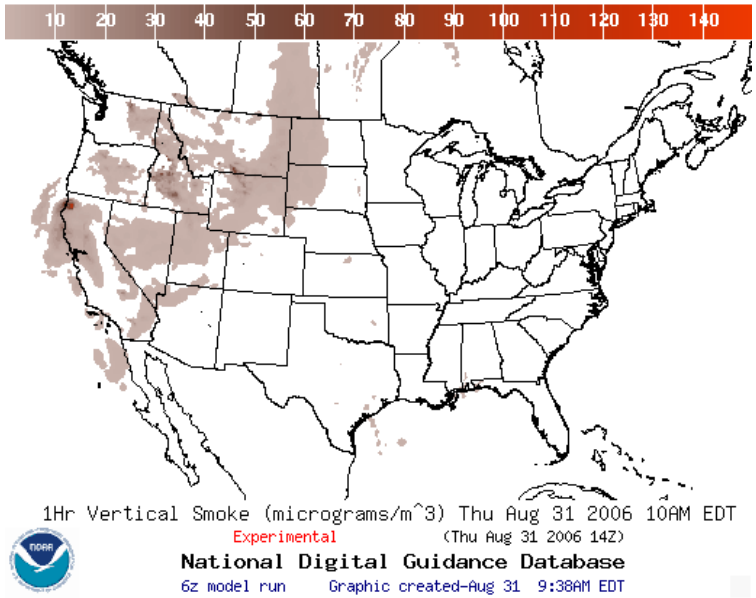
# NGDG Smoke Forecast Guidance Product

## www.weather.gov/aq-expr

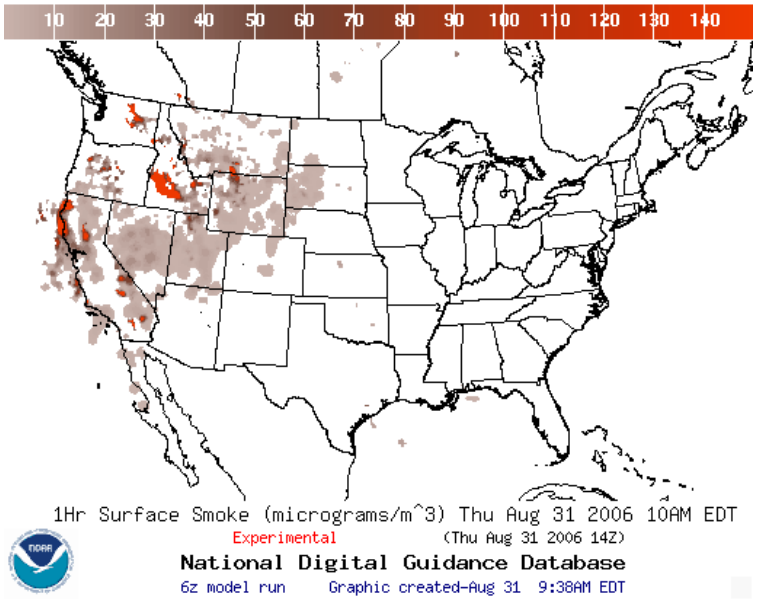


# Sample Smoke Forecast Guidance

**Column Integrated surface to 5000 m hourly averaged**




**Column integrated surface to 100 m hourly averaged**

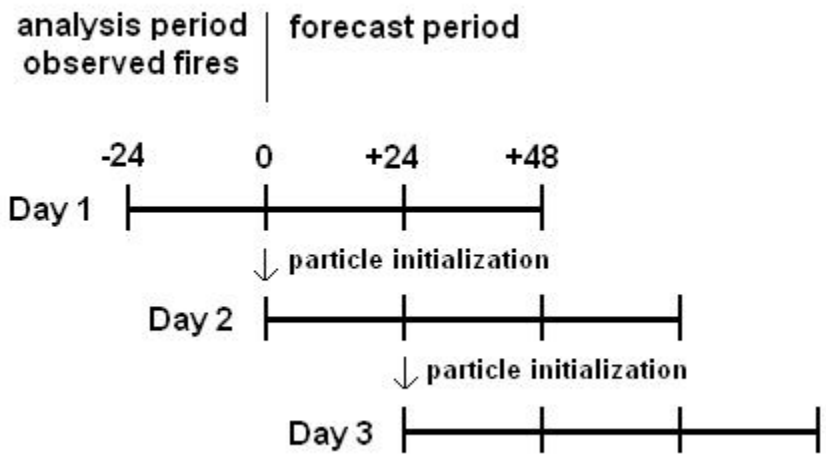


# Experimental Smoke Forecast Tool

## *Overview*

- Experimental testing phase began March 28, 2006
- Run daily at NCEP using the 6Z cycle to produce a 24-hr analysis and a 48-hr forecast
- Transport & dispersion computed with HYSPLIT using WRF-NMM (AQF version) and GFS meteorology (outside the WRF-NMM domain)

## *Computational Cycle*

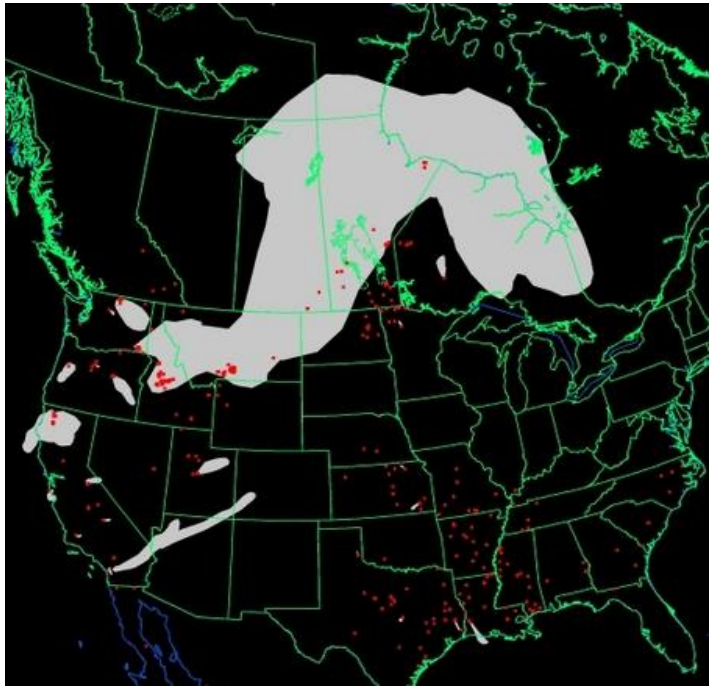



**All smoke particles and large fires initialize the next day's calculation**

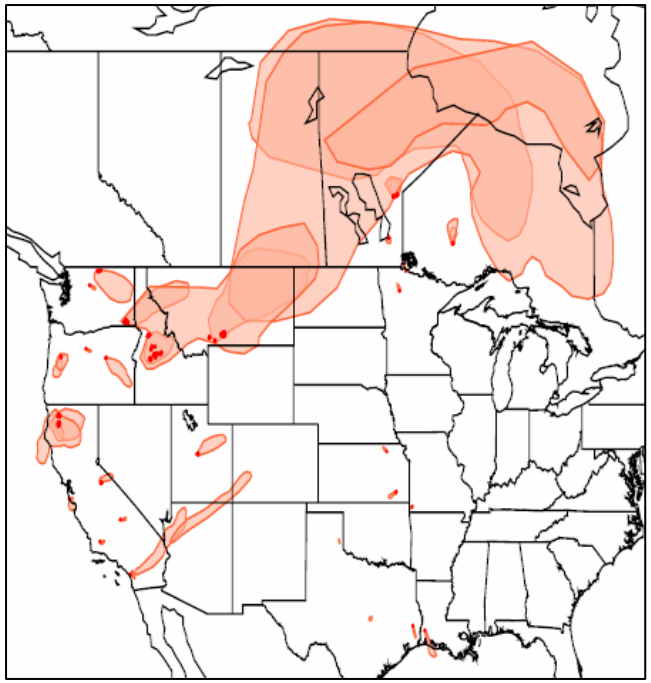
# Experimental Smoke Forecast Tool

## *Fire Locations*

- Produced by NESDIS operational staff from satellite imagery
- Only fires with observed associated smoke are used in calculation
- Fires are noted as continuous or by a start time and duration
- “Undetected” old fires decay at 75% / day with each new analysis
- Fire intensities remain constant during the forecast period



**All HMS fire locations**



**Fire locations with smoke**

# Experimental Smoke Forecast Tool

***Emissions***

- USFS' BlueSky emissions algorithm gives emission rates for PM2.5
- Emission rate and area is computed from sum of number of fire locations in each 20 km emission grid cell
- Only 10% of each fire pixel (1 $km^2$) is assumed to be burning
- BlueSky incorporates a land use and fuel loading data base

***HYSPLIT Transport/Dispersion***

- Starting late May, release height computed from final plume rise (Briggs) based on combustion heat from BlueSky and meteorology
- Produces surface to 100 m and surface to 5000 m 1-hr average PM2.5 concentrations on a 15-km resolution grid
- Only continuous fires emit into the forecast period
- The focus is on primary rather than secondary pollutants
  - ***All smoke particles are dropped after 72 hrs travel time***
- Wet and dry deposition can also reduce smoke concentrations

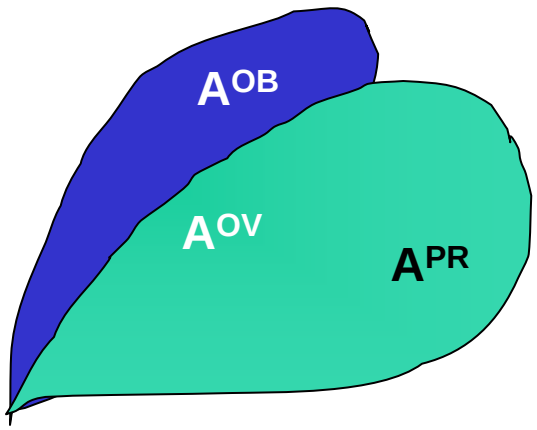
## *Additional Developmental Tools*

- Web-based diagnostic tool developed using SVG to display/overlay HYSPLIT, HMS and fire locations on a map
- Creation of GIS shapefiles of smoke plumes and fire locations which are then used in the verification process and SVG graphic

## *Verification*

- Currently based on overlap comparison of NESDIS Hazard Mapping System (HMS) observed smoke footprint with HYSPLIT atmospheric column footprint
  - Threshold for smoke in the column (5 µg/m$^3$)
  - Figure of Merit in Space (FMS):
    $FMS = (A^{OV}) / (A^{PR} \cup A^{OB})$
  - Measure of Effectiveness (MOE):
    $MOE = (A^{OV} / A^{OB}, A^{OV} / A^{PR})$

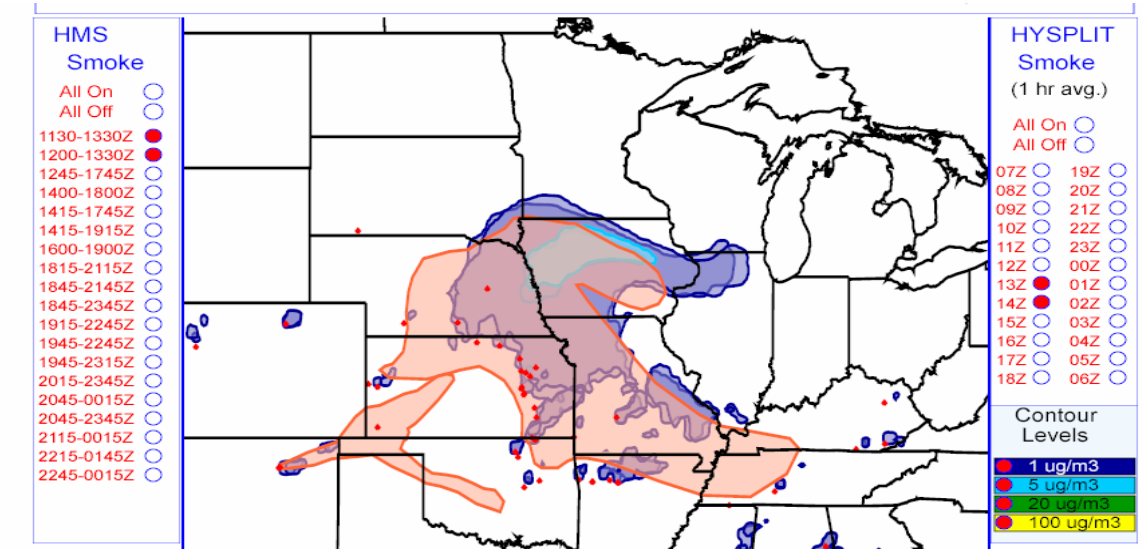
- Results posted daily to ARL website:
  ***http://www.arl.noaa.gov/smoke/verify.html***



# Sample Smoke Evaluation - April 13, 2006

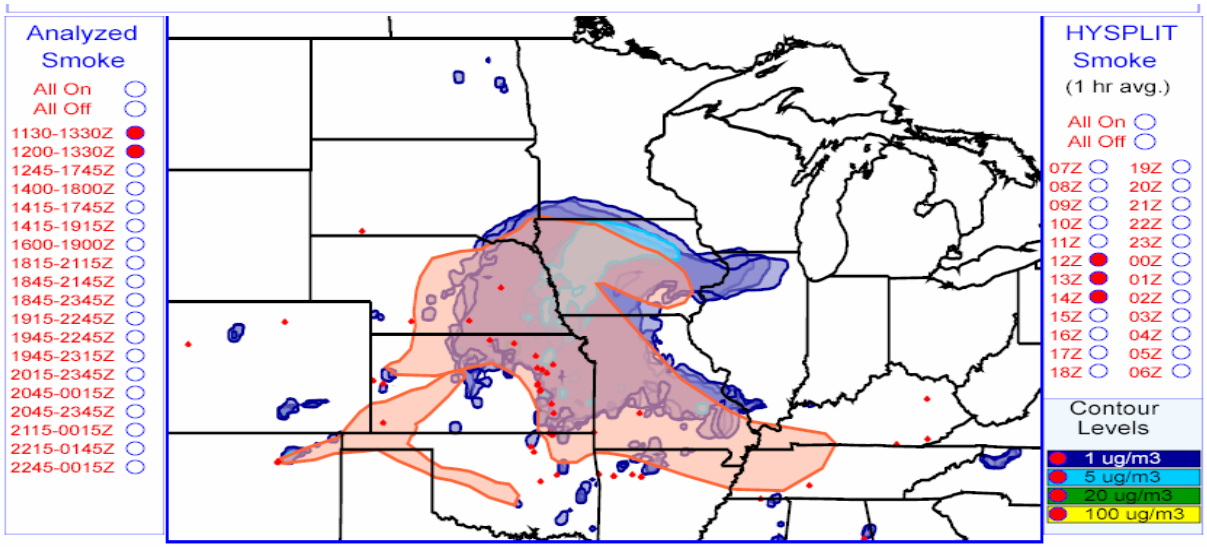
## *NAM/HYSPLIT 1-d Forecast & HMS Analysis*

**12 -14 UTC**




**HYSPLIT Analysis**

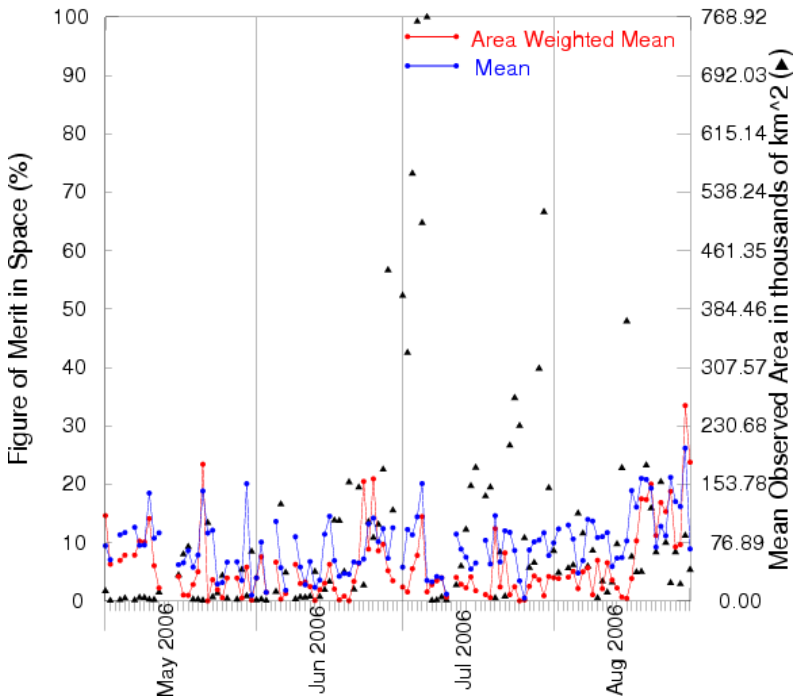
**HYSPLIT 24-hr Forecast**



# Sample FMS Verification with HMS

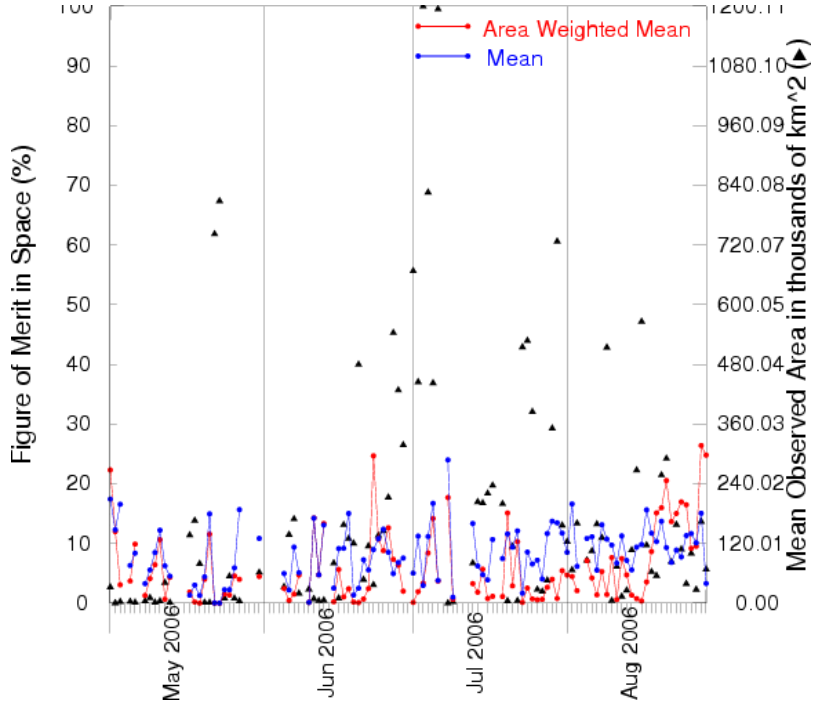
## May-August 2006

### Analysis




**30-d mean (August 31) = 12.0%**

### Forecast




**30-d mean (August 31) = 9.4%**

**5 ug/m3 threshold,**

**0-5 km column average**

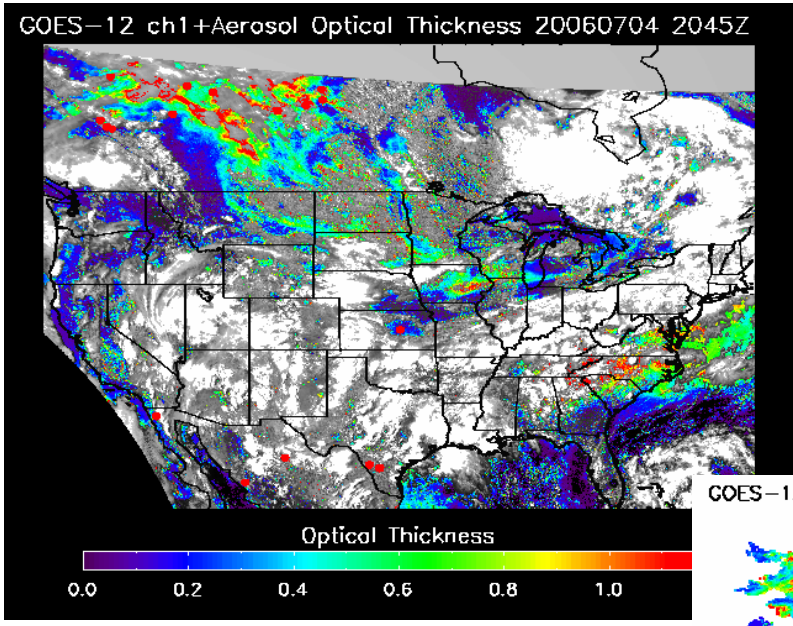
# Next Step for Objective Verification: Automated Smoke Detection with GOES

***Limitations of using HMS plumes***

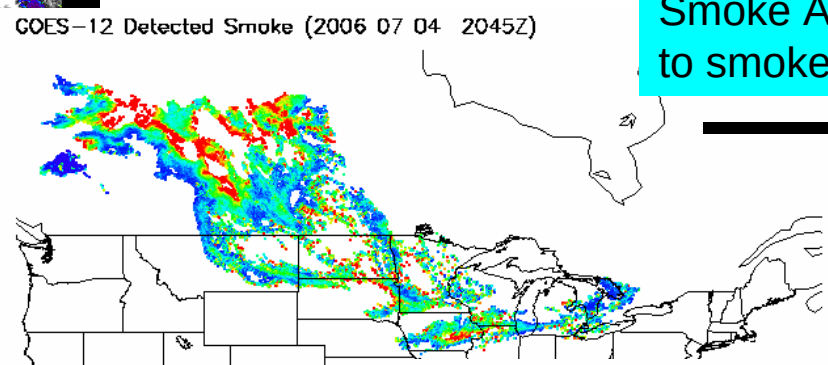
• Subjective: verification with HYSPLIT using only pattern matching
• No information over cloudy regions
• Dependence on visible inspection of imagery. Smoke/cloud discrimination becomes difficult, especially when smoke is removed from the source
• Biased toward low values due to narrow range of plume azimuths that give non-zero intersection areas

***New Objective Approach***

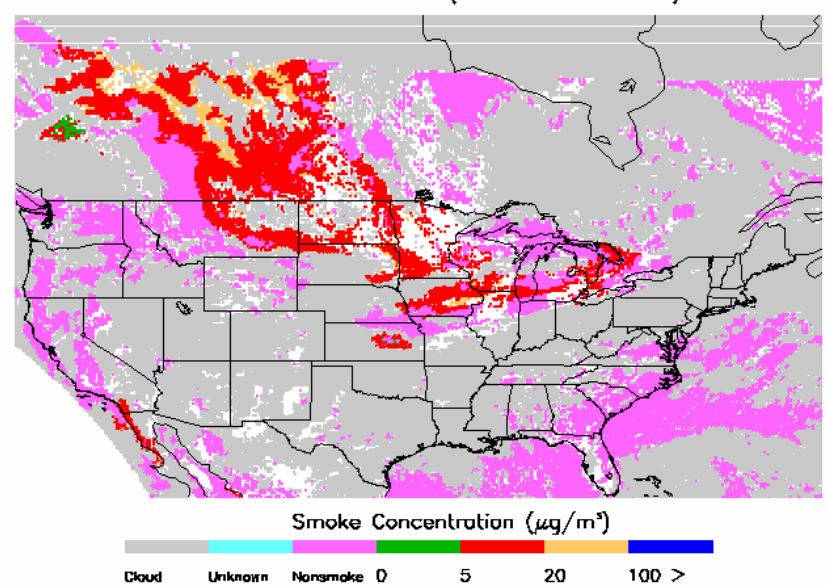
• Develop an automated smoke Aerosol Optical Depth (AOD) identification technique by integrating GOES fire locations and AOD imagery
• Use 30-minute GOES Aerosol Optical Depth (AOD) imagery
• Determine plume direction & extent for all identified fire sources using AOD
• Keep AOD associated with fire and drop other AOD values in the domain
• Use automated AOD product to compare with HYSPLIT predictions




Original GOES AOD image transformed to smoke AOD image




Smoke AOD converted to smoke concentrations




Original GOES AOD Image with fire hot spots in red circles. Clouds are shown in white. Gray area is where there is no AOD retrieval

# Next Steps and Challenges: Smoke Modeling System

***Fire Locations***

• Algorithm to continuous and and those with an anthropogenic diurnal cycle
• Real-time estimate of burn area from the automated fire detection

***Emissions***

• Use observed plume area or AOD to calibrate model emission factors

***Meteorology***

• Increase vertical resolution (NAM-AQF uses 22 of 60 levels available)

***Transport***

• Analysis period iterative loop to optimize plume rise – which height gives the best directional fit to the observed plume