Wildland Fire National Emissions Inventory

Past, Present and Future

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Acknowledgements

- Dev Roy, Tom Pierce & David Mobley (US EPA-ORD/RTP)
- Sim Larkin (USFS PNW Lab)
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- Dave Randall (Air Sciences)
- Amber Soja (NAI at NASA Langley)

Overview of Fire EI

Evolution of Fire EI Methods
Past, Present & Future

- **Past (prior to 2002) Fire EI was "simplified"**

  ~ Emission estimates were "top-down, county-level"

- **Present (2002) is much improved, but costly**

  ~ But, there is no ongoing funding available to repeat it for other years (using the same approach)

- **Future is bright…**

  ~ This requires a melding of new databases and technologies

Pollutants in NEI for Wildland Fires

- **Criteria & Other:**

  PM2.5, PM10, VOC, NOx, SO_2, CO, NH_3

- **HAPs:**

1,3-Butadiene	Benzo[e]Pyrene	Methyl Chloride
1-Methylpyrene	Benzo[g,h,i,]Perylene	Methylanthracene
Acetaldehyde	Benzo[k]Fluoranthene	Methylbenzopyrenes
Acrolein	Benzofluoranthenes	Methylchrysene
Anthracene	Carbonyl Sulfide	Perylene
Benz[a]Anthracene	Chrysene	Phenanthrene
Benzene	Fluoranthene	Pyrene
Benzo(a)fluoranthene	Formaldehyde	Toluene
Benzo(c)phenanthrene	Hexane	Xylenes
Benzo[a]Pyrene	Indeno[1,2,3-c,d]Pyrene	

"Prior to 2002" Fire EI Development

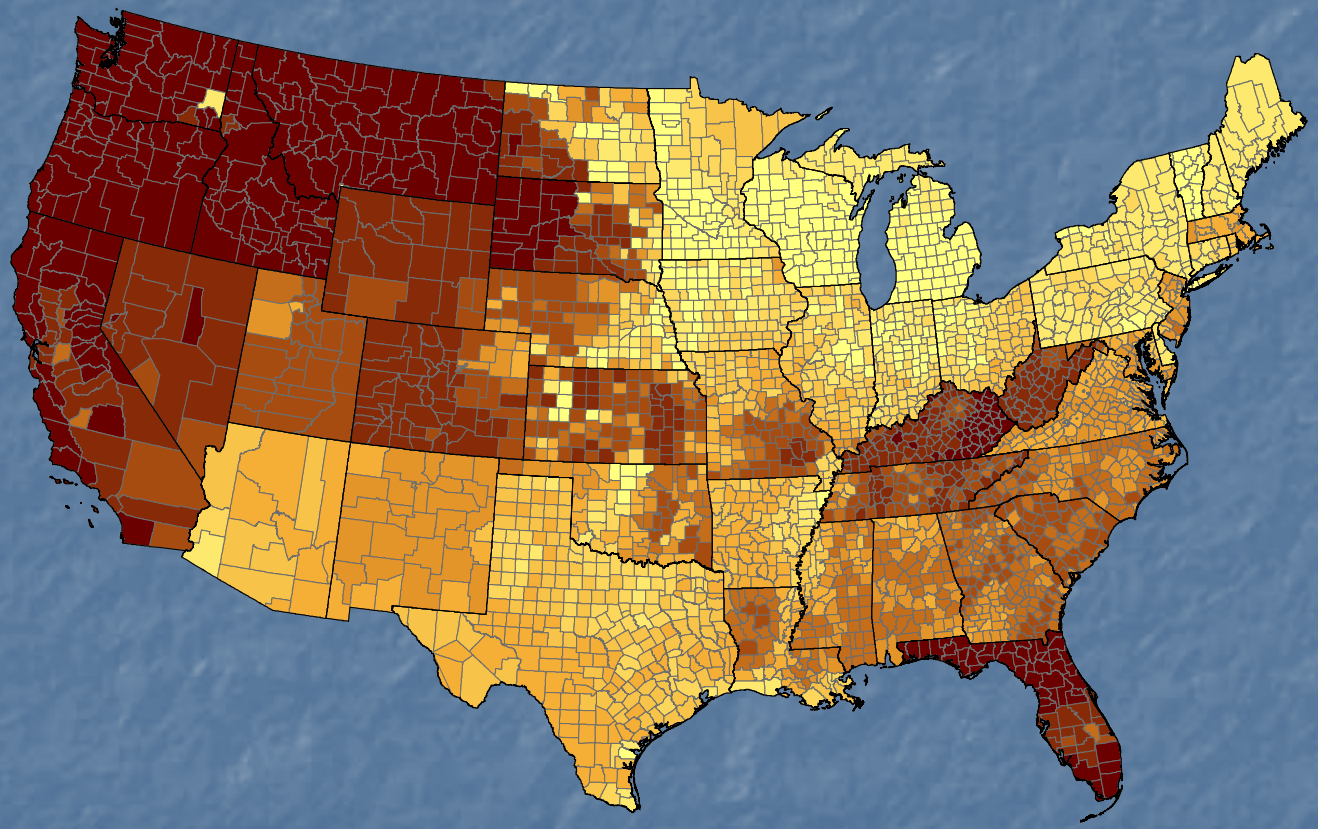
How "simplified" was it?

- Pre 2002 Fire EI was *NOT* "time & location" specific
  - Total annual acres burned *by State*.
    - National Interagency Fire Center (NIFC) fire statistics
    - Annual acres burned estimates – USFS, DOI, most States
- State-level annual emissions

  = Emissions / acre burned **X** acres burned in State

  (EF's for multi-state averages of fuel type & consumption)
- Allocate annual State emissions to county-level
  - Apportioned by % of State's forested land in each county
- Allocate annual county-level emissions to month
  - Use State-level temporal allocation factors

2001 Fire Emissions in NEI



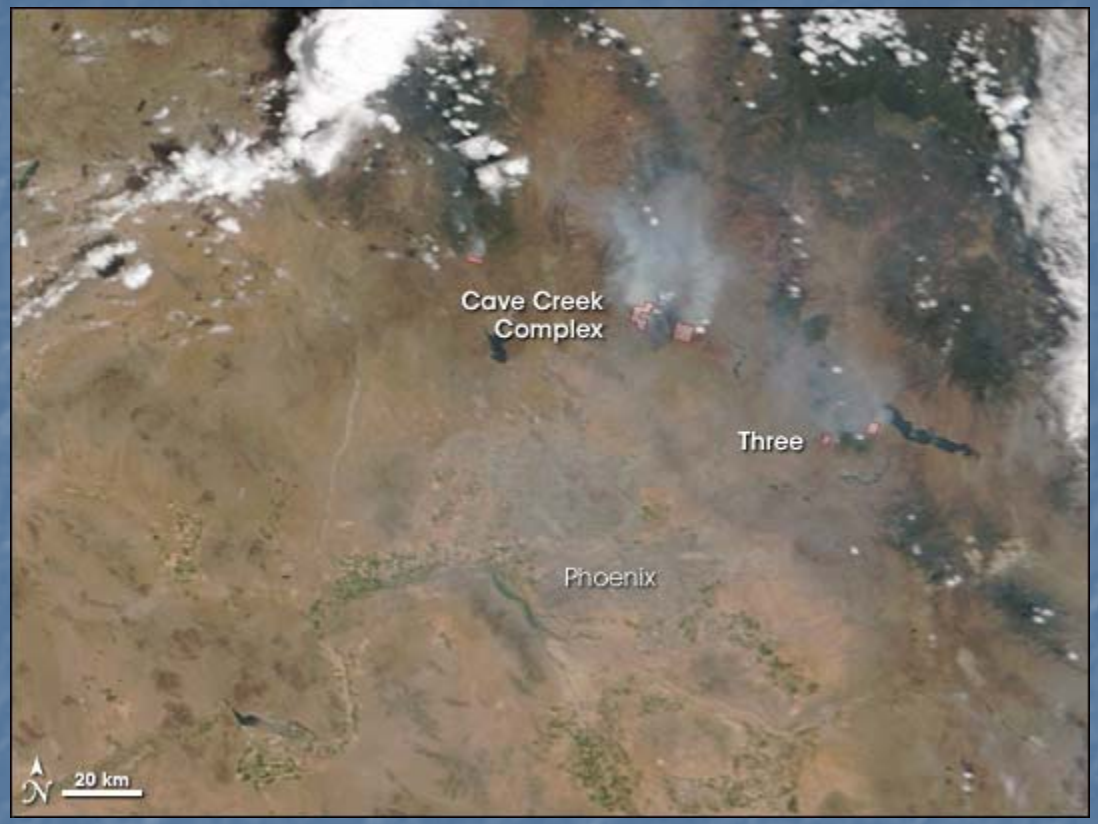
Regional Fuel Characteristics
State- to County- level “allocation”
Annual to monthly “allocation”

Pre 2002 > 2002 Fire EI

Evolution from "Top-down" to "Event-based"

- **Pre-2002** – event level fire EI wasn't a priority
- **2002** – new needs and capabilities
  - Daily PM, O3 & Haze programs put more "pressure" on the Fire EI

Satellite View of Cave Creek Fire
One of the Largest Fires in US in June '05

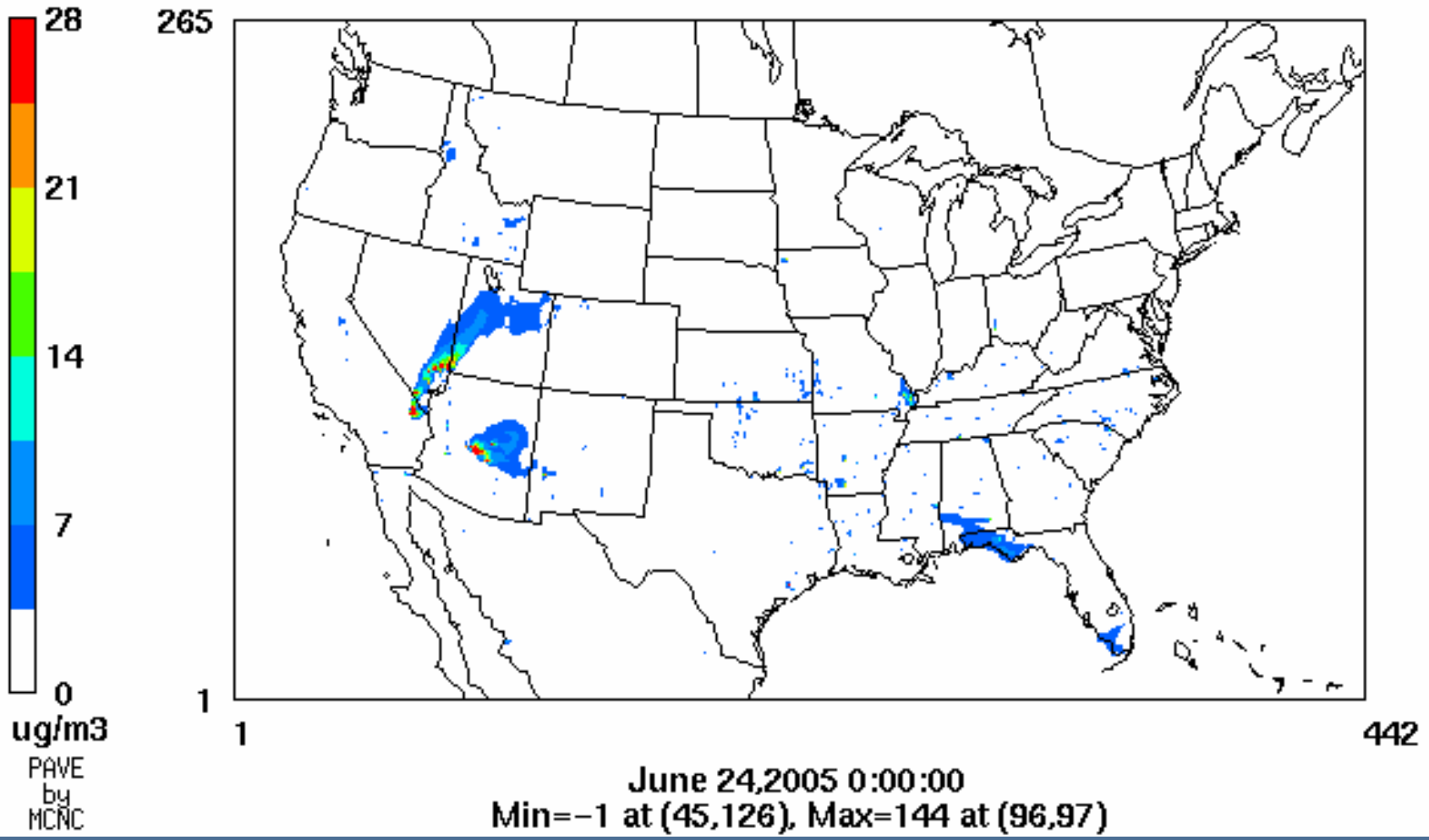


The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured this image of the fire on June 23, 2005, at 11:50 a.m., local time

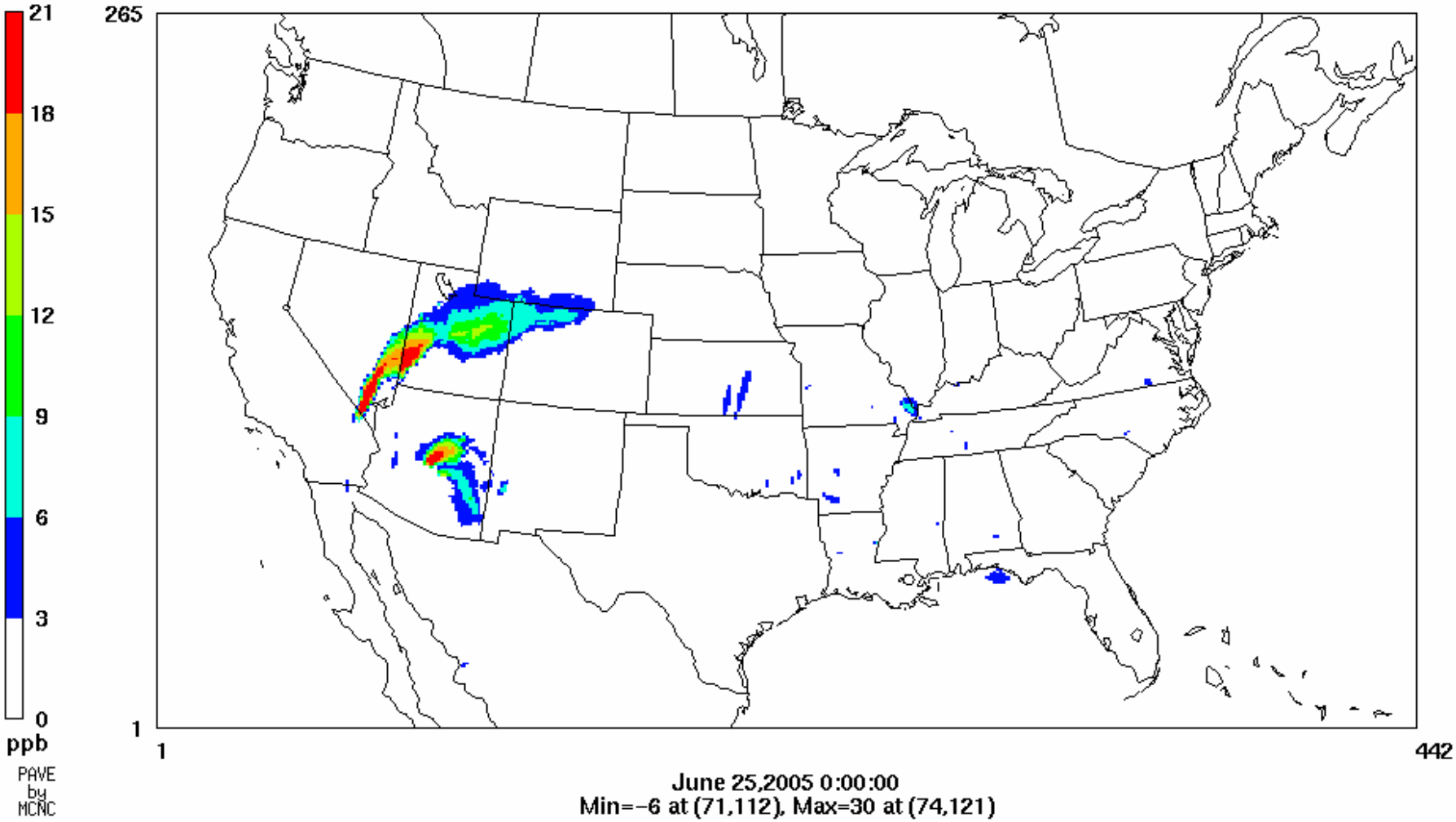
Source:
http://www.nasa.gov/vision/earth/lookingatearth/Arizona_Wildifire06.23.05.html

Difference in 24-hr Average PM2.5 June 24 Forecast

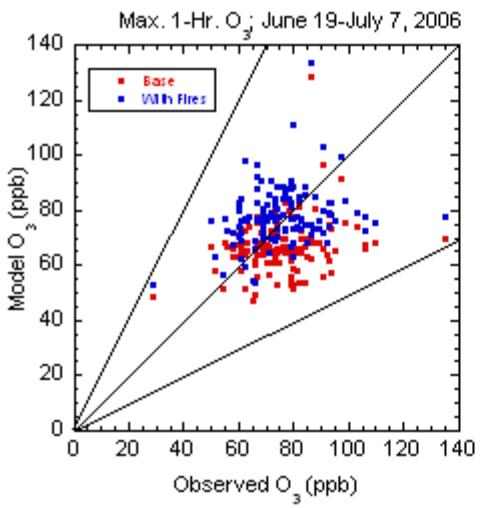
Fires – No Fires

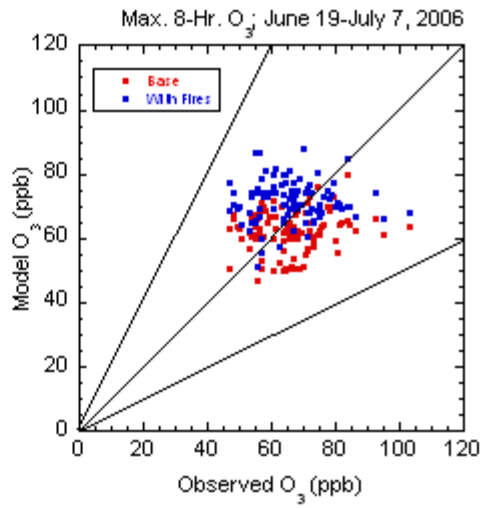


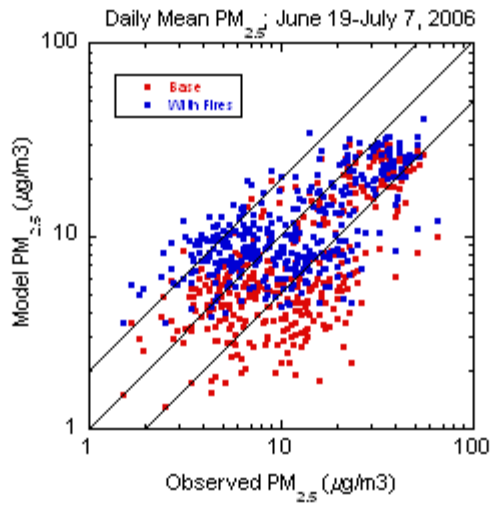
Difference in Max 8-hr Ozone for June 25 Forecast (Fires – No Fires)



Scatter Plots of Max 1-hr Ozone, Max 8-hr Ozone and daily Mean PM2.5 for June / July episode







Note: only model-obs. pairs selected where a fire impact was detected:

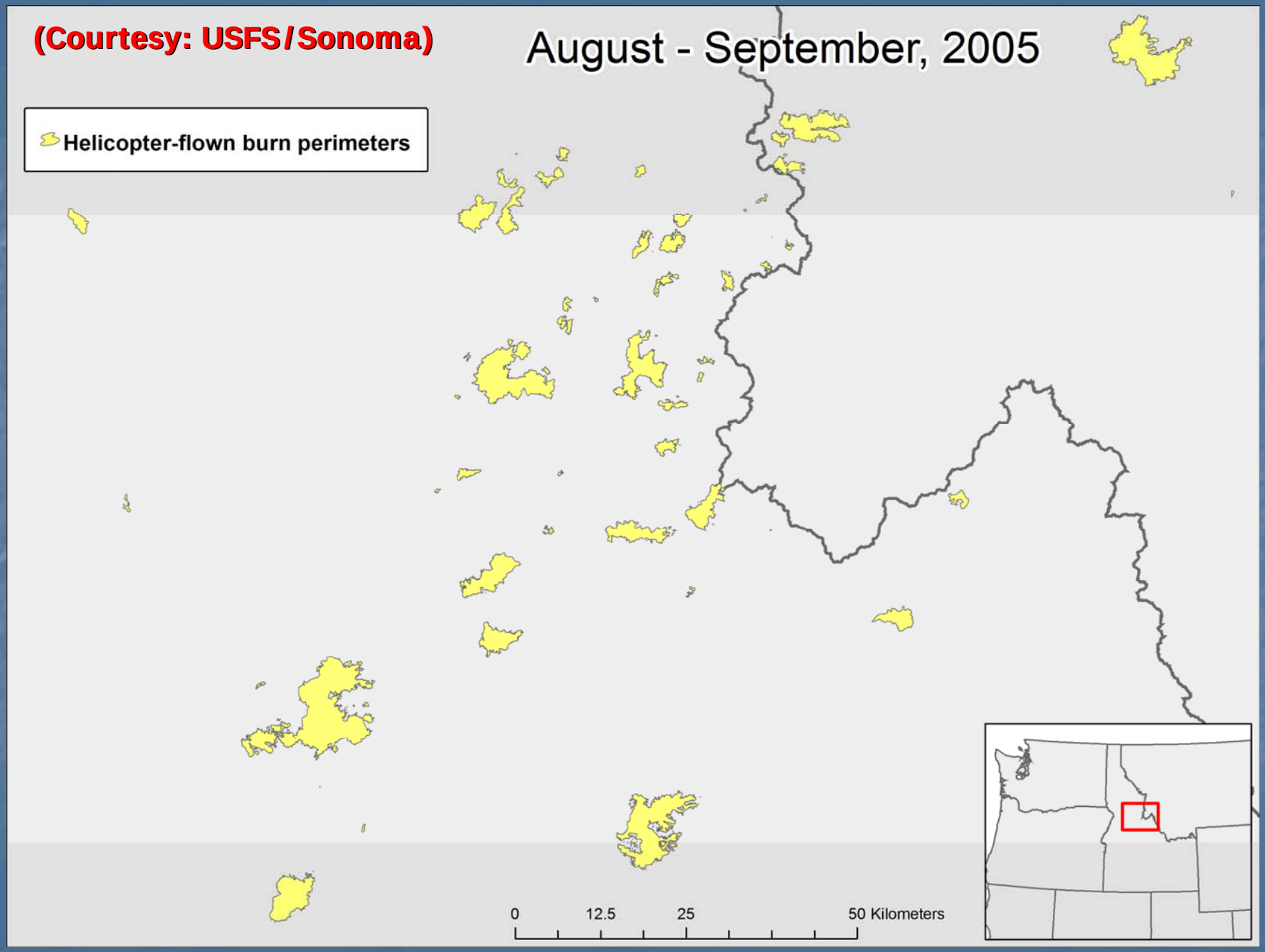
O3 (Fire-base)>4ppb
PM25 (Fire-base)> 2ug/m3

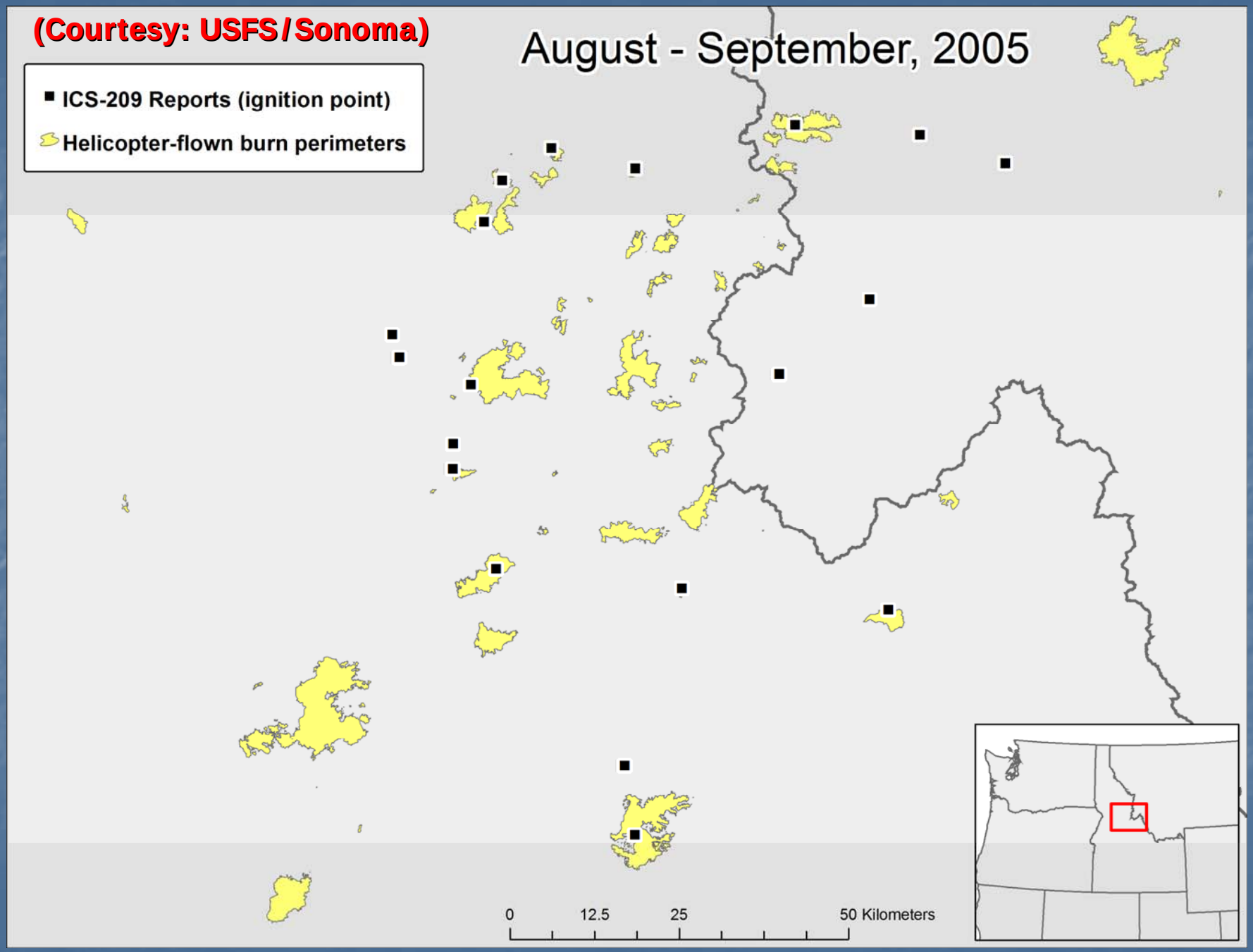
Legend
- With Fires
- Without Fires

Pre 2002 ⟶ 2002 Fire EI

Evolution from "Top-down" to "Event-based"

- **Pre-2002** – event-based fire EI not a priority
- **2002** – new needs and capabilities
  - Daily PM, O3 & Haze programs "pressured" the Fire EI
  - Improved tools improve the quality of the emissions estimates
- **Event dataset deficits** (ICS 209, DOI 1202)
  - Fire growth rate data (acres/event, NOT acres/day)
  - Fire names ~ often inconsistent over the life of fire
  - Errors & omissions, date & location differences,
  - Costly process to track down & resolve the issues


(Courtesy: USFS/Sonoma)
August - September, 2005
Helicopter-flown burn perimeters
0
12.5
25
50 Kilometers


(Courtesy: USFS/Sonoma)
August - September, 2005
ICS-209 Reports (ignition point)
Helicopter-flown burn perimeters
0
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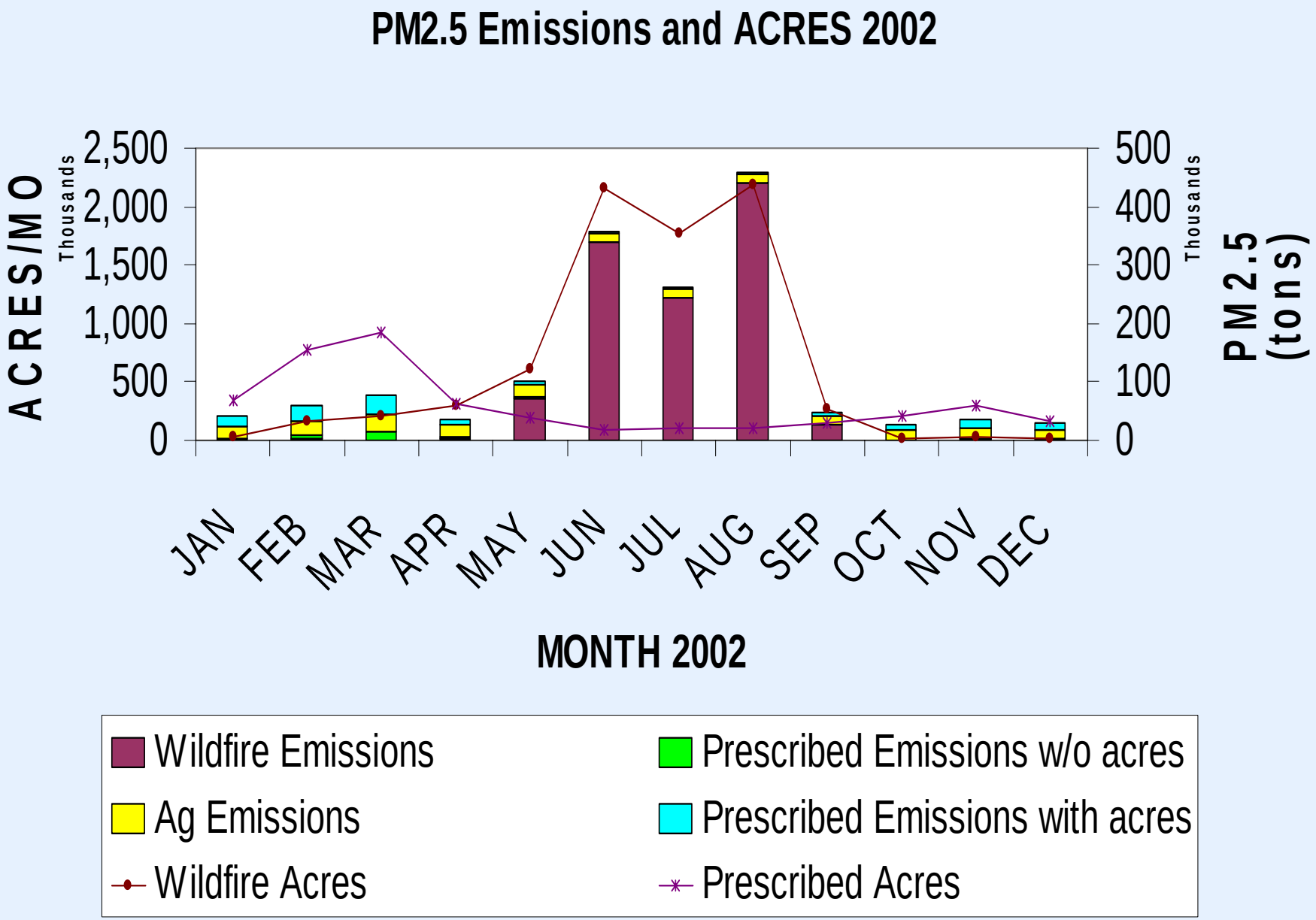
2002 Fire EI Development

- Fire Incident Datasets *(ICS 209, DOI 1202, some States)*
- Huge Effort *(by RPO's / Air Sciences)* to QA Datasets
  - Errors & omissions
  - Average daily fire size
  - special emphasis on 14 fires >10,000 acres in size
- Geo-referenced fuel type (NFDRS)
- Geo-referenced moisture by date/location
- FEPS used to calculate fuel consumption
  - Lookup matrix ~ combinations of regional fuels, moistures
- WF & PB estimate emissions for all Criteria & 29 HAPs

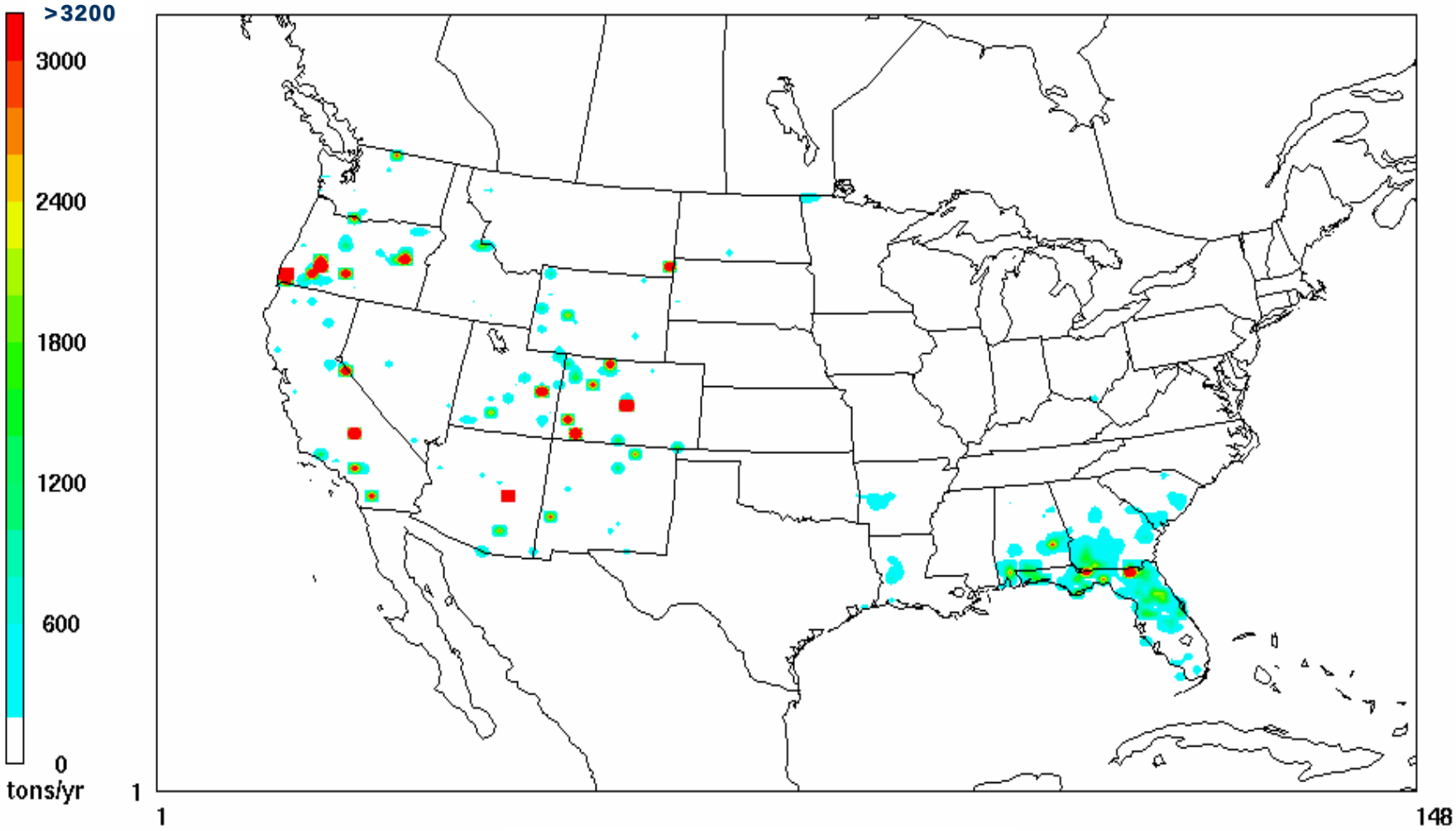
(Note: Agricultural burning, where available was provided by RPO's/States)

WF EI preparation by Air Sciences ~ funded by RPO's
PB EI preparation by EC/R ~ funded by US EPA
(HAP emission estimates added by US EPA)

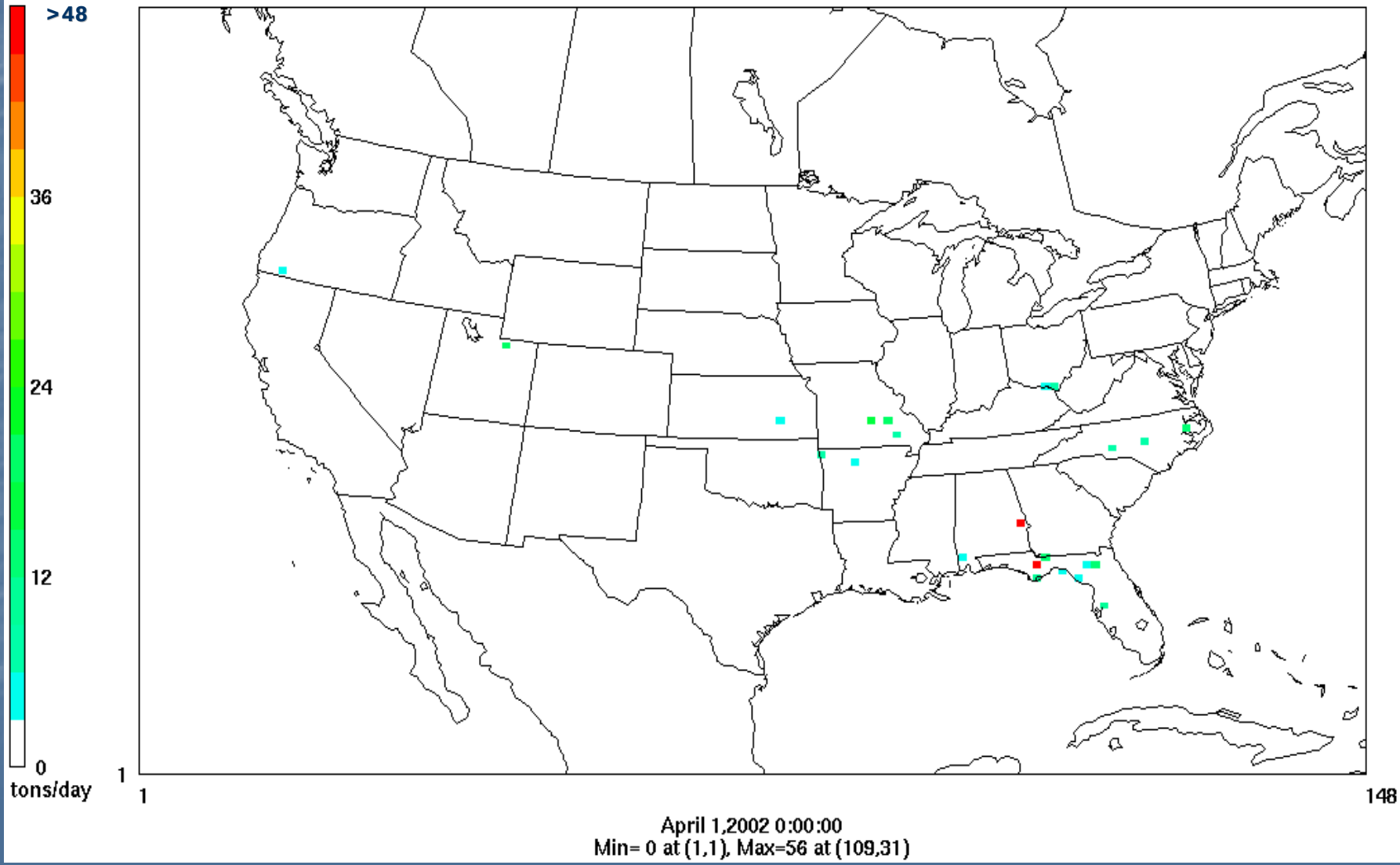

PM2.5 Emissions and ACRES 2002
ACRES/MO
Thousands
2,500
2,000
1,500
1,000
500
0
500
400
300
200
100
0
Thousands
PM2.5 (tons)
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH 2002
Wildfire Emissions
Ag Emissions
Wildfire Acres
Prescribed Emissions w/o acres
Prescribed Emissions with acres
Prescribed Acres

2002 PM2.5 Annual Emissions from Wildfires and RX Burning

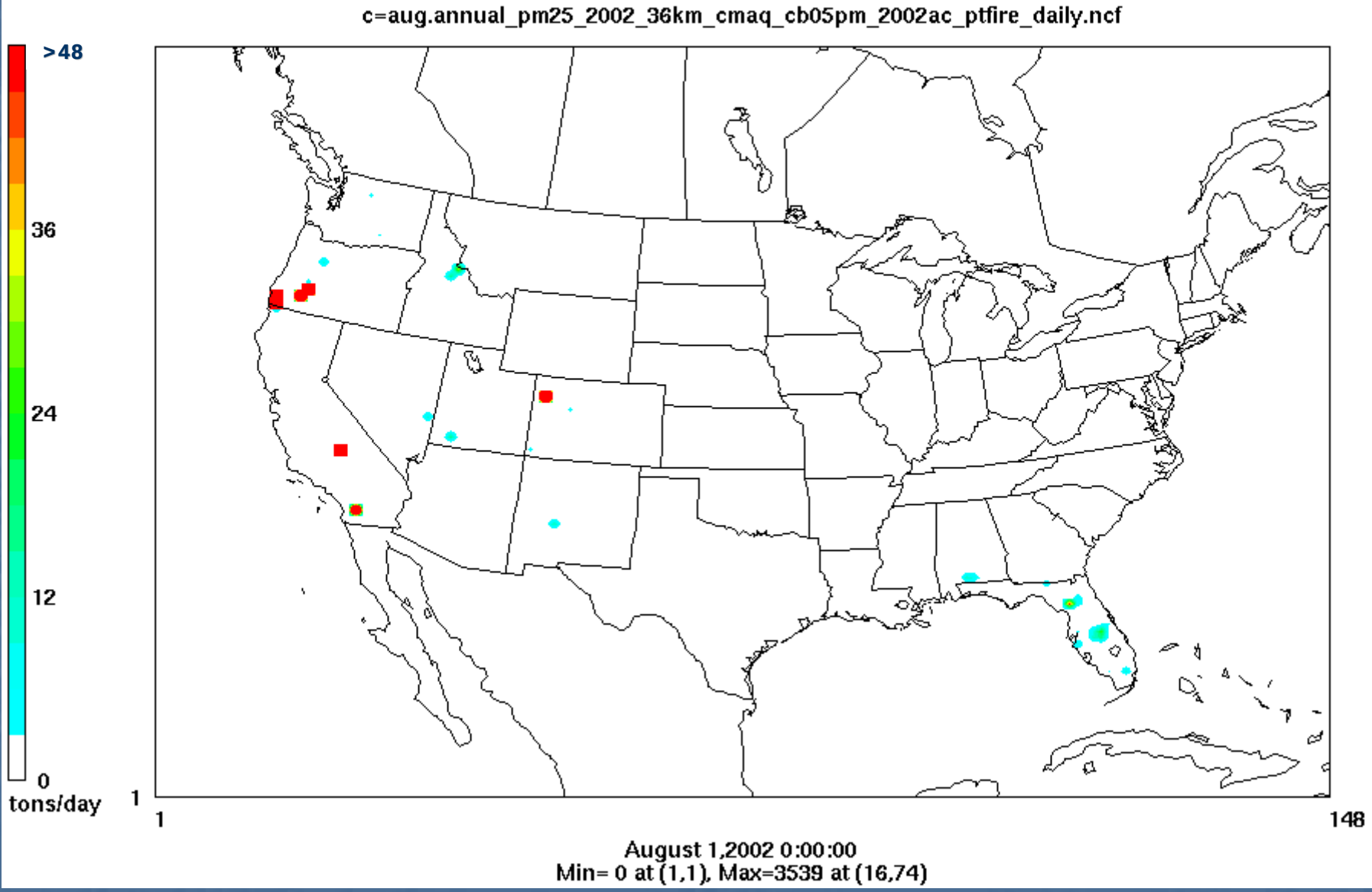
36km Grid Cells



April 2002 PM2_5 Emissions RX and Wildfire (except GA)



August 2002 PM2_5 Emissions RX and Wildfire (except GA)



2005 Fires EI Goals & Resources

Evolution from Event-based to Hybrid

- **Goals: Develop a method to estimate biomass burning emissions that is….**
  - **Better than pre-2002 methods and**
  - **Not as costly as 2002, but provides…**
  - **"acceptable" emissions information until the "next generation" of databases & satellite tools are available.**

- **Data Resources & Tools**
  - **209 & 1202 Reports**
  - **MODIS satellite products**
  - **GOES** satellite products
  - **Estimation tools** e.g., Consume 3, FCCS, BlueSky Framework

2005 Fire EI Development

1st Generation Hybrid (Events / Satellite Data)

- **Who?** EPA/ORD with OAQPS
- **Obtain** MODIS 2005 fire detects, 209 Reports
- **Fuel moisture** ~ from fuel moisture models
- **Fuel Consumption** ~ adapted from Inter-RPO 2002 EI project's matrix of fuel types & moistures
- **Combine** (manually) MODIS 2005 fire detects with 209's
  - Use each method to cross-check / supplement the other
  - Resolve mismatches in location-timing-size (as resources permit)
  - Estimate event dates, daily fire sizes, locations
- **Compare** with other 2005 EI data as available
  - NOAA, BlueSky, NCAR, NASA, SMARTFire
  - Refine as resources permit

EI Quality: Pre 2002 < **2005** < 2002

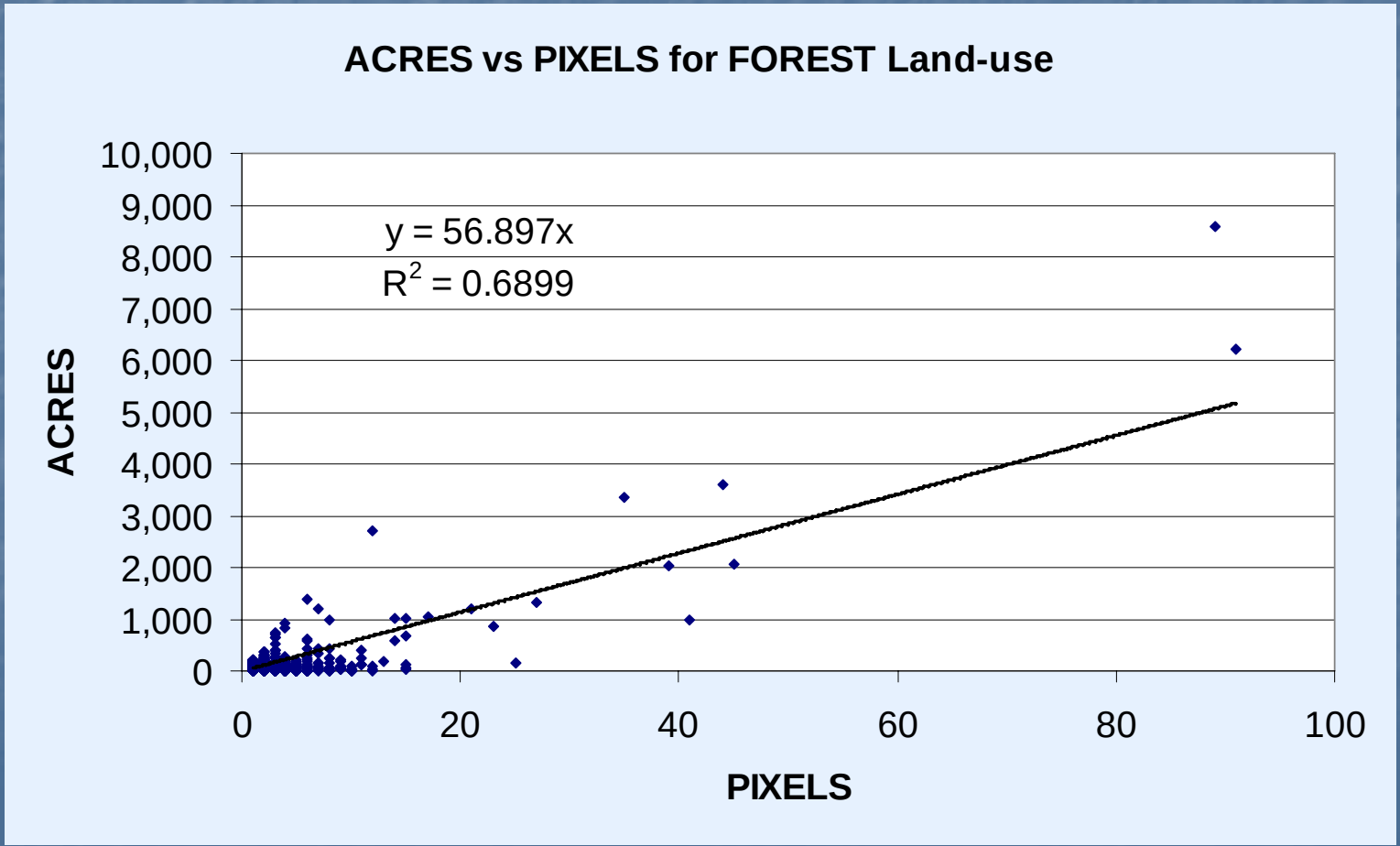
Resources: Pre 2002 < **2005** << 2002

Satellite-derived Fire Data & Event Databases
Advantages & Limitations

- **Satellite-derived Data**
  - Eliminates human error in database preparation
  - Provides more accurate info on day-to-day progression of large fires
  - Potential for retrospective analysis of area burned (burn scar - R&D)
  - Real time estimate of heat release (R&D)
  - Detection limit ~ 50-250 acres (depending on intensity)
  - Cloud interference (limitation)
  - Conversion of pixels to acres (challenging issue)

Acres vs Pixel Relationship for FOREST Land Use

Excludes matches where Acres > pixels*247 (e.g., where satellite "missed" most of the fire)



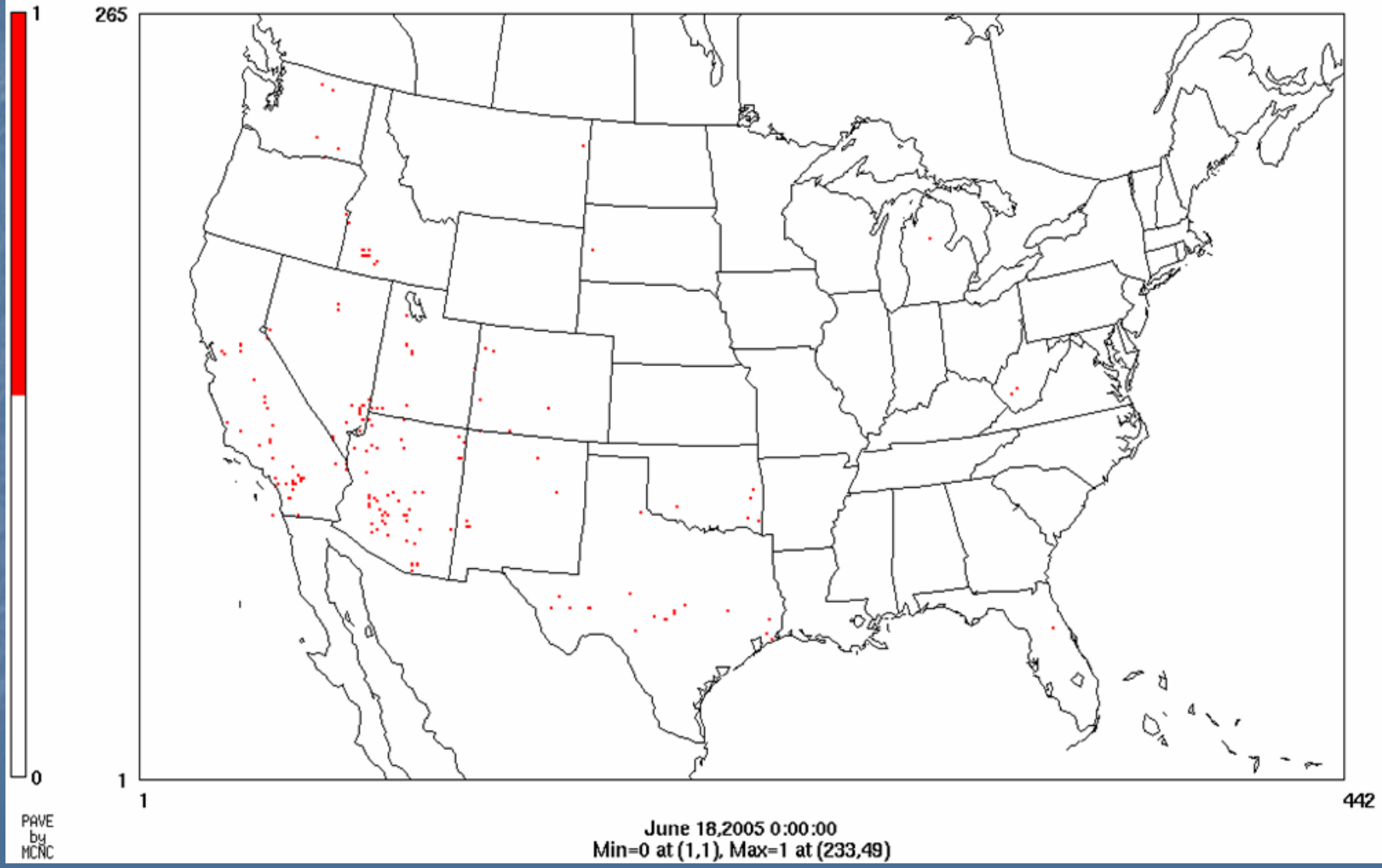
Satellite-derived Fire Data & Event Databases

Advantages & Limitations

- **Satellite-derived Data**
  - Eliminates errors in database preparation (fire location, size, date)
  - Provides more accurate info on day-to-day progression of large fires
  - Potential for retrospective analysis of burn scar (R&D issue)
  - Real time estimate of heat release (R&D issue)
  - Detection limit ~ 50-250 acres, depending on intensity (limitation)
  - Cloud interference (limitation)
  - Conversion of pixels to acres (challenging issue)
- **Events Databases**
  - Will contain data on fires not detected by satellite
- **1st Generation Hybrid Approach**
  - Synergy ~ 209 database ***and*** satellite data
  - 2005 EI - integration will be a manual, somewhat subjective process
  - Powerful tool, high potential ~ for example...

209 Reports

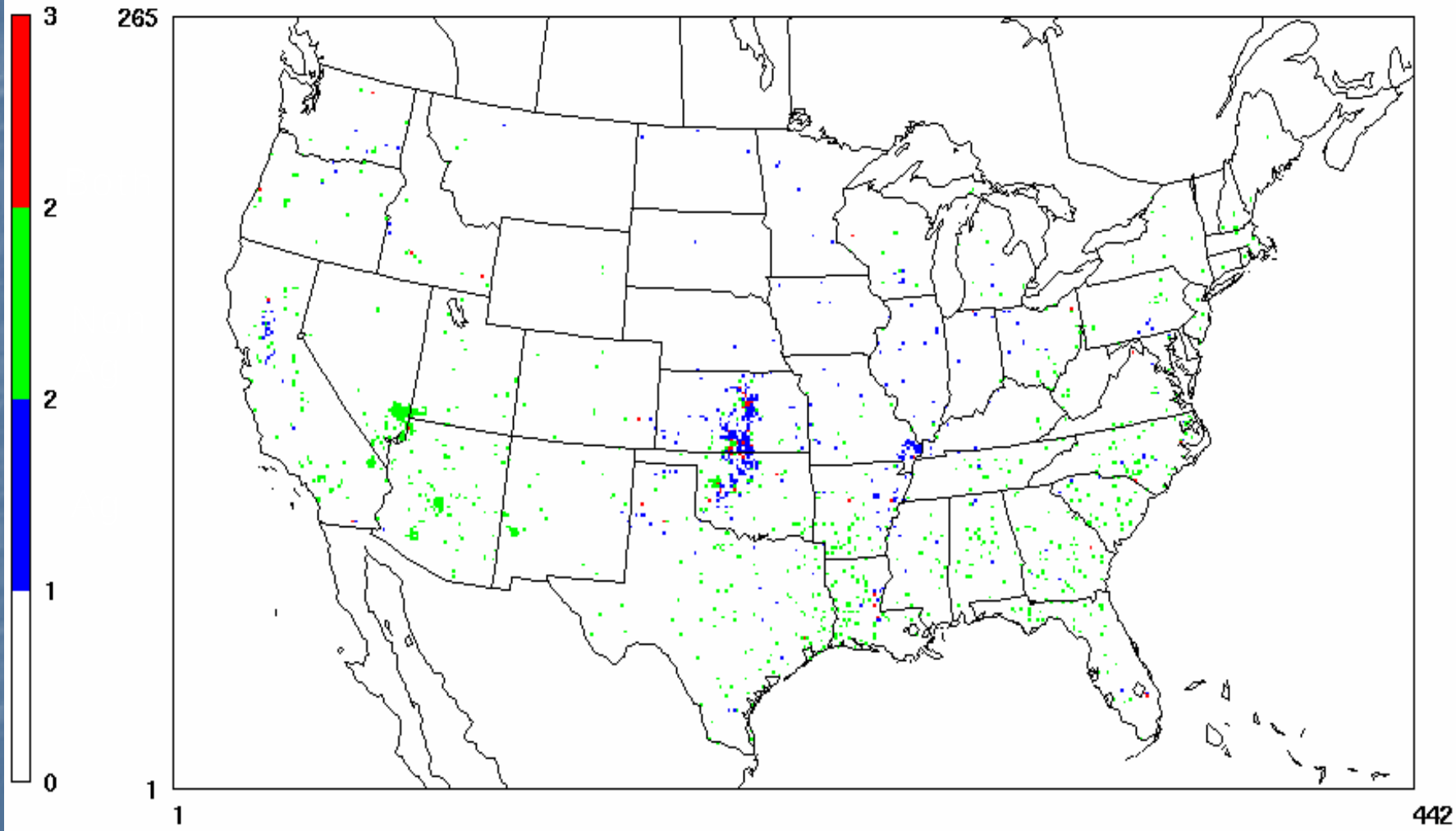
June 18, 2005 – July 9, 2005
Note: Fire Size not indicated, detect only



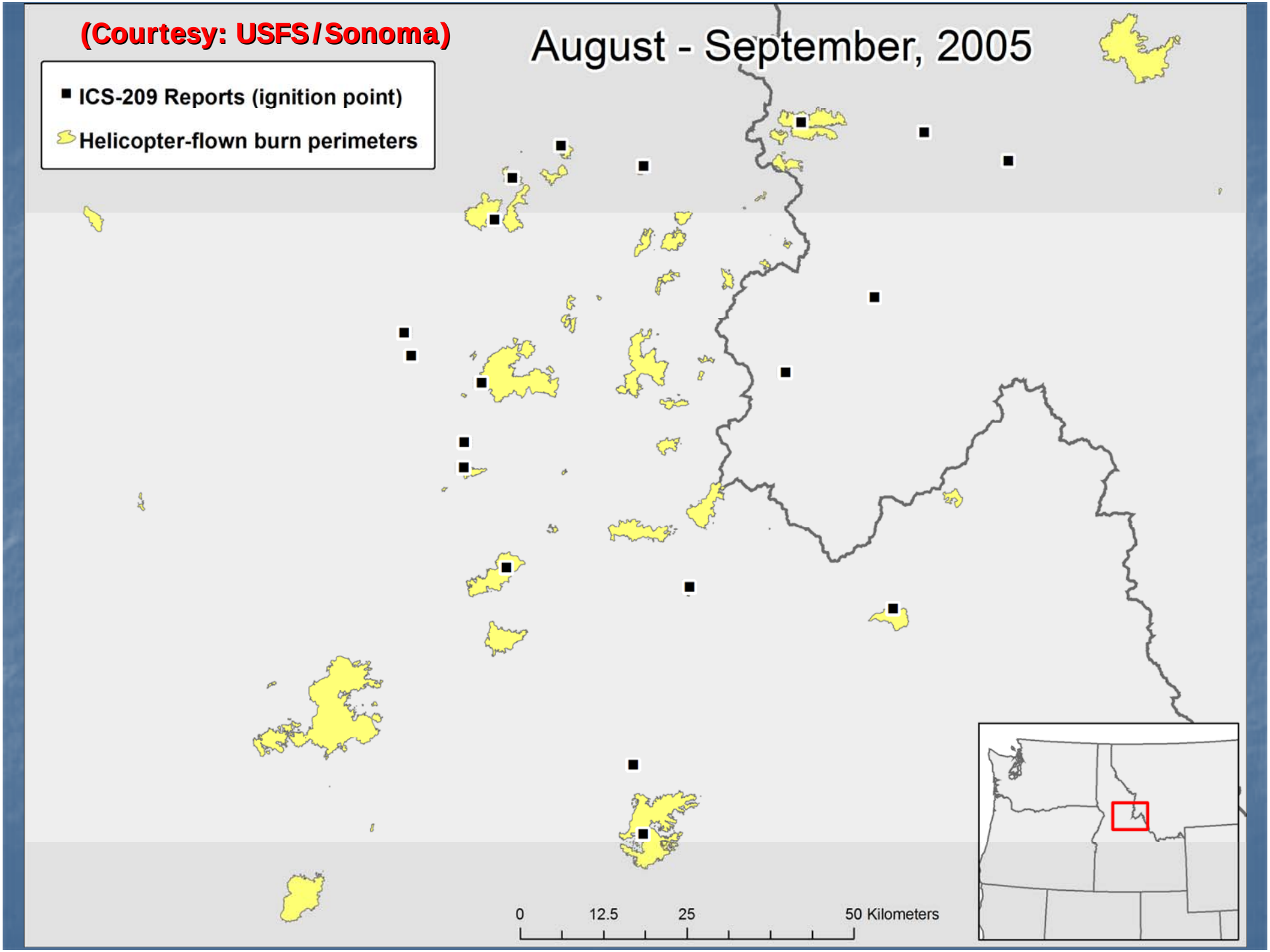
June 18,2005 0:00:00
Min=0 at (1,1), Max=1 at (233,49)

MODIS FIRE DETECTS

blue=ag only,green=non-ag only,red=ag and non-ag in same grid cell
June 18, 2005 to July 9, 2005



June 18,2005 0:00:00
Min= 0 at (1,1), Max= 3 at (348,32)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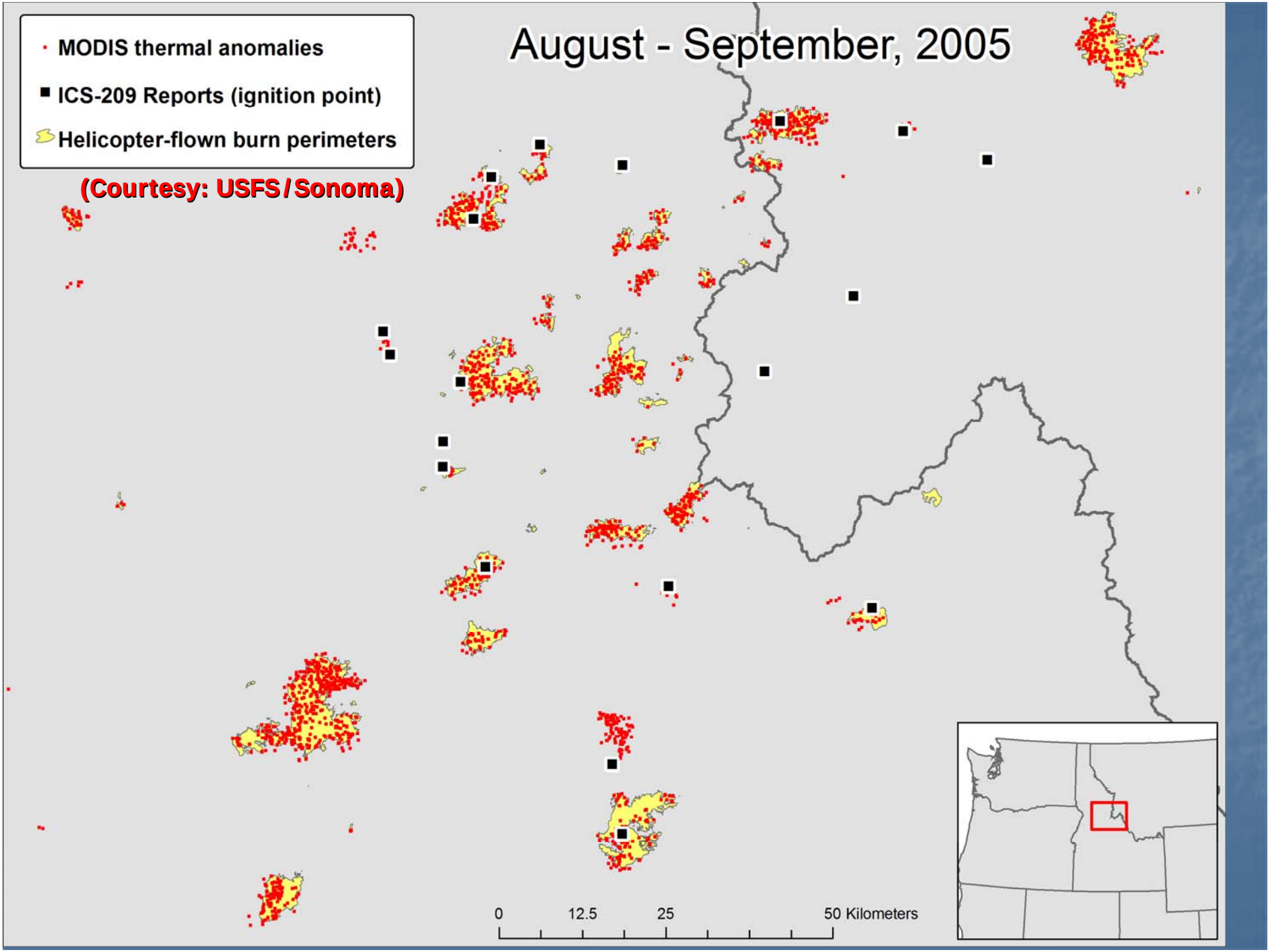
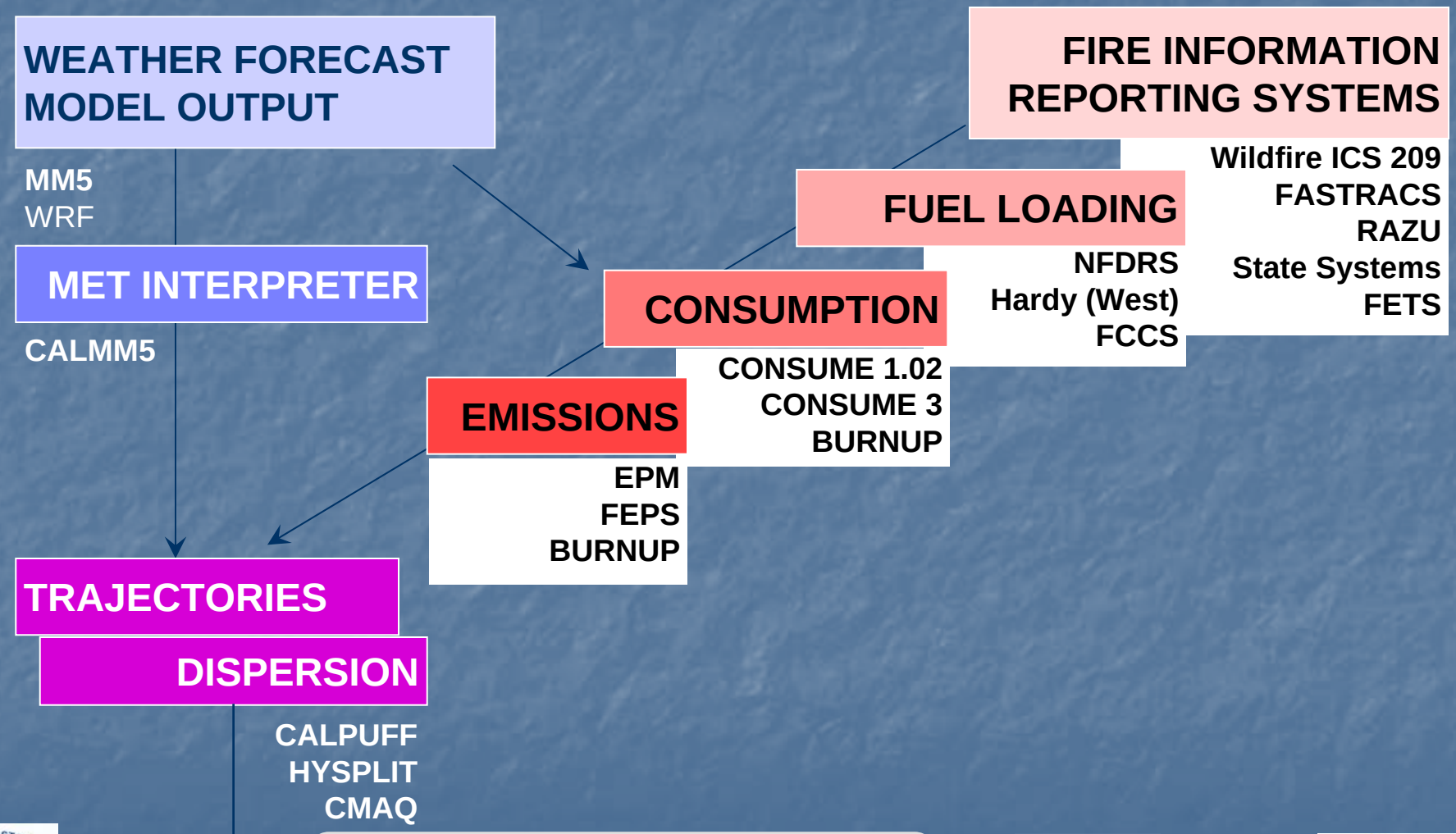

MODIS thermal anomalies
ICS-209 Reports (ignition point)
Helicopter-flown burn perimeters
(Courtesy: USFS / Sonoma)
August - September, 2005
0
12.5
25
50 Kilometers

Post-2005 Fire EI Development

Next Generation of Hybrid Fire EI Methods

- **Fire Emissions Tracking System (FETS)**
  - WRAP States – on-line this summer
- **State Fire Tracking Systems**
  - e.g., North Carolina
- **SMARTFire**
  - Automated integration of Events database & Satellite data
- **Other Tools Development & Research**
  - **BlueSky Framework Enhancements**
  - **Integrating multi-platform data (GOES, AVHRR)**
  - **Integrating multiple event databases**
  - **Burn scar, GPS and/or remote sensing of perimeters**
  - **Heat-release analysis, multi-chimney, plume rise**
  - **Near real-time emissions modeling**

BlueSky Framework: *An Evolving Toolset*



Leaders in Satellite - Fire Research

Partial List of Key Players

USFS Pacific Northwest Lab
Sonoma Technologies
US EPA Research Triangle Park
NOAA Research Triangle Park
NOAA Silver Springs
NASA Langley
NASA Goddard
U of Maryland
U of Wisconsin
Nat. Center for Atmospheric Research (Boulder)
USFS Remote Sensing Applications Center (SL City)
US Navy
Many Others....

Summary

Evolution of Fire Emissions Estimation

- Pre 2002 ~ simplified, top-down
- 2002 ~ event-based, extensive “cleanup”
- 2005 ~ 1st generation hybrid w/ satellites
- Post 2005 ~ 2nd generation hybrid
  - Automated integration ~ “events & satellites”
  - Post-fire burn scar analysis
  - Quantitative use of heat release sensors

Acknowledgements

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Thank you!

More Info:

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