Wildland Fire in the National Emissions Inventory

Past, Present and Future

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- Amber Soja (NAI at NASA Langley)

What will be Covered

- **Intro** to the Fire Emissions Inventory
- **Evolution** of the Fire EI over Time
  - Pre-2002 Vs 2002
- **Ground Reports / Satellite Detects / Hybrid**
  - Why is a Hybrid Important?
- **2005** Fire EI Development
- **Future** of Fire EI's at EPA (Post 2005)
  - Automation of decision-making
  - Multi-platform, multi tool, plume rise

Wildland Fire Emissions Inventory What it is & How its Used

- Emissions = f (fuel type, loading, moisture)
- Emissions of Criteria & Hazardous Air Pollutants
  - Magnitude, Time & Location
  - Data to infer initial plume rise
- Real Time AQ Modeling
  - Health advisories & AQ forecasting
  - Forest ~ Agricultural ~ AQ Resource Planning
- Retrospective AQ Modeling
  - Exposure Modeling
  - AQ Management planning

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	

Fire EI Development is Changing

- **Past (pre-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…**
  ~ Requires use of new databases and technologies

"Pre 2002" Fire EI Development

How "simplified" was it?

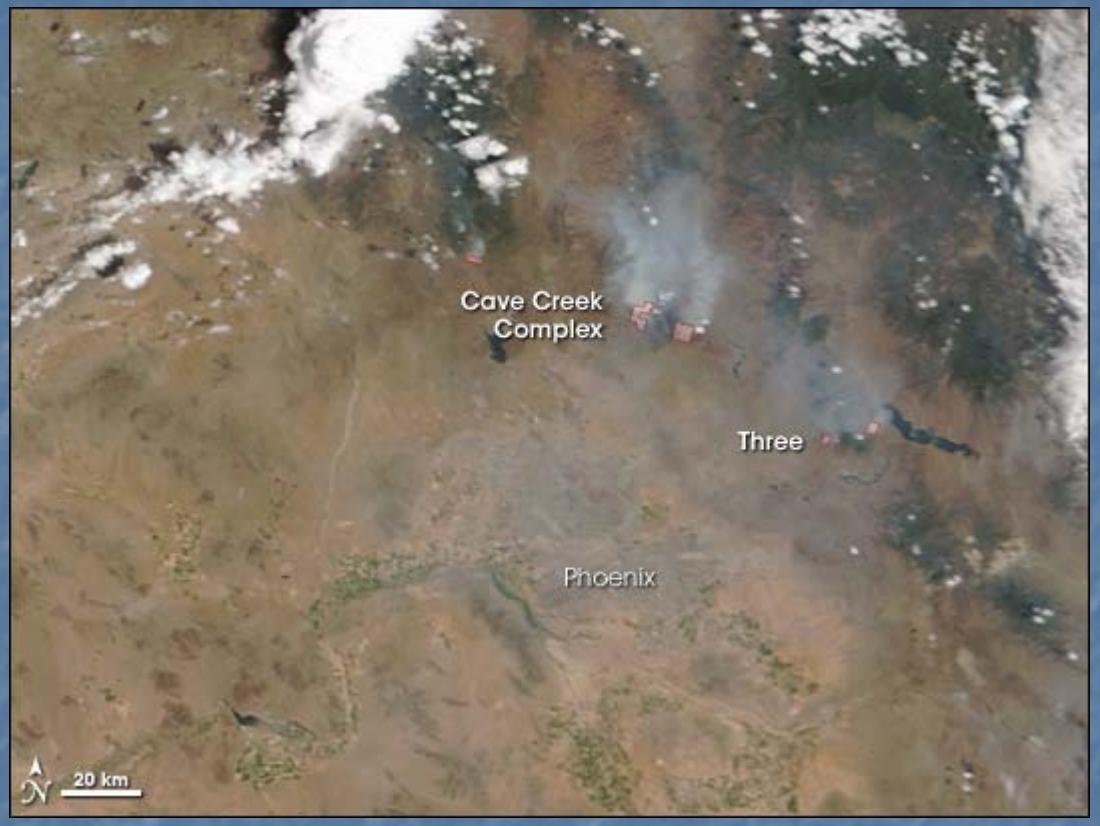
- ***NOT*** **"time & location" specific**
- ***State-level*** **annual emissions**
  - = Emission Factor (Tons / acre) **X** acres burned in State
    (EF's for **multi-state averages** of fuel type & consumption)
- ***Allocate Spatially*** **State- to county-level**
  - Apportioned by % of State's forested land in each county
- ***Allocate Temporally*** **annual to monthly**
  - Use State-level temporal allocation factors

Pre-2002 to 2002 Fire EI

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

- **Pre-2002** – event-specific fire EI not a priority
- **2002** – new needs and capabilities
  - Daily PM, O3 & Haze programs need a daily Fire EI
  - Use of Ground-based reports for event-specific EI -- $$$$$
- **Why** is an event-specific fire EI important?
  - Better allocation of valuable AQ & natural resources
  - Improved accuracy of AQ modeling analyses

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

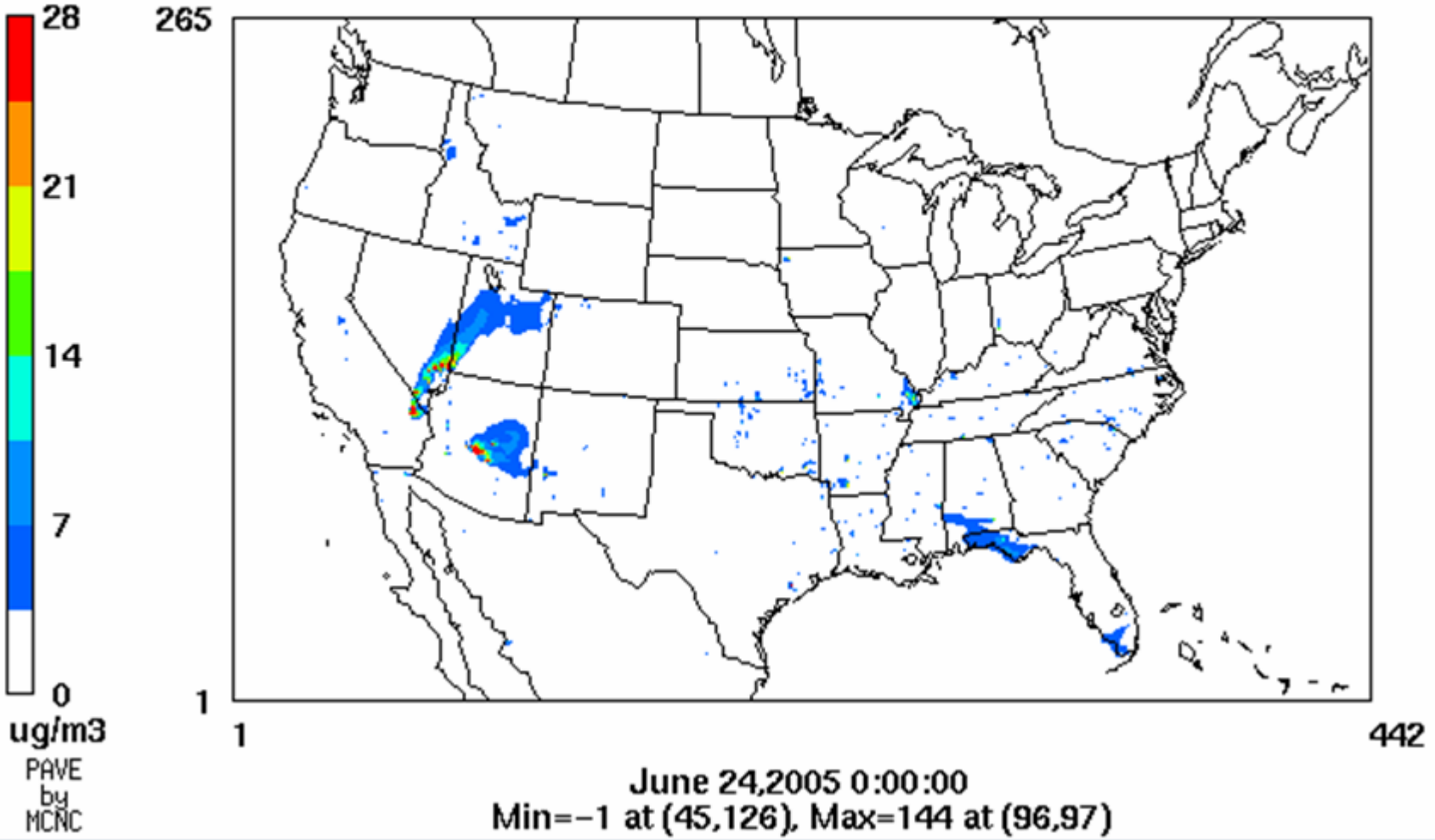


The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured this image of the fire on June 23, 2005, at 11:50 a.m., local time

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

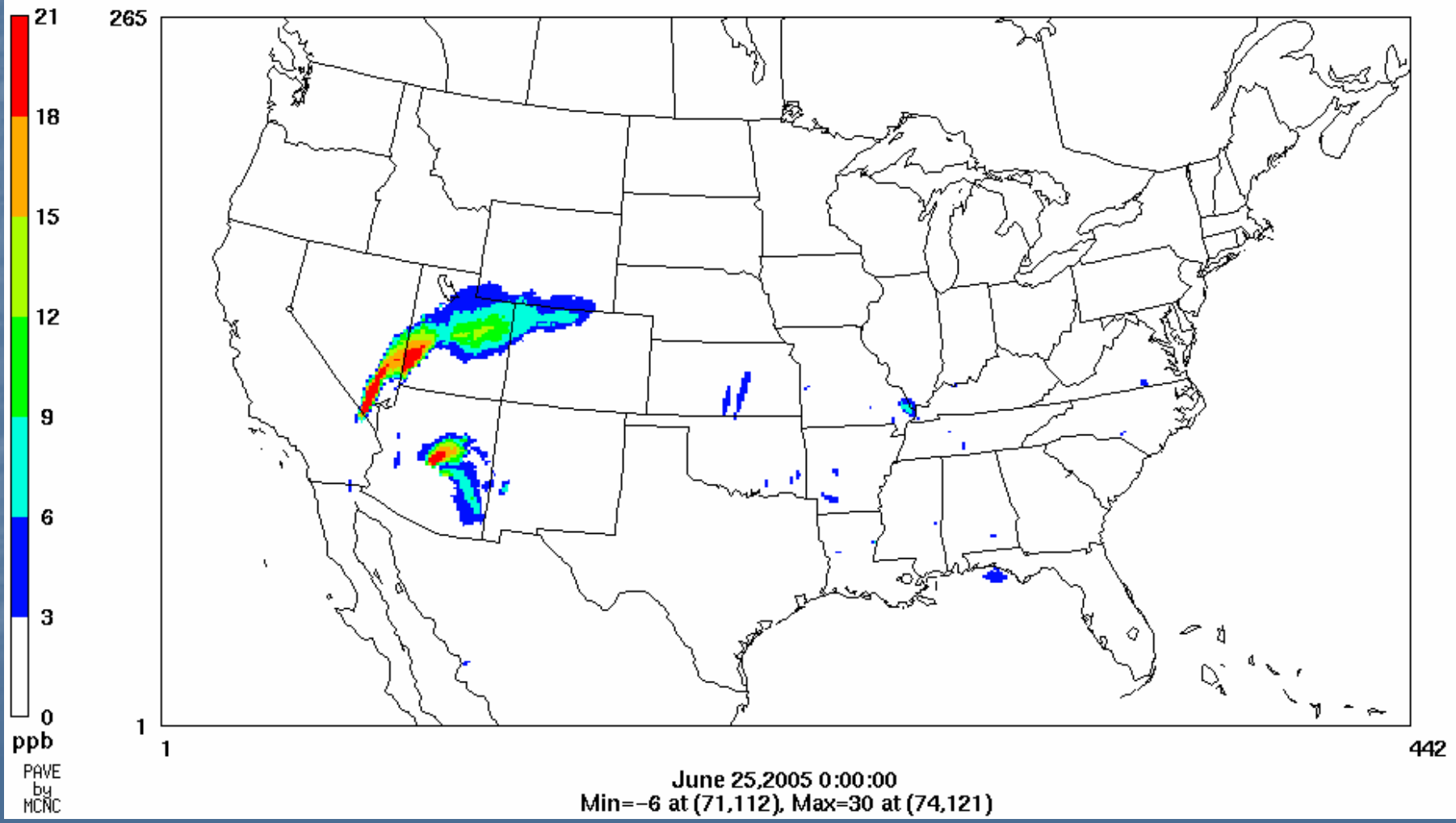
Difference in 24-hr Average PM2.5 June 24 Forecast

Fires – No Fires

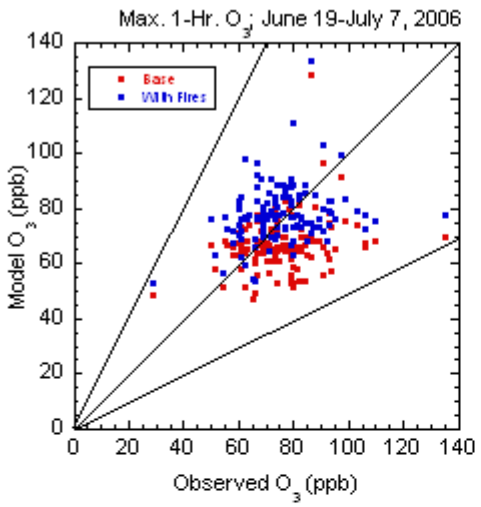


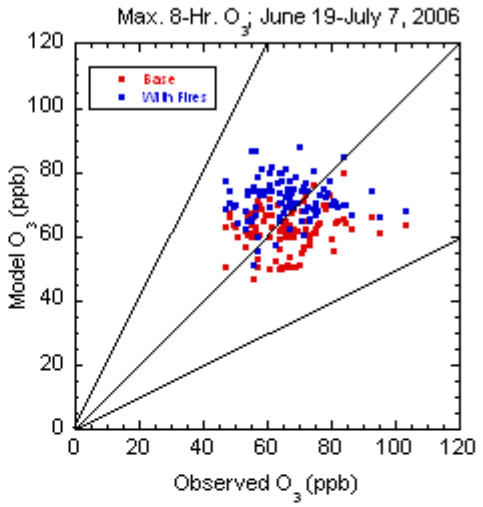
Difference in Max 8-hr Ozone for June 25 Forecast

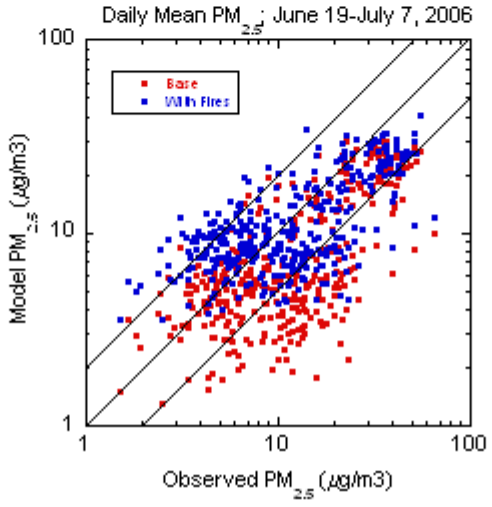
(Fires – No Fires)



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

2002 Fire EI Development

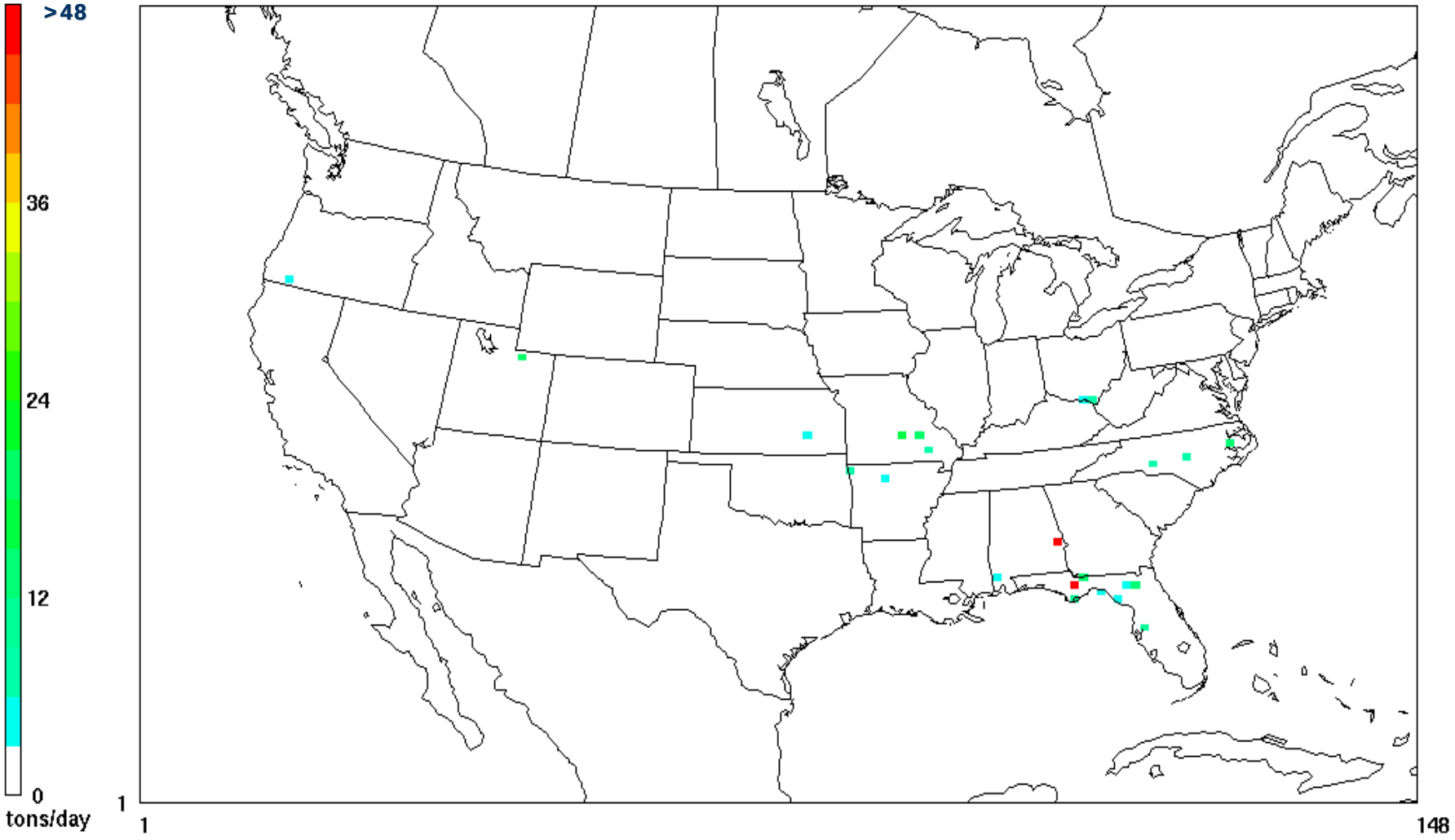
- Ground-based incident reports *(ICS 209, DOI 1202, some States)*
- Huge Effort *(by RPO's / Air Sciences)* to QA Datasets
  - Errors & omissions
  - Average daily fire size
  - special emphasis on 14 fires >10,000 acres in size
- Geo-referenced fuel type (NFDRS)
- Geo-referenced moisture by date/location
- FEPS used to calculate fuel consumption
  - Lookup matrix ~ combinations of fuel types & moistures

WF & PB ~ emissions estimate ~ all Criteria & 29 HAPs

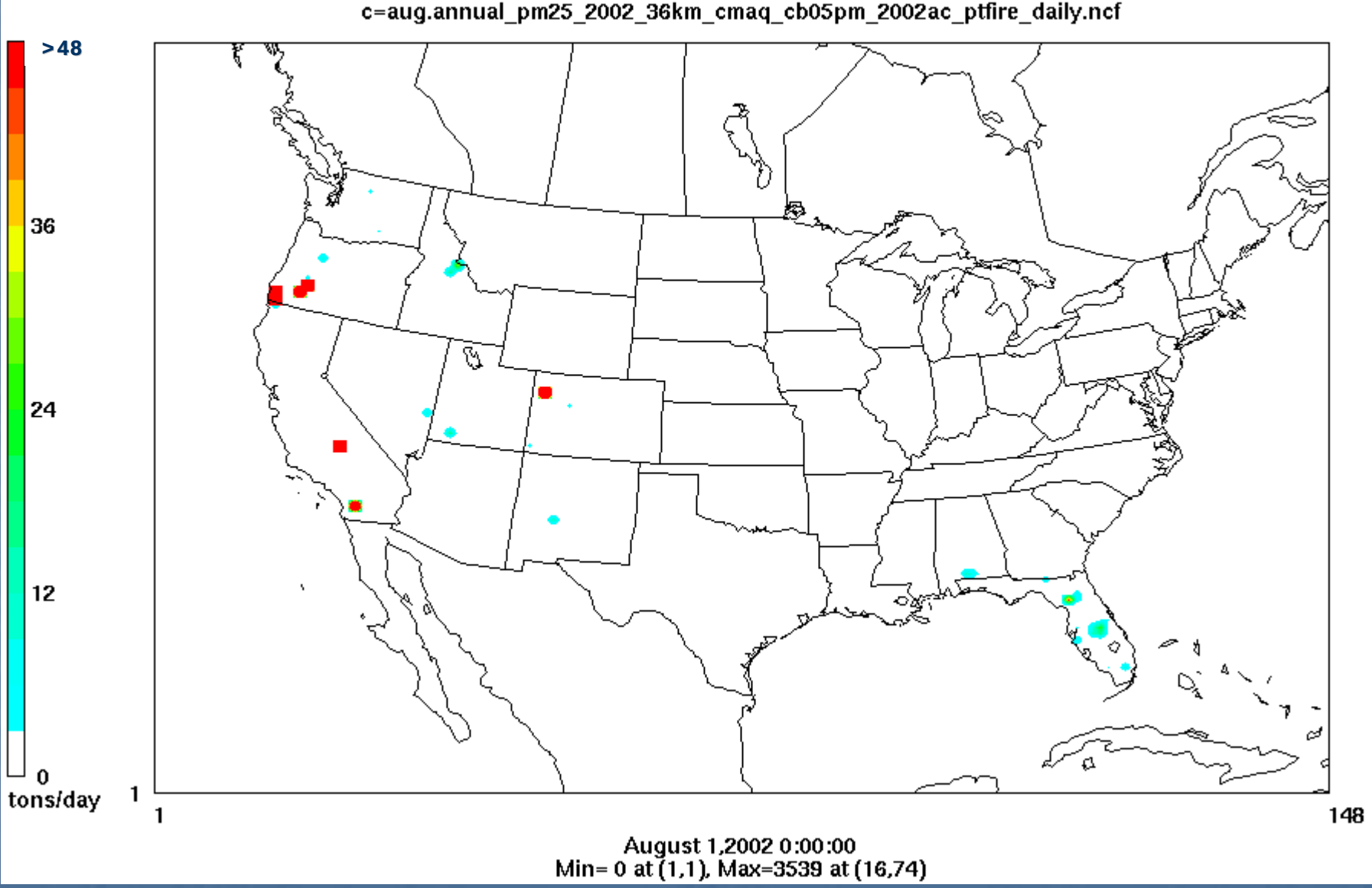
(Note: Agricultural burning, where available was provided by RPO's/States)

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)

April 2002 PM2_5 Emissions RX and Wildfire (except GA)



August 2002 PM2_5 Emissions RX and Wildfire (except GA)



2002 to 2005 Fire EI

Why do we need to move beyond the 2002 approach?

"Ground-based report" Issues (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,
- Nothing to "ground-truth" against

Costly process to track down & resolve the issues

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.**
  - **Exploit “value” of *BOTH* Satellites *AND* Ground Reports**

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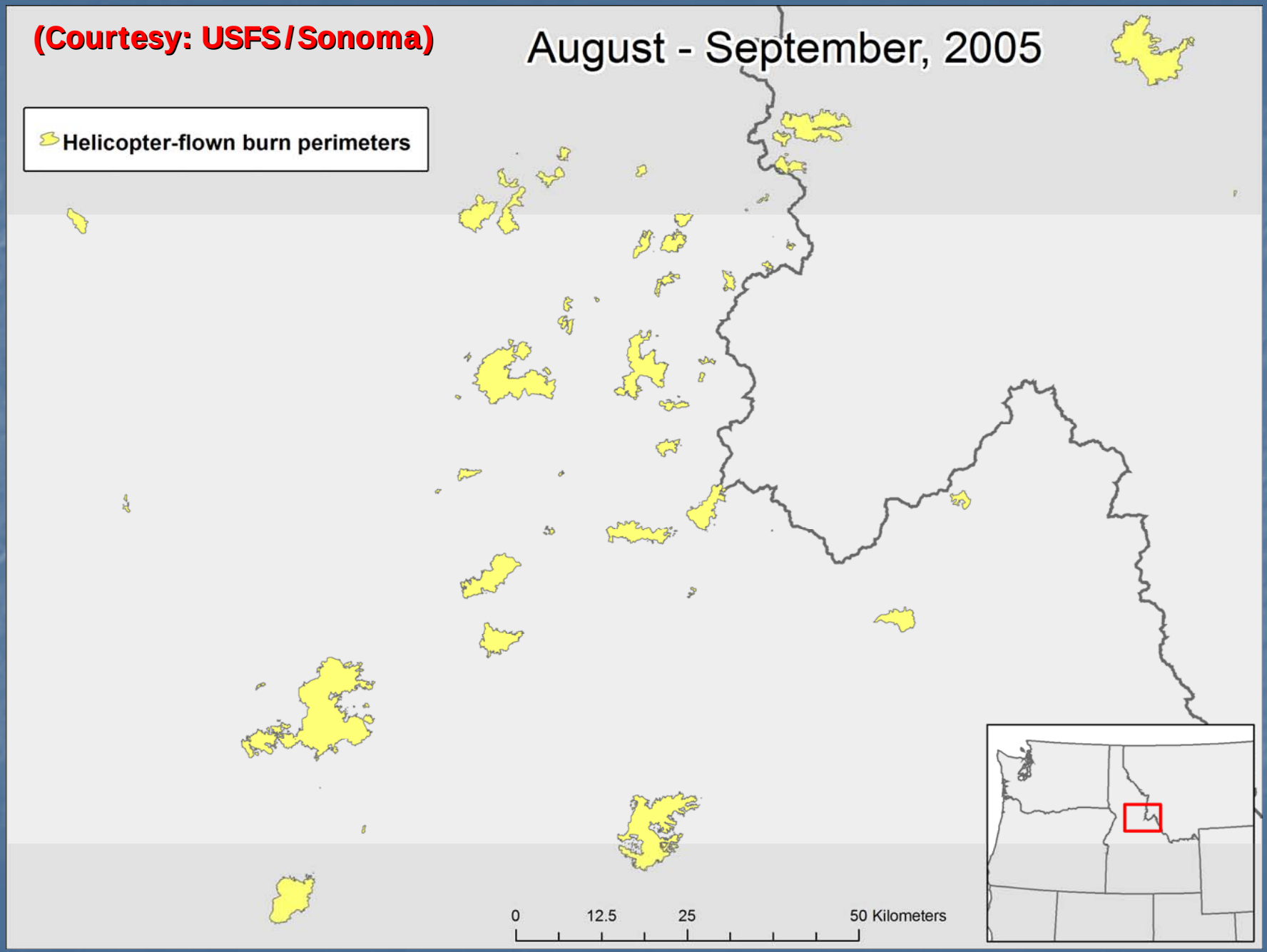
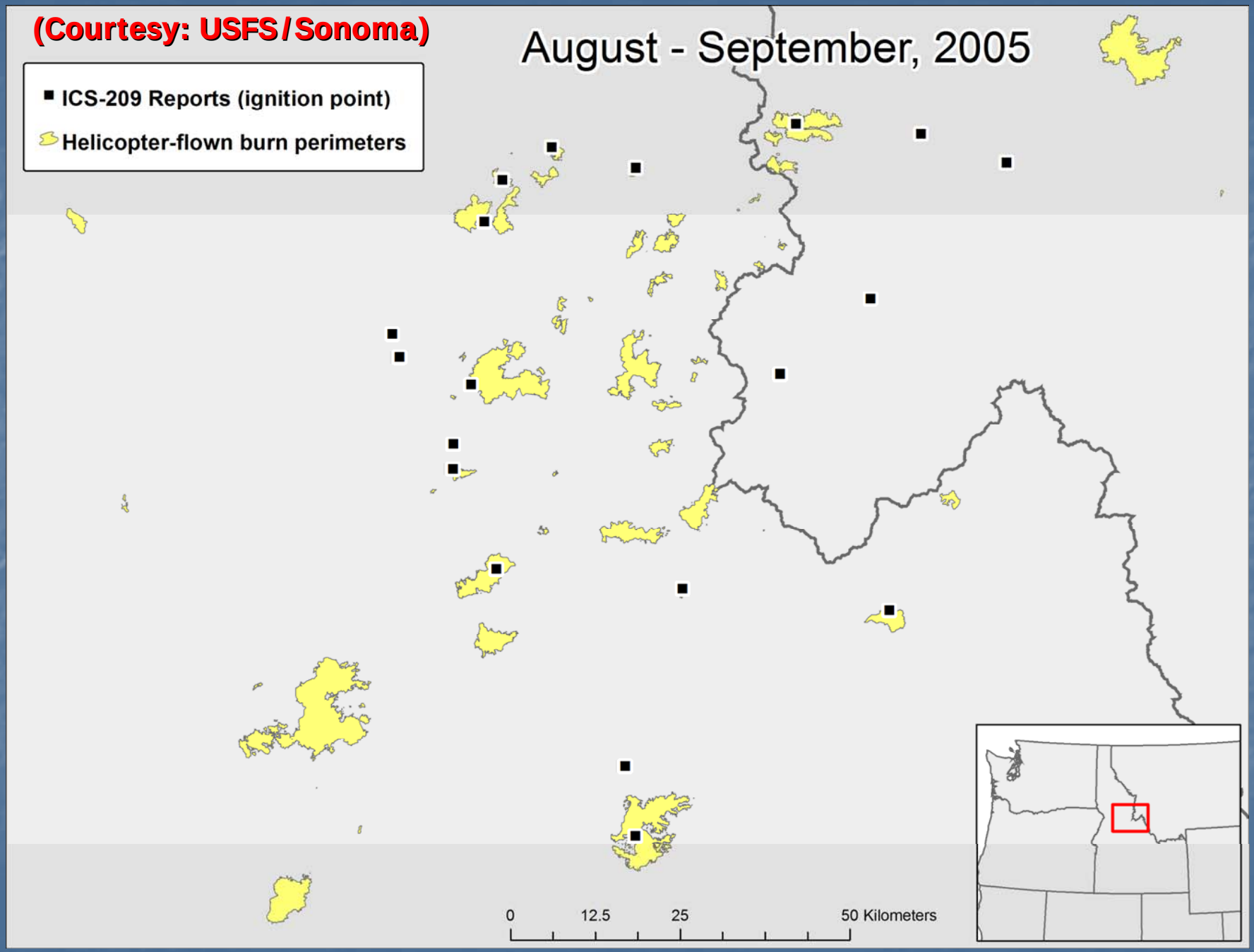
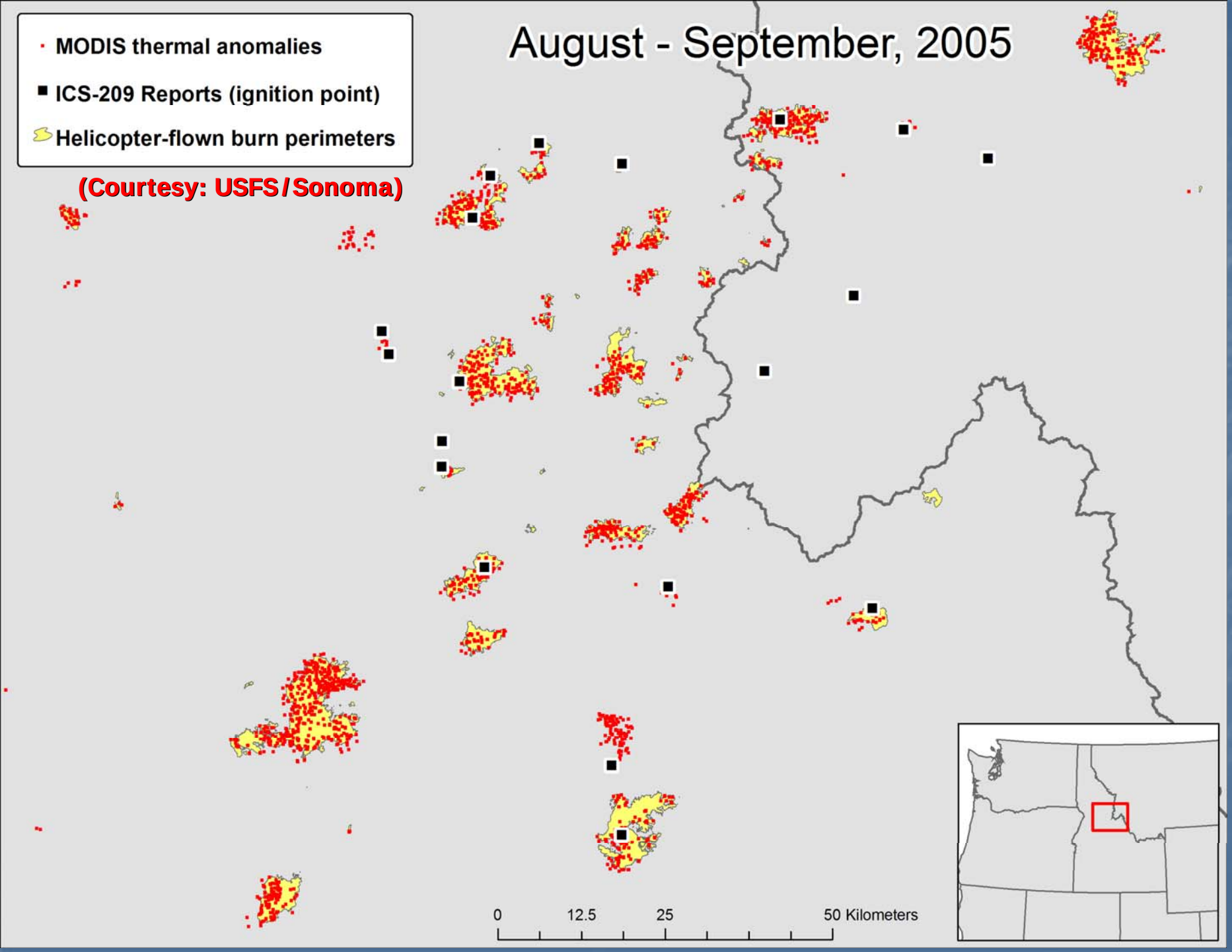
  - **Exploits "value" of *BOTH* Satellites *AND* Ground Reports**
- **Why is the Hybrid Important?**
  - **Ground reports: fires not "seen" by satellites – *but errors***
  - **Ground reports (soon): more accurate & comprehensive**
  - **Satellites: fire movement; location & temporal accuracy,**
  - **Satellites (soon) burn scar area, initial plume rise**

(Courtesy: USFS/Sonoma)




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


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

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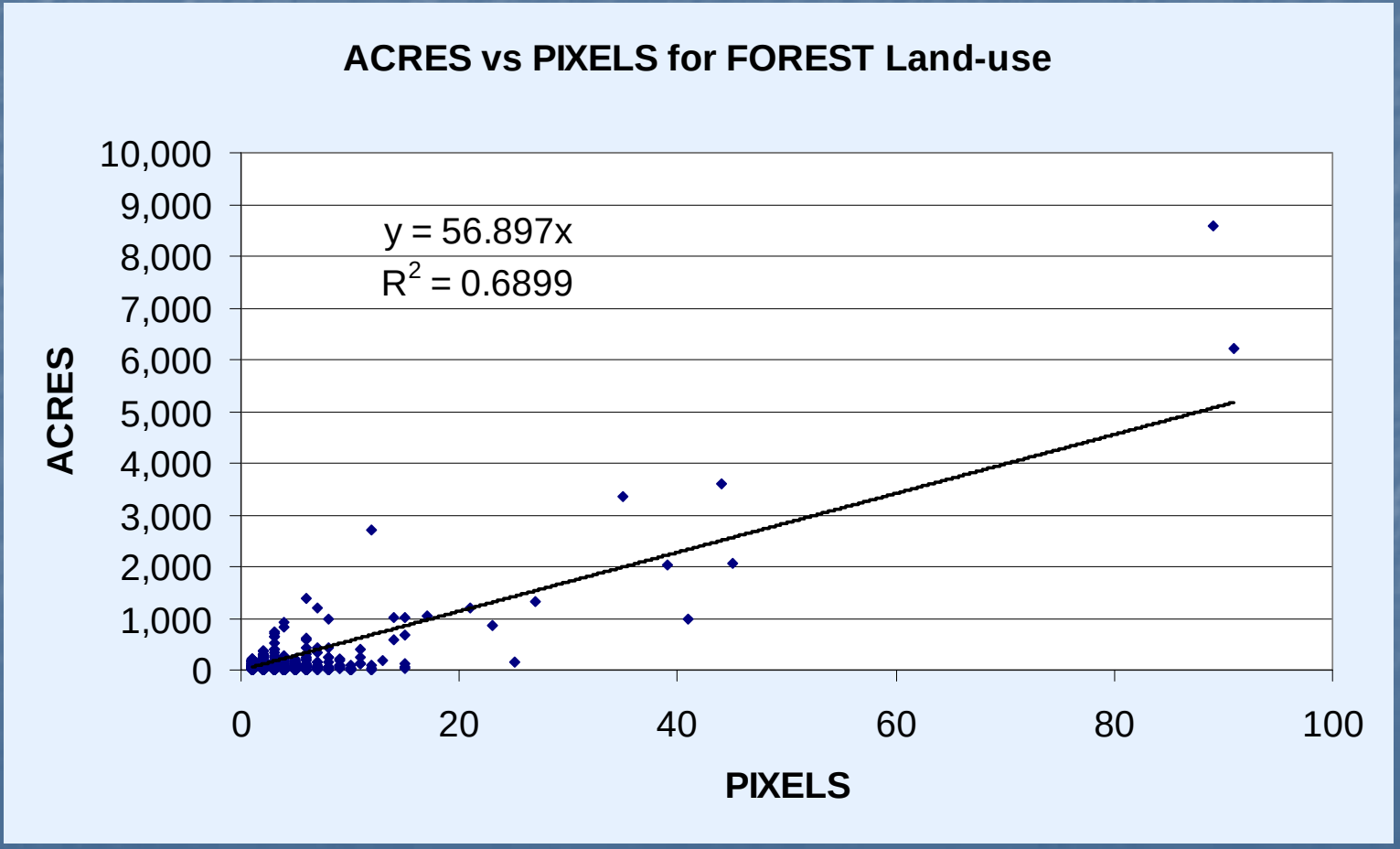
- **Data Resources & Tools to Develop the 2005 Fires EI**
  - **ICS 209** Reports**, MODIS, GOES** satellite products
  - **Fuels / Emissions** matrix from 2002 Inter-RPO / NEI
  - **Insights, Lessons Learned** ~ compare MODIS, 2002 Inter-RPO / NEI

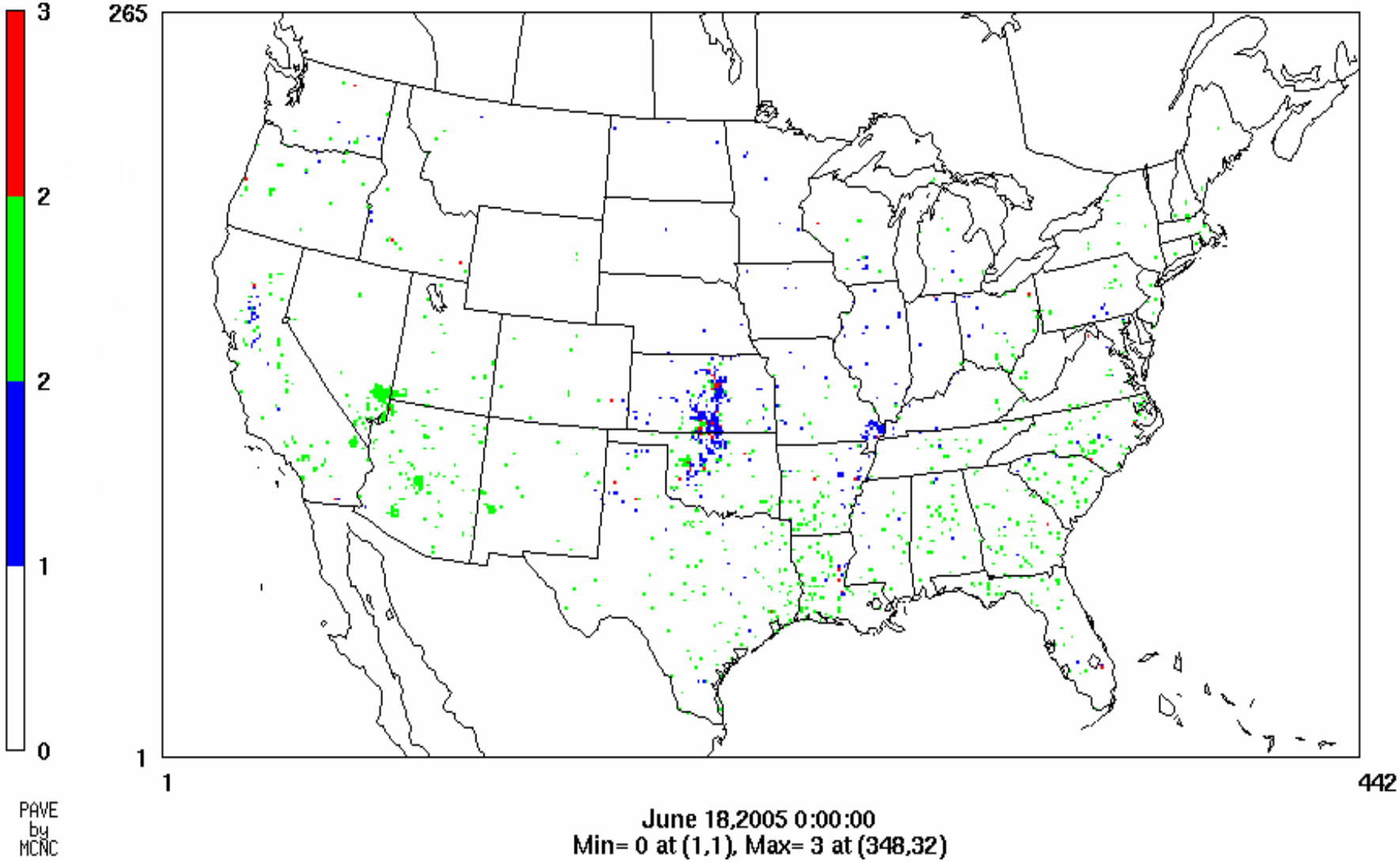
Learning from the 2002 NEI:
Acres vs Pixel Relationship

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



MODIS FIRE DETECTS

Agriculture **Non Agriculture** **Mixed**



2005 Fire EI -- Development

1st Generation Hybrid

- **Who:** EPA/ORD with OAQPS
- **Data Sources:** MODIS 2005 fire detects, 209 Reports
- **Draw upon the 2002 EI**
  - Pixels-to-acres relationship
  - Gap-filling for Ag & Prescribed Burning
- **Process:**
  - **Merge:** MODIS 2005 fire detects with 209's
  - **Resolve mismatches:** in location-timing-size (as resources permit)
  - **Identify / Separate** agricultural fires using land use databases
  - **Fuels / Emissions:** adapted from 2002 Inter-RPO / NEI
  - **Create event-specific EI:** dates, daily fire sizes, locations, emissions
- **Compare:** with other 2005 EI data as available
  - NOAA, BlueSky, NCAR, NASA, SMARTFire
  - Refine as resources permit

EI Quality: Much better than Pre-2002
Resources: Much less than 2002

Post-2005 Fire EI

"Next Generation" Hybrid

- **Fire Emissions Tracking System (FETS)**
  - WRAP States – on-line this summer
  - Other State Tracking Systems – e.g., North Carolina
- **SMARTFire**
  - Automated integration of Ground-based & Satellite data
- **Other Likely Enhancements**
  - **BlueSky Framework Enhancements**
  - **Multi-platform integration (MODIS, GOES, AVHRR)**
  - **Integrate multiple ground-based reporting systems**
  - **Burn scar, GPS and/or remote sensing of perimeters**
  - **Heat-release analysis, multi-chimney, plume rise**
  - **Model evaluation using remote sensing (e.g., AOD)**

Summary

Past, Present & Future of Fire Emissions Estimation

- Pre 2002 ~ NOT Event-specific
- 2002 ~ Event-specific
  - Ground-based reports ~ extensive “cleanup”
- 2005 ~ 1st generation hybrid (w/ satellites)
- Post 2005 ~ 2nd generation hybrid
  - Automated integration ~ “ground / satellite data”
  - Burn scar / Heat release / AOD
  - Learn / improve methods by intercomparison:
    - ground reports,
    - helicopter/aircraft sensors,
    - on-site evaluations,
    - other platforms (e.g., Calypso)

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Thank you!

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