WRAP Fire Tools and Support for Smoke Management Programs, Land Managers, and Air Quality Planning

DEASCO$_3$ Tool - Purpose and Usefulness for the Central and Midwestern States

+

Case Studies – Impact of Fires on Ozone in the Central / Midwest U.S.

Tom Moore, WRAP

2014 Midwest and Central States Air Quality Workshop

April 23, 2014

WESTAR

Western States Air Resources Council

Western Regional Air Partnership

Joint Fire Science Program

Acknowledgements

- WRAP Tools Team
  - Deterministic and Empirical Assessment of Smoke's Contribution to Ozone (DEASCO_3)
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    - ENVIRON – Ralph Morris, Bonyoung Koo, Ed Tai
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    - DEASCO_3 +
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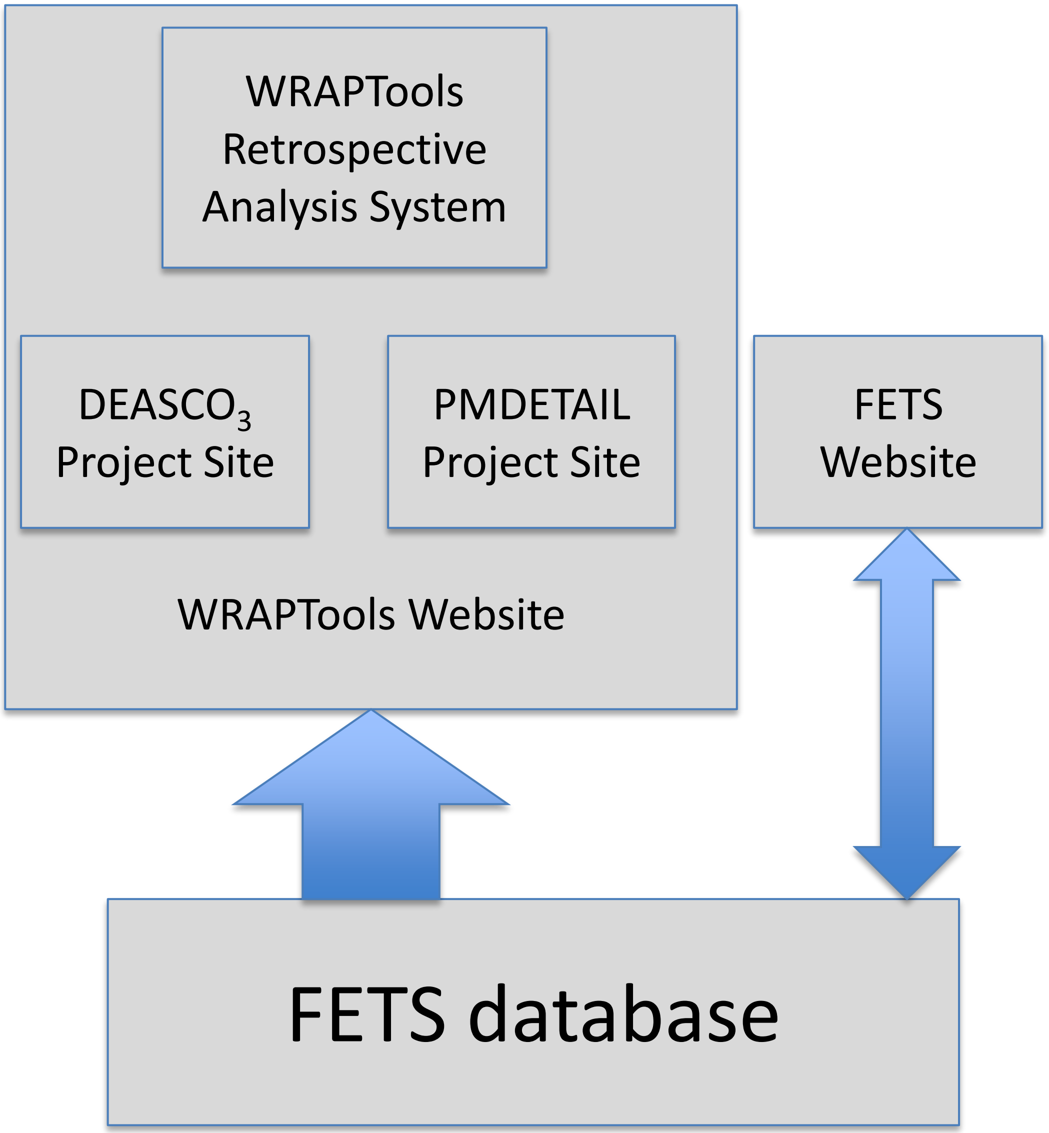
    - Carnegie-Mellon University – Allen Robinson and Spyros Pandis
- Funding from
  - JFSP
  - Leveraged against and integrated with past and ongoing projects funded by BLM, USFS, NPS, State of NM, and EPA

WRAP Fire Tools Landscape

- Fire Emissions Tracking System
  - Gathering daily WF and S/L/T data
  - QA/QC and reporting tools for activity, emissions, NEI
- DEASCO$_3$
  - JFSP-funded project
  - DSS for Ozone impacts
  - Temporal analysis, area impacts
- PMDETAIL
  - JFSP-funded project
  - DSS for PM impacts
  - Temporal analysis, vulnerability matrix



WRAPTools Toolbar Approach

What questions do we need to address to perform retrospective case study analyses?

What data are available to us?

How do we organize results to accommodate differing analysis types?

- Start with basic criteria from user: time, space
- Build a set of modular tools that produce analysis results
- Build a one-page "workspace" and plug in tool results, commentary.

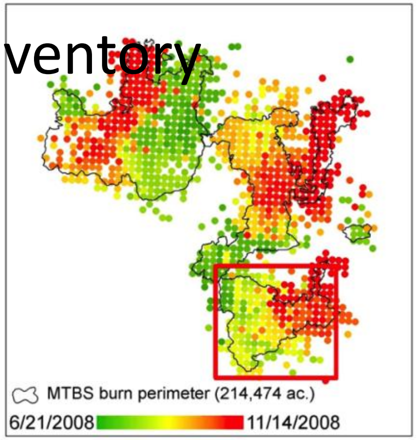
Joint Fire Sciences Program: Sponsoring applied research and tools for analyzing air quality impacts from smoke

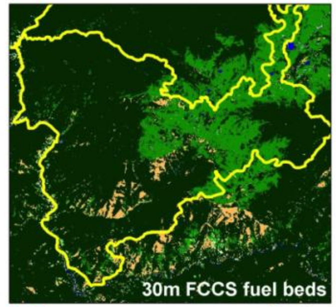
- Example Project: $DEASCO_3$ Case Studies
- 19 Case Studies from around the United States
- Fire Events from 2002 – 2008
- Large wildfire events
- Managed burning

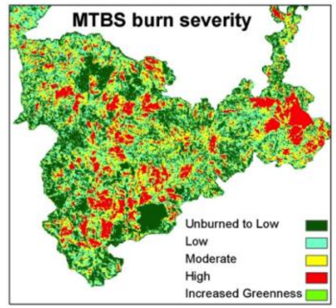
Examples later are pulled directly from the project website

Interactive results accessible at http://deasco3.wraptools.org

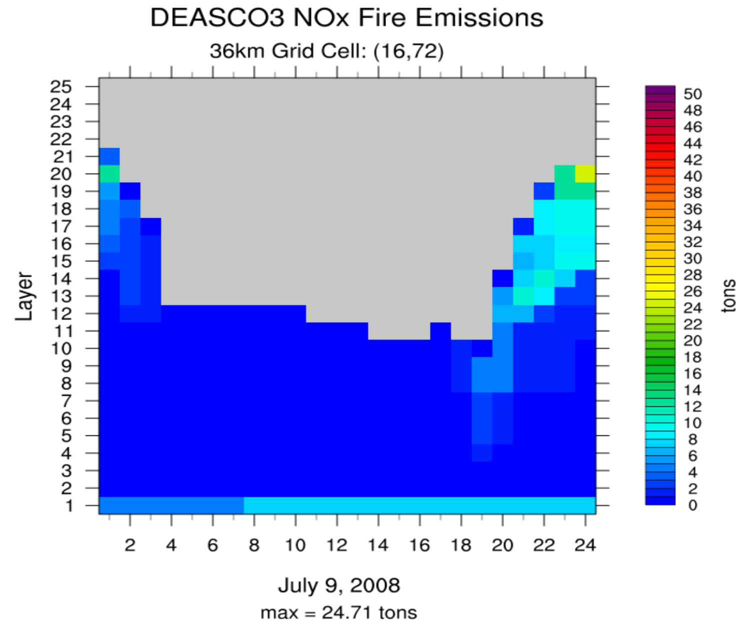
Smoke and Emissions Inventory Research



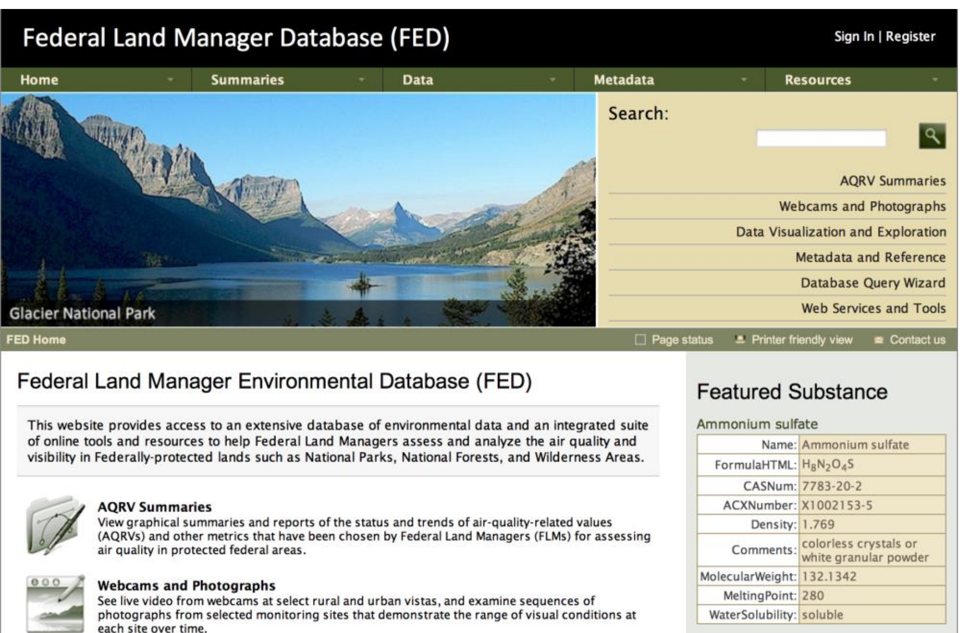




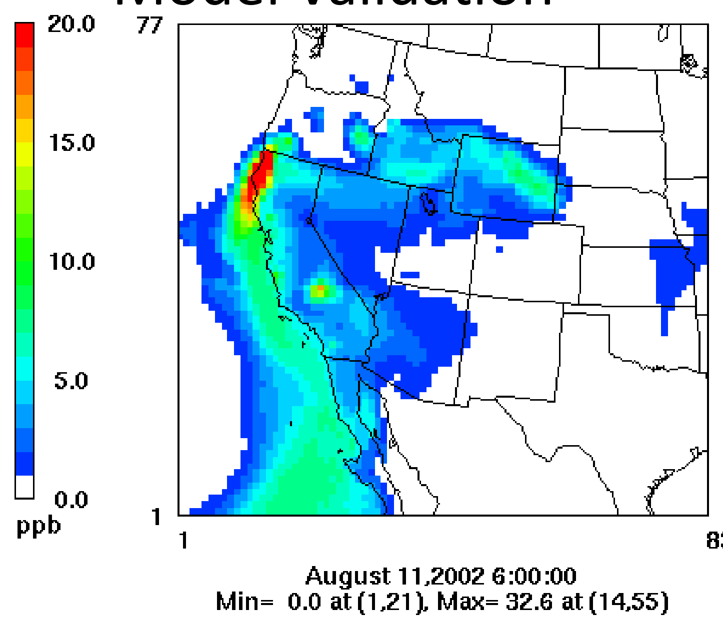
- Acres constrained by perimeter
- Daily growth & composite fuel loading
- Consumption scaled by severity



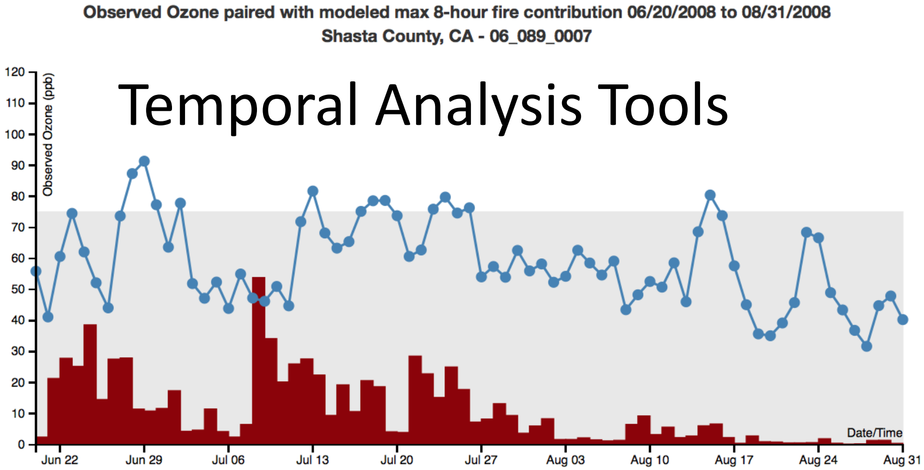
Smoke and Populations



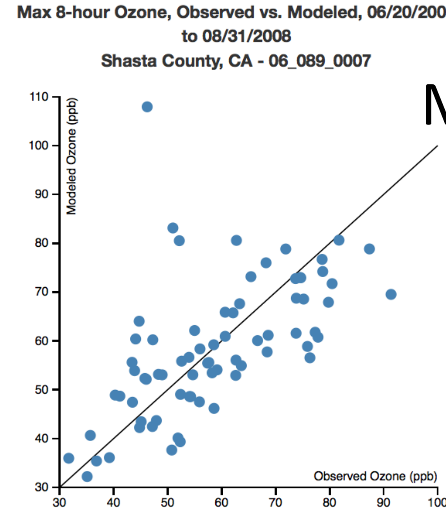
Fire and Smoke Model Validation



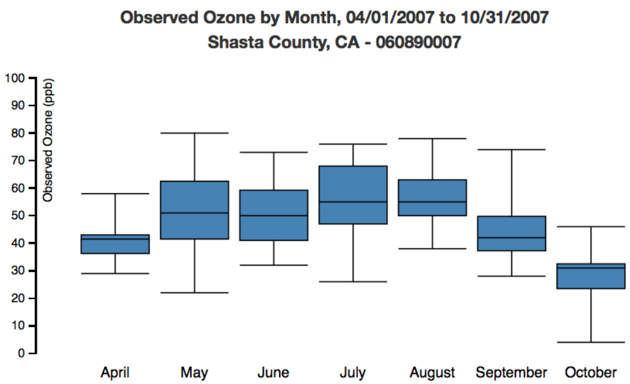
Temporal Analysis Tools



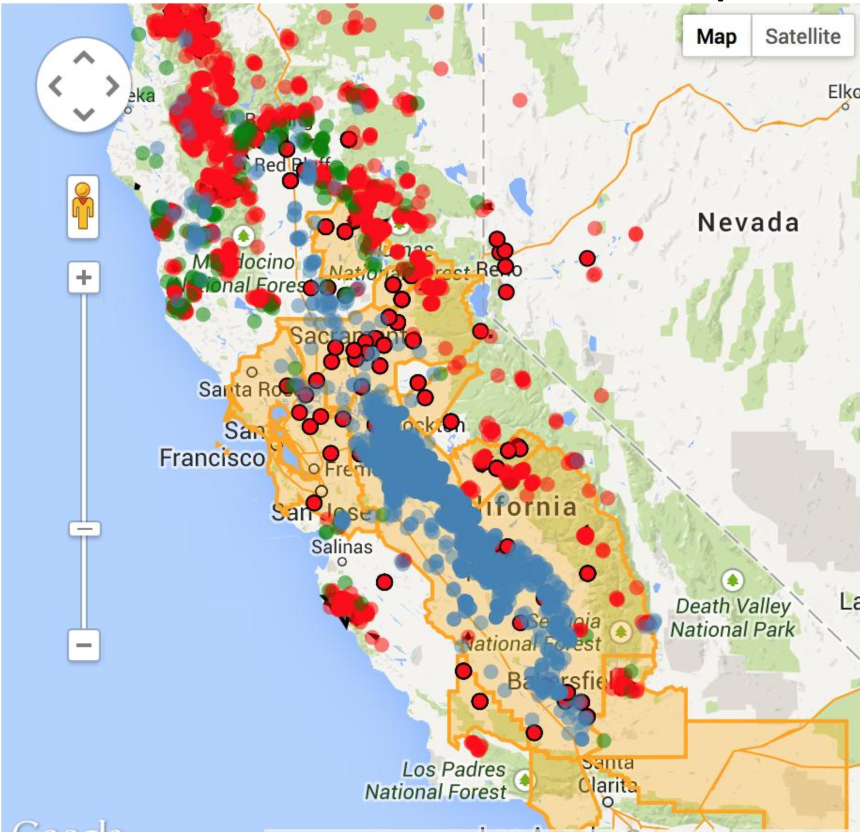
Model Validation



Inter-annual Observational Analysis



Fire Contributions to AQ Impacts



Area Impacts Analysis Tool

Number of days where planned fire caused an exceedance of 70ppb -- weight: 10

Number of days where planned fire caused an exceedance of 65ppb -- weight: 0

Number of days where planned fire caused an exceedance of 65ppb NAA ONLY -- weight: 2

Number of days where planned fire caused an exceedance of 70ppb NAA ONLY -- weight: 2

Number of 70+ ppb days where planned fire contributed > 1 ppb -- weight: 1.5

Number of 65+ ppb days where planned fire contributed > 1ppb -- weight: 1.25

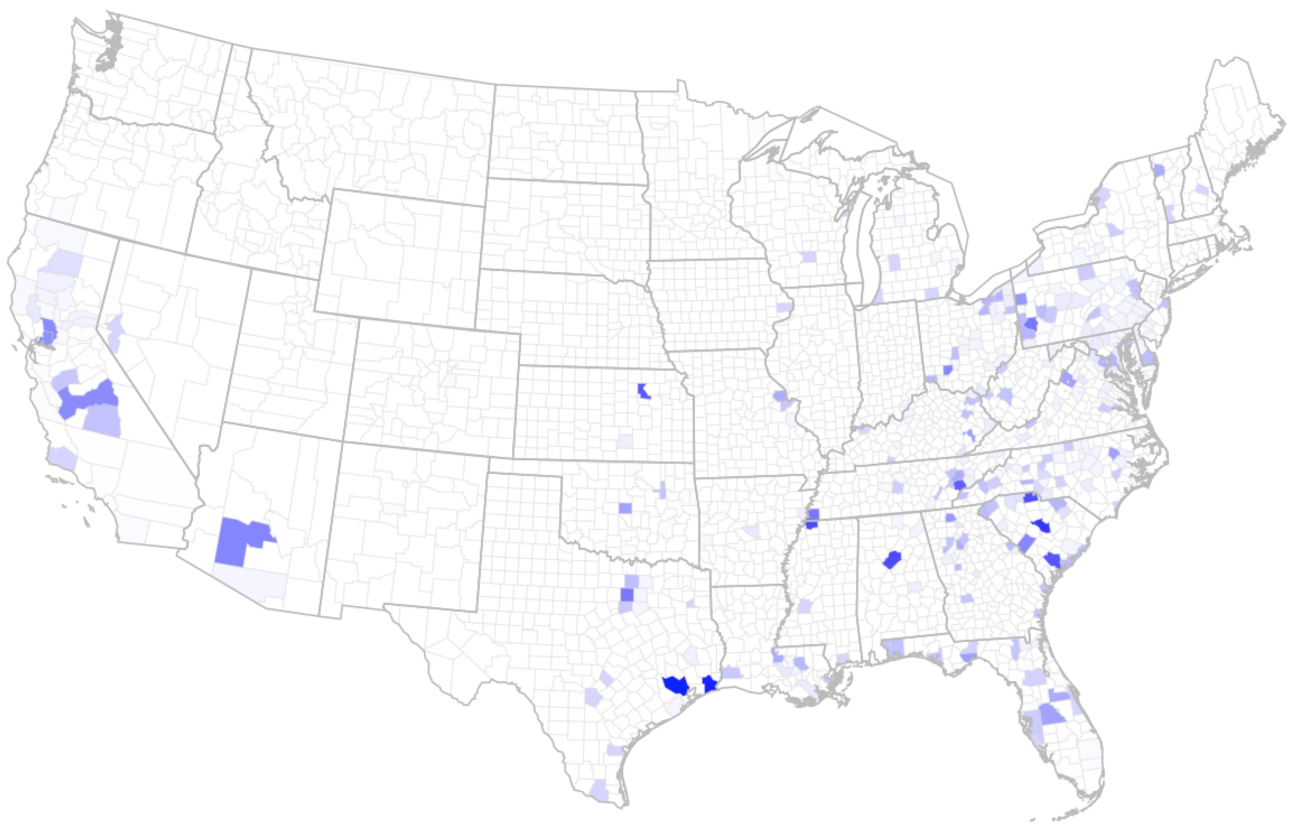
Tons consumed from planned fires near NAA during the ozone season -- weight: 1

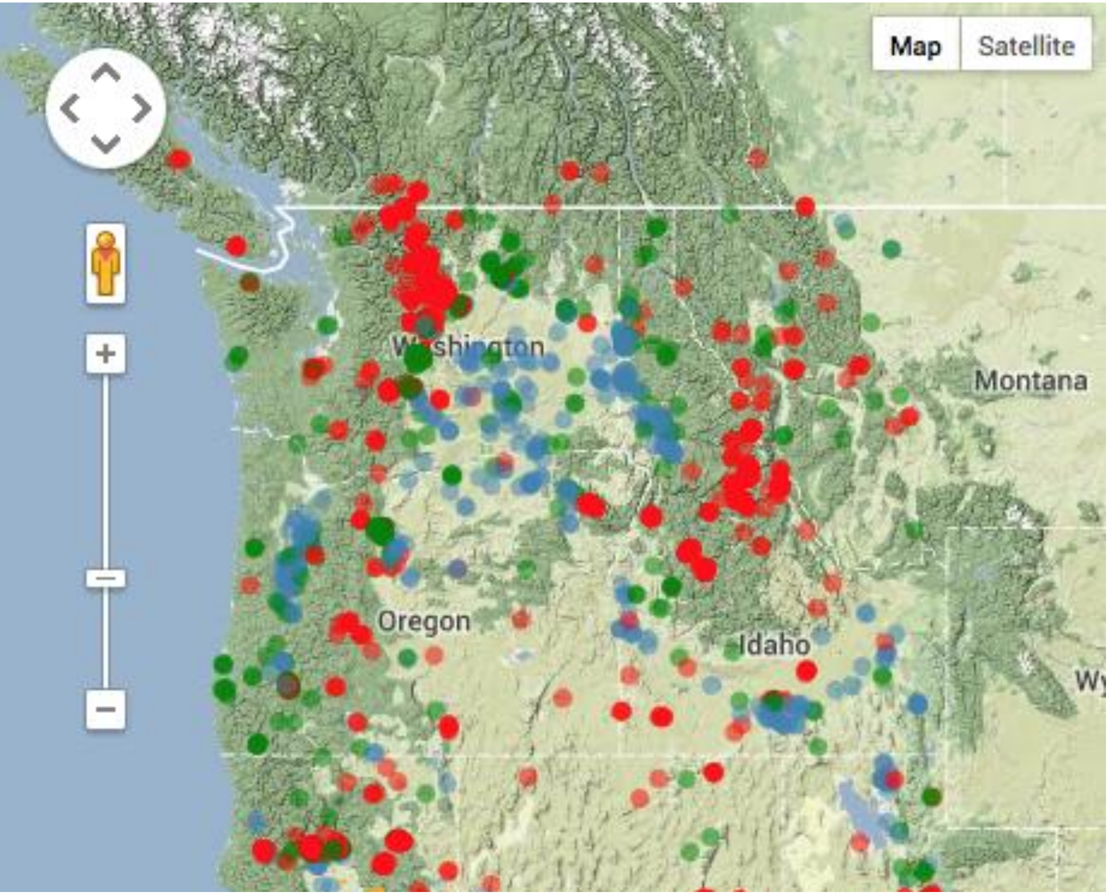
Tons consumed from planned fires near NAA during the ozone shoulder season -- weight: 1

Average tons consumed prior to exceedance -- weight: 1

Number of 65+ days -- weight: 0.01

Number of 70+ days -- weight: 0.01



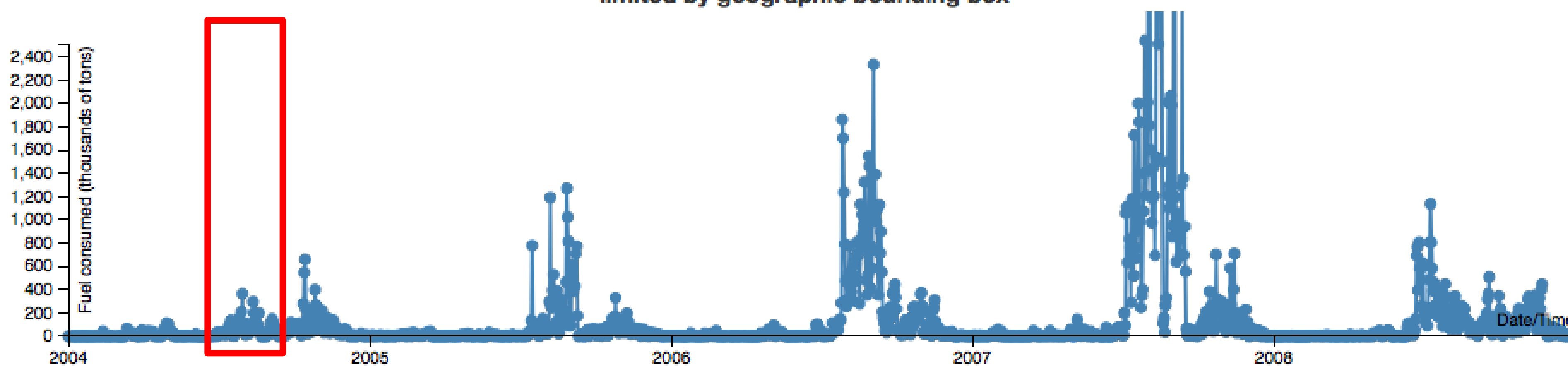


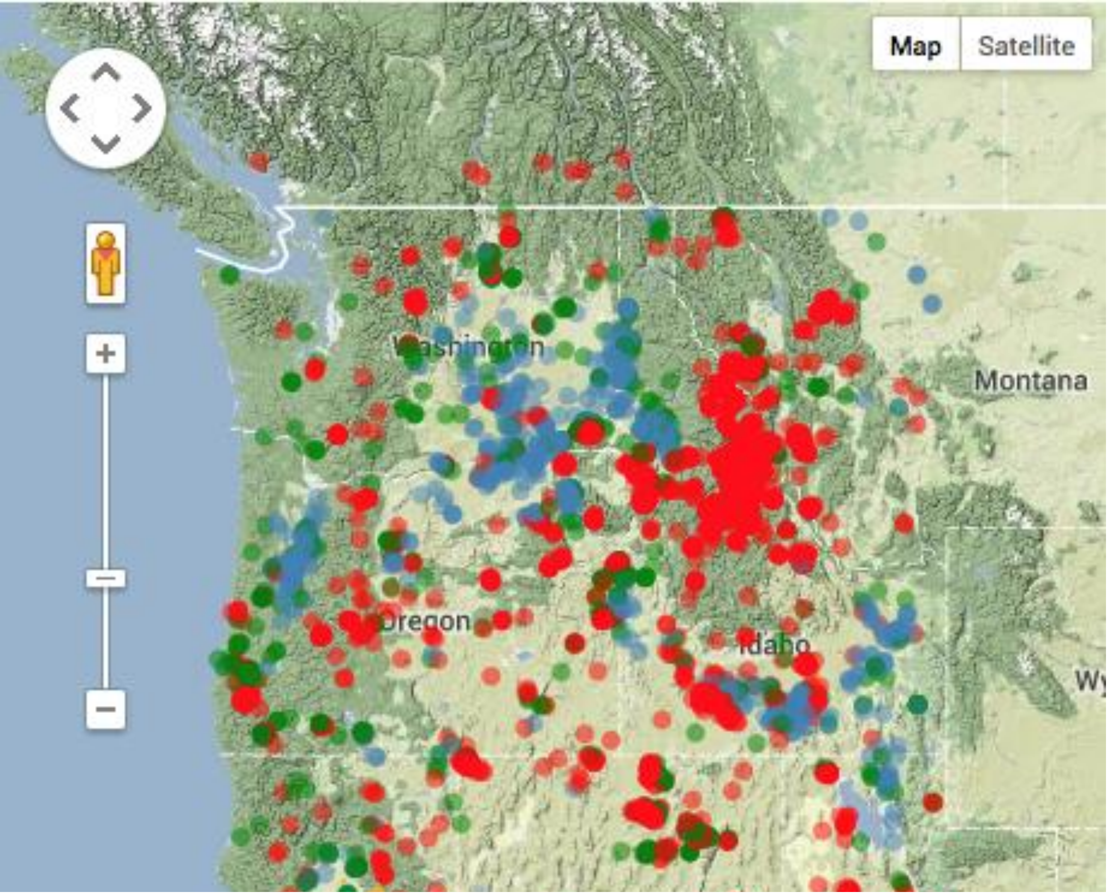
2004

6/20 – 8/31

Limited by bounding box

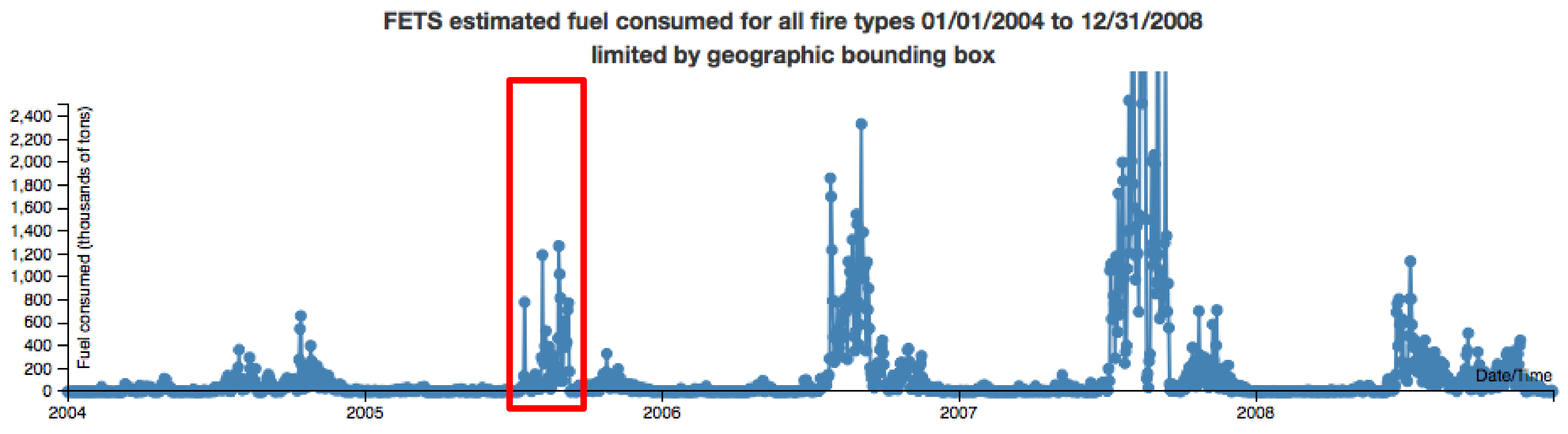
FETS estimated fuel consumed for all fire types 01/01/2004 to 12/31/2008
limited by geographic bounding box

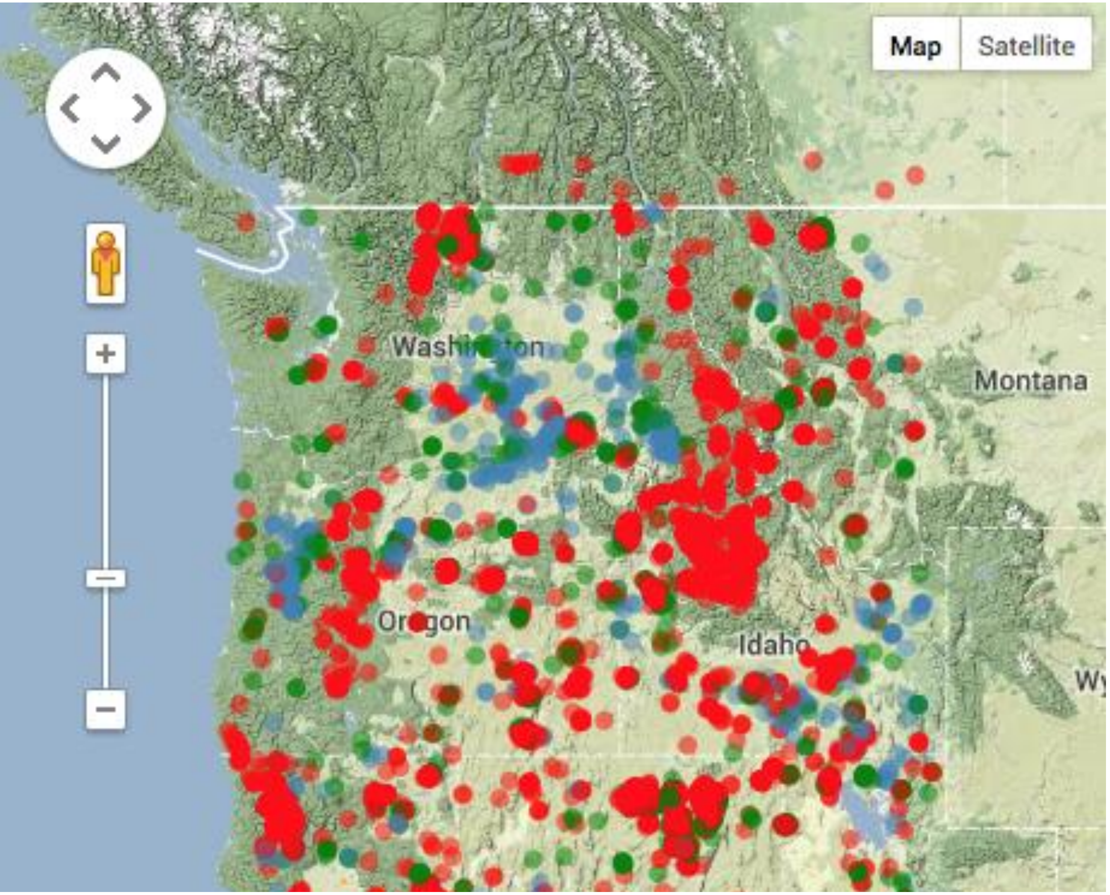




2005

6/20 – 8/31
Limited by bounding box

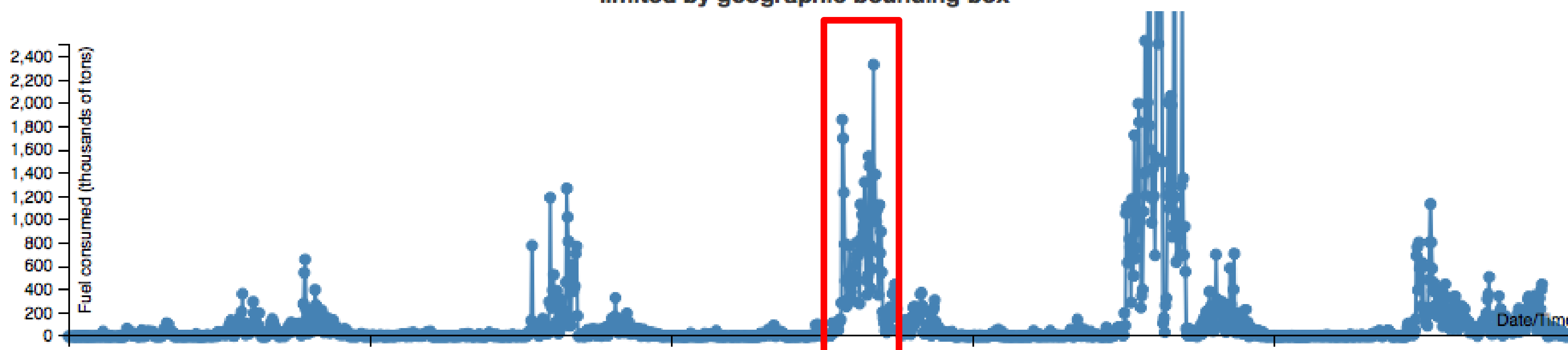


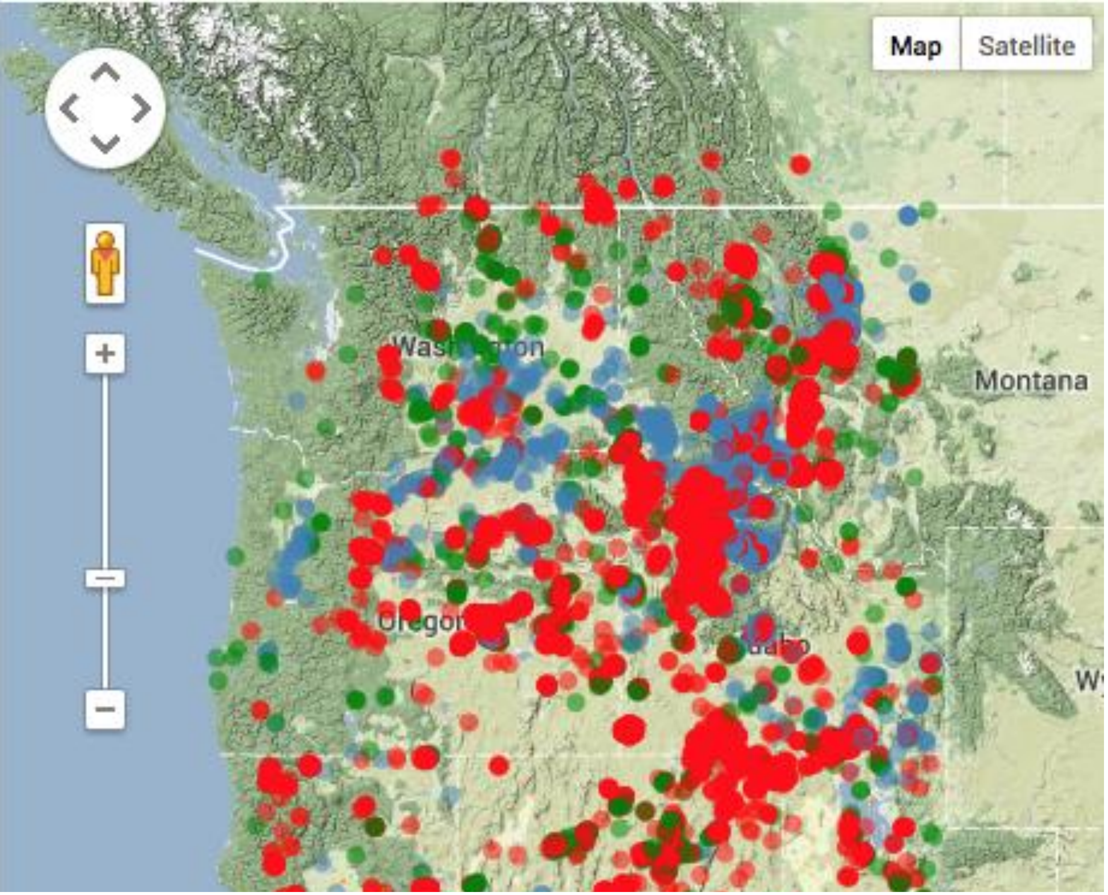


2006

6/20 – 8/31
Limited by bounding box

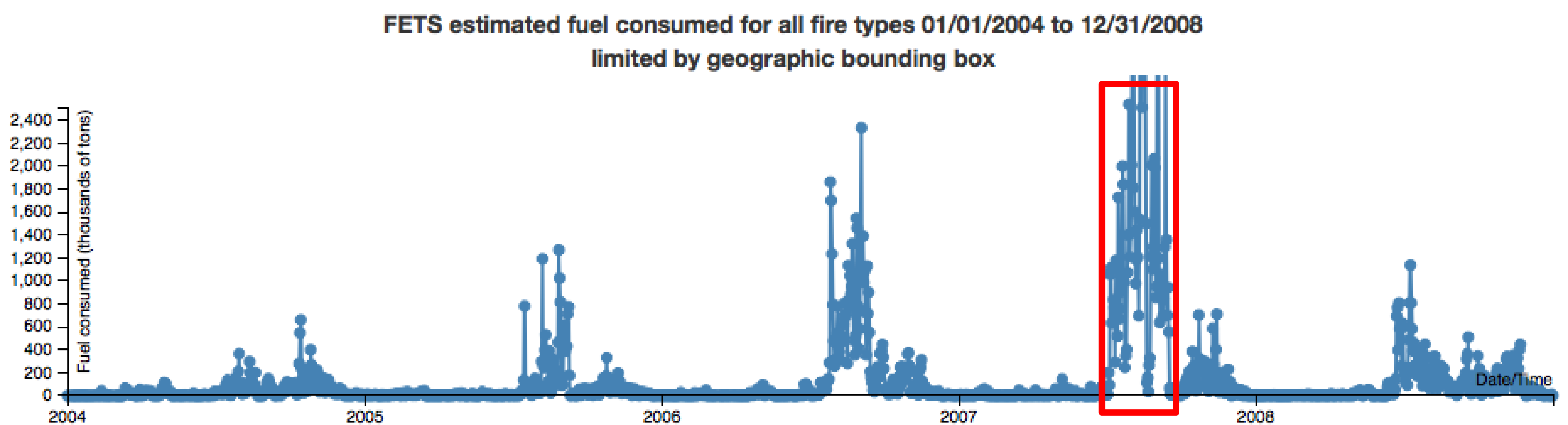
FETS estimated fuel consumed for all fire types 01/01/2004 to 12/31/2008 limited by geographic bounding box

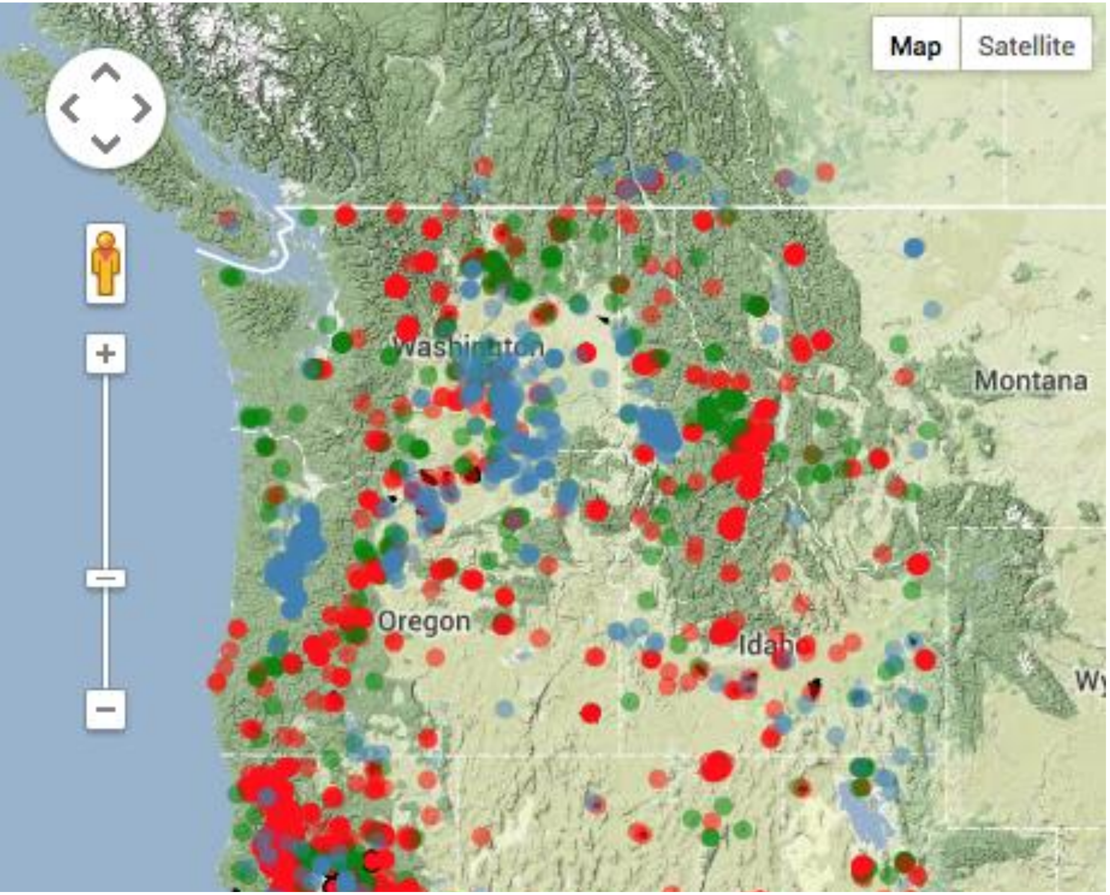




2007

6/20 – 8/31
Limited by bounding box

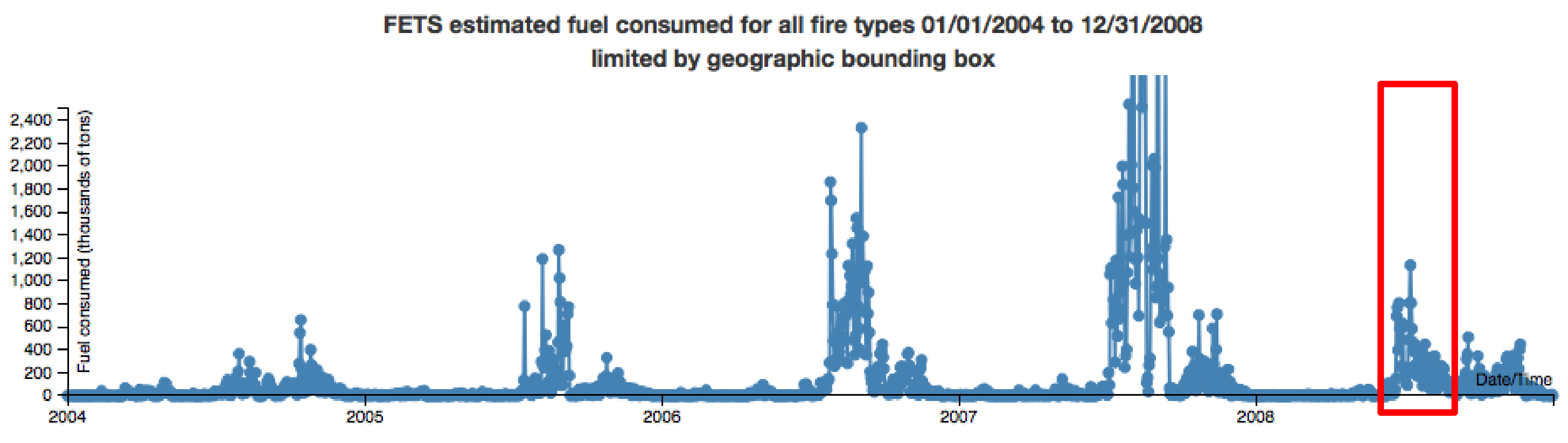




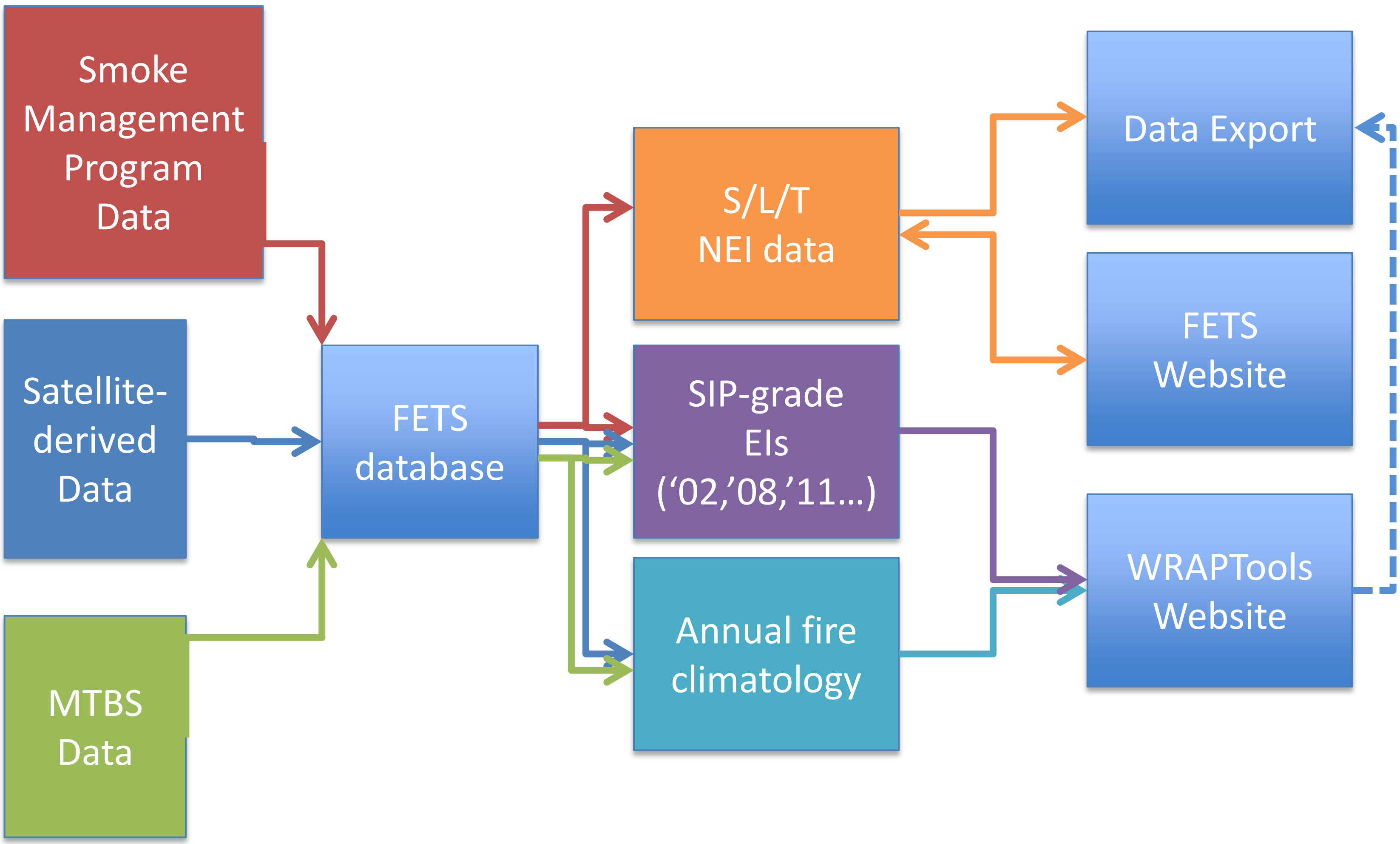
2008

6/20 – 8/31

Limited by bounding box

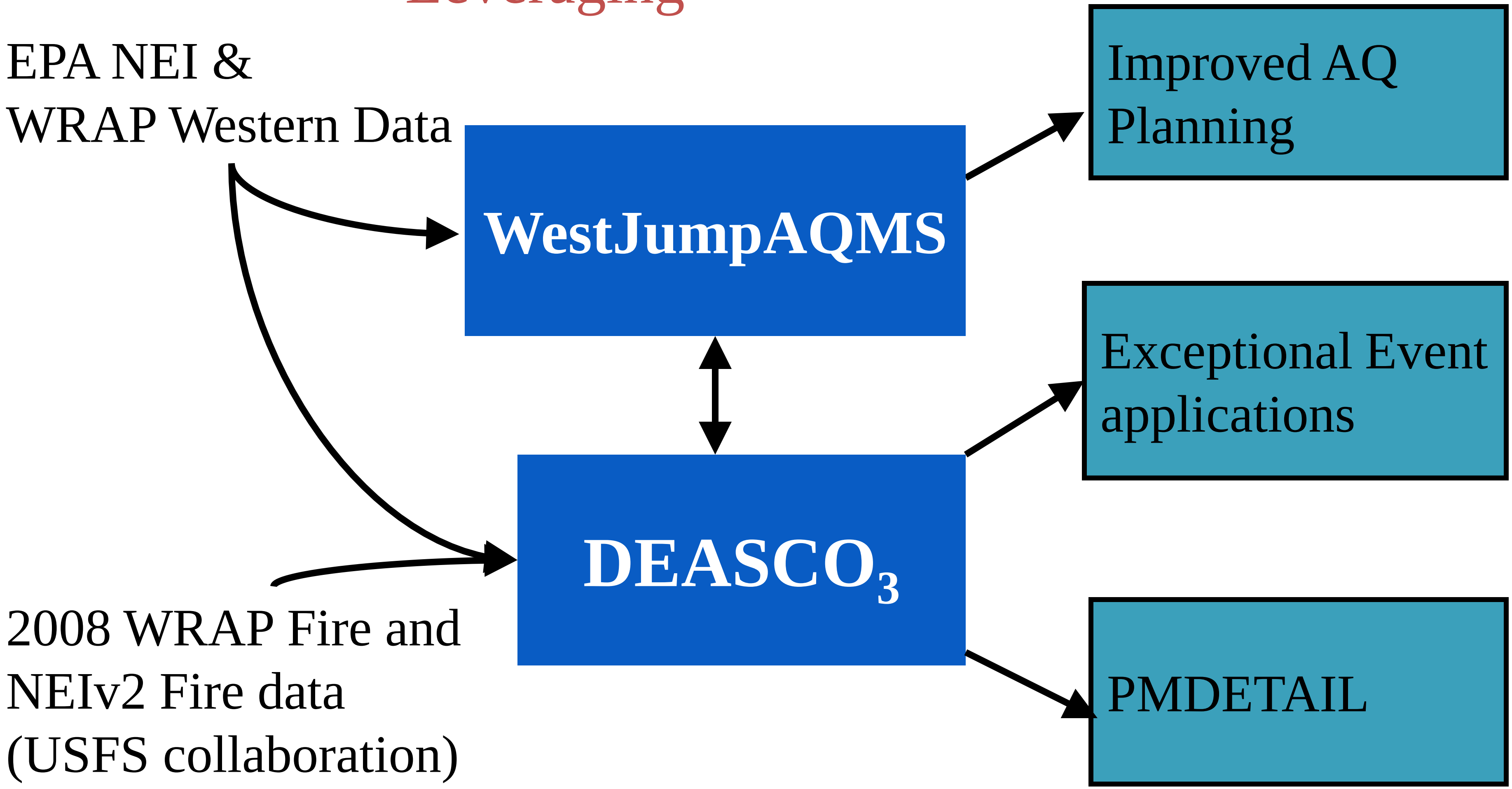


Where do your data go, how are they used?

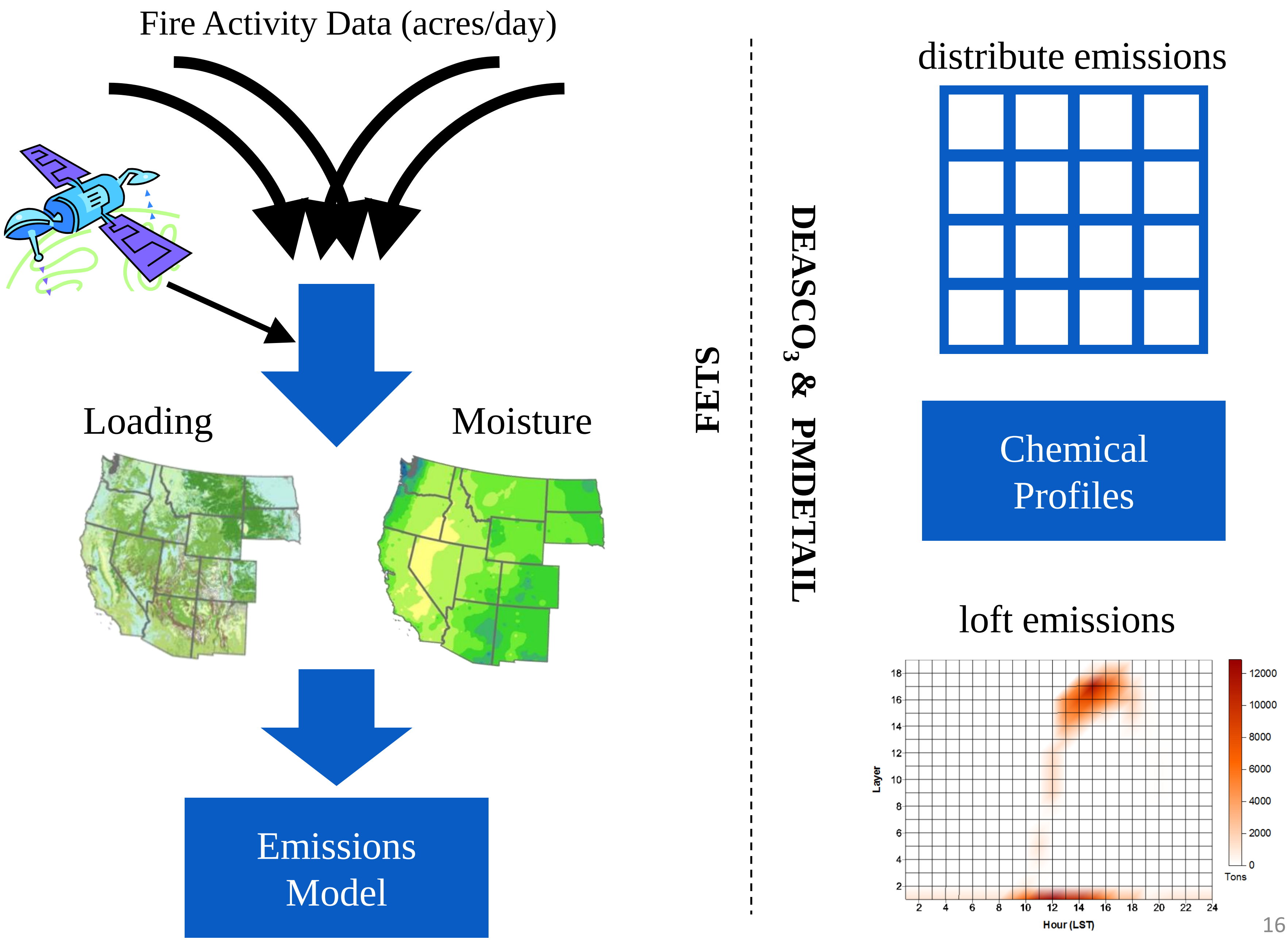


User-supplied data maintain their identity throughout the system

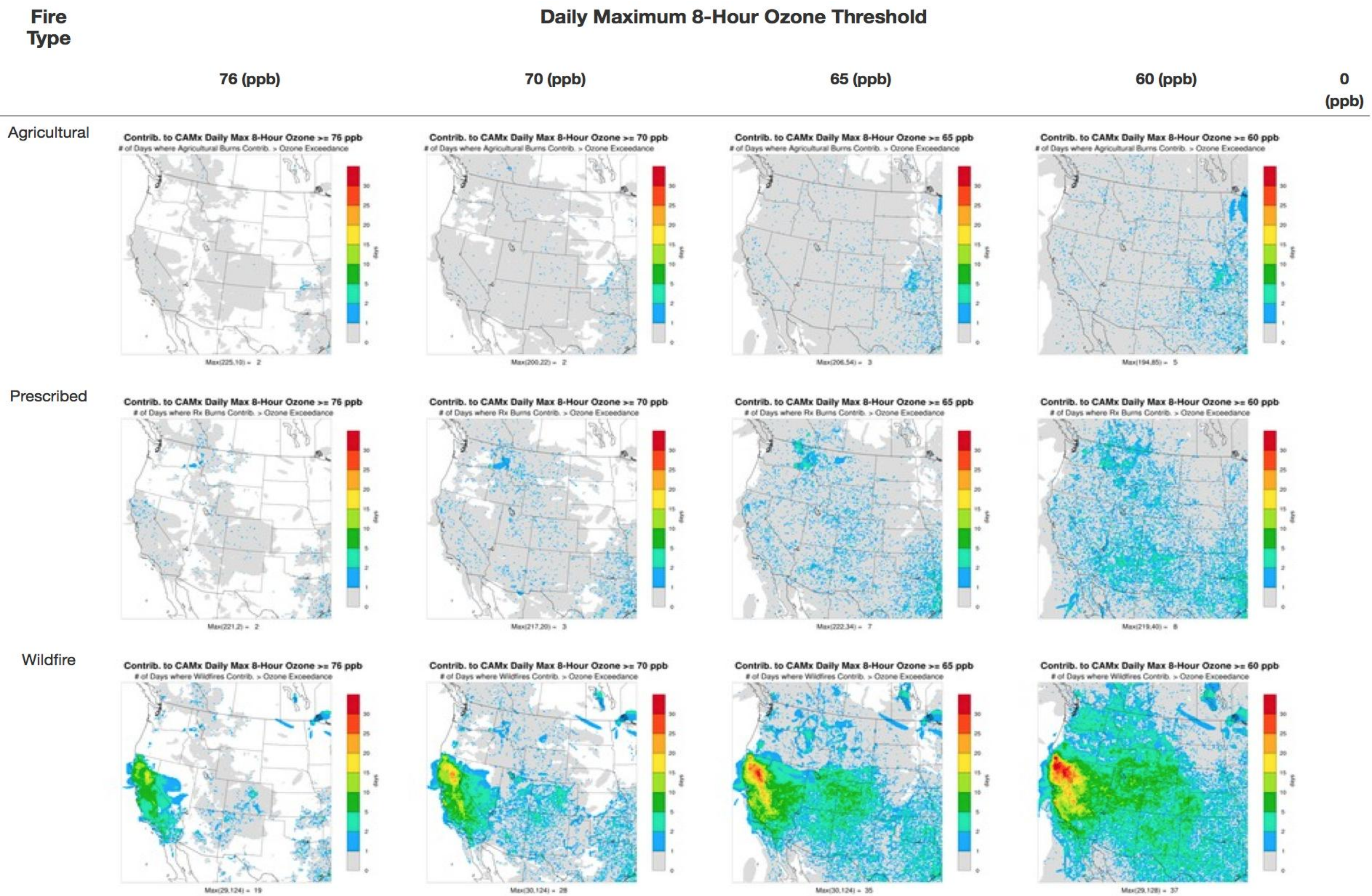
Leveraging


EPA NEI &
WRAP Western Data
WestJumpAQMS
DEASCO$_3$
2008 WRAP Fire and
NEIv2 Fire data
(USFS collaboration)
Improved AQ
Planning
Exceptional Event
applications
PMDETAIL

Track activity and emissions **Determine source impact / contribution**

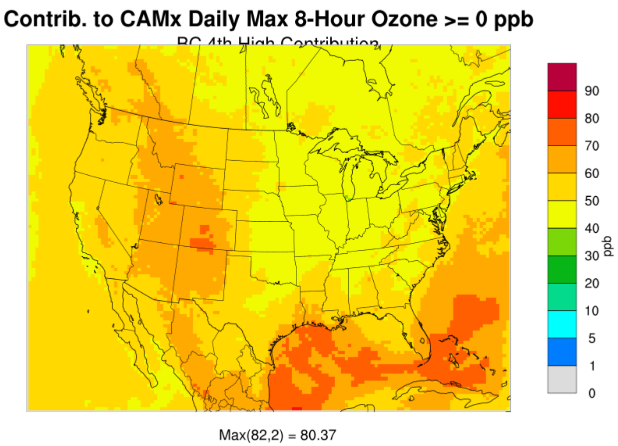


WestJumpAQMS (http://www.wrapair2.org/WestJumpAQMS.aspx)

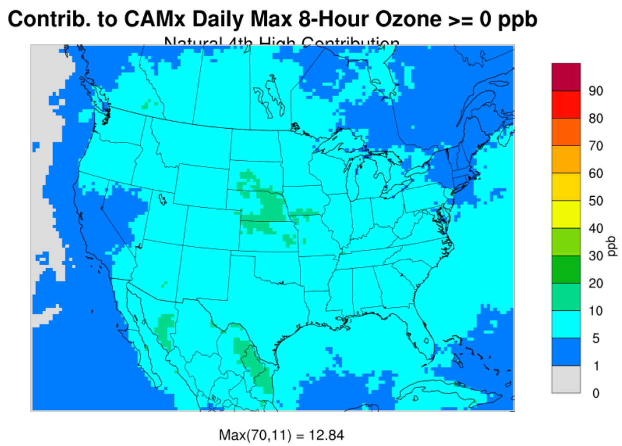


WestJumpAQMS (http://www.wrapair2.org/WestJumpAQMS.aspx)
"Other Sources" Max Contrib. 4th High DMAX8 Ozone

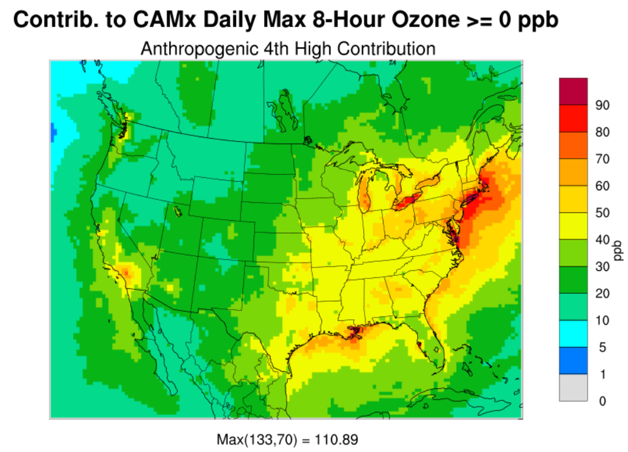
Boundary Conditions

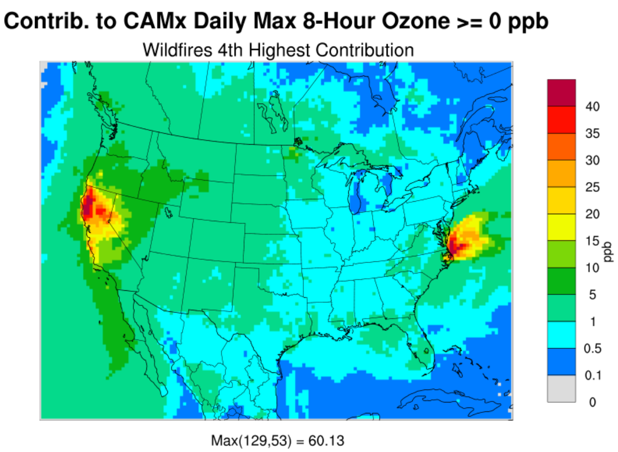


Natural

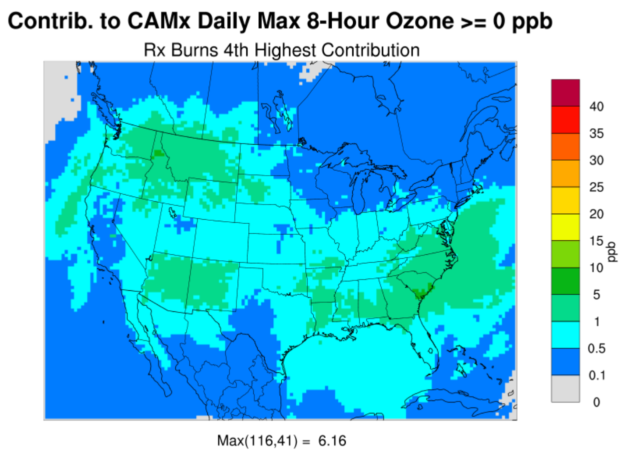


Anthropogenic

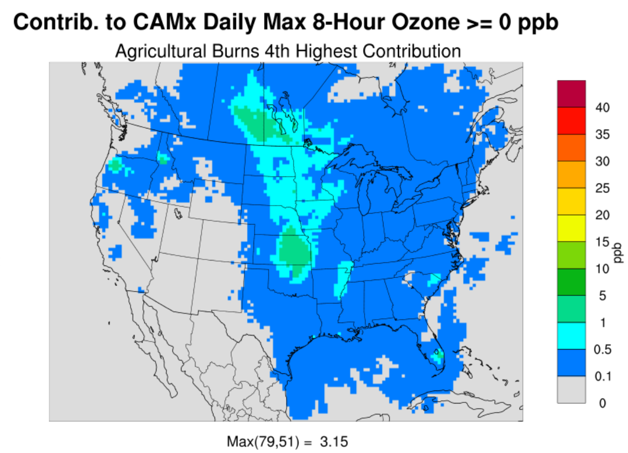




Wildfire

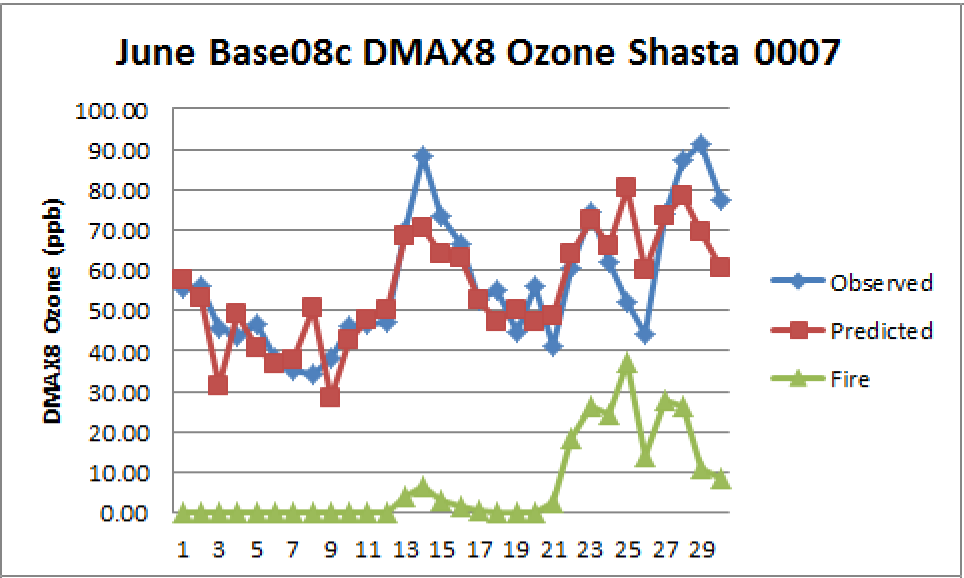


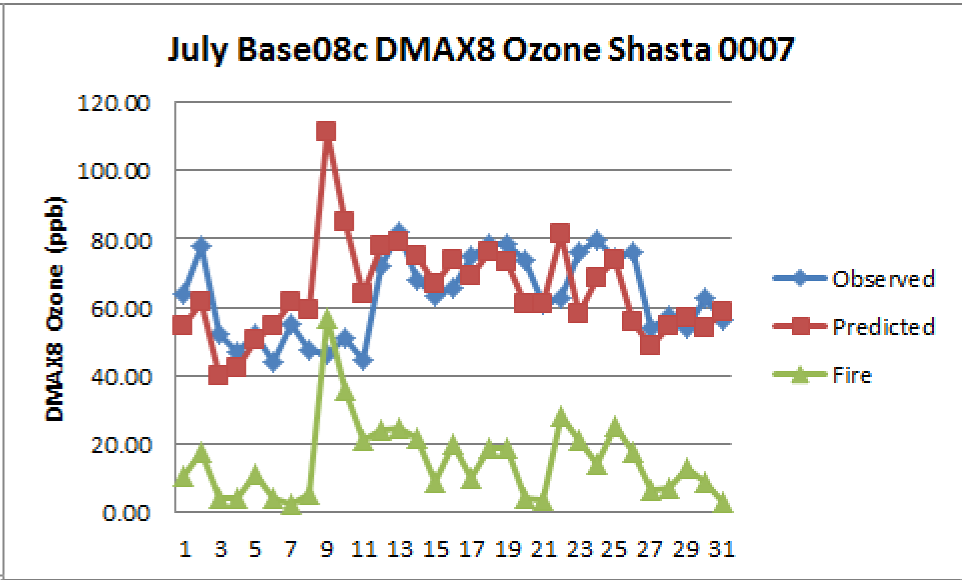
Prescribed Fire

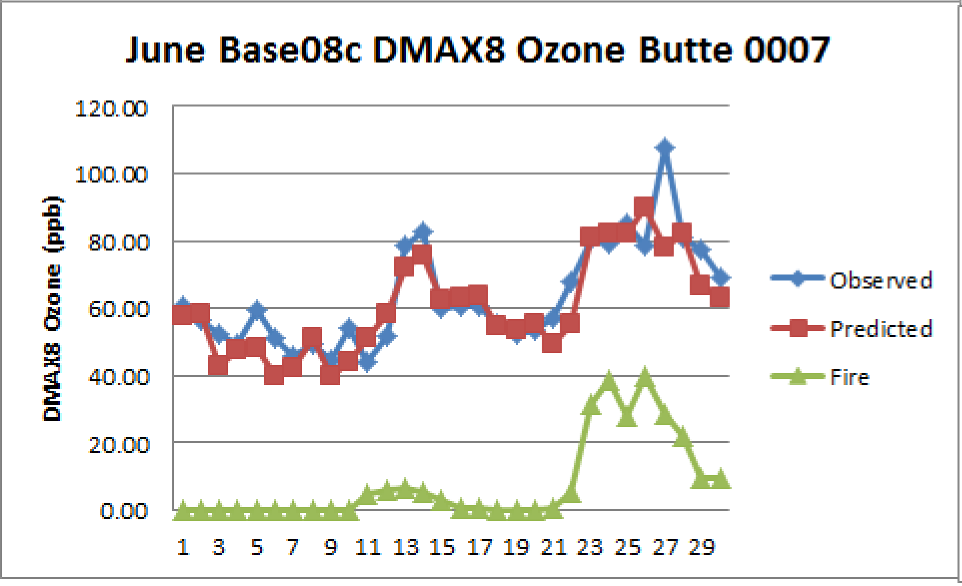


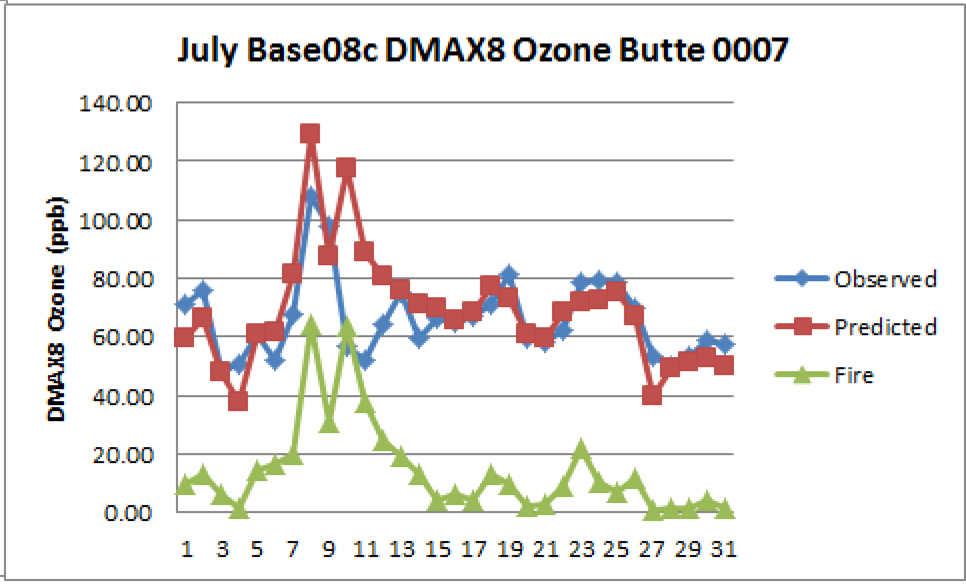
Agricultural Fire

Northern California Wildfires June-July 2008

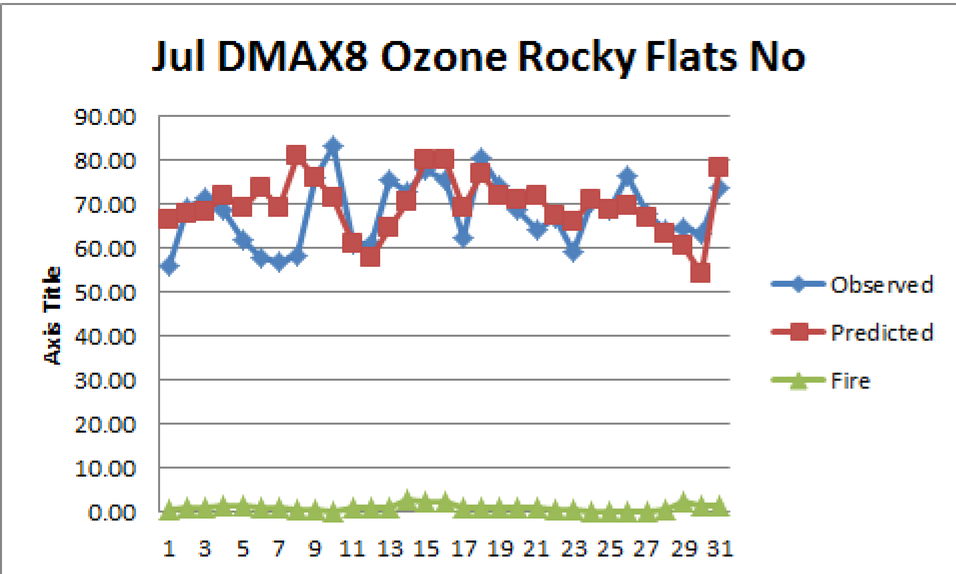


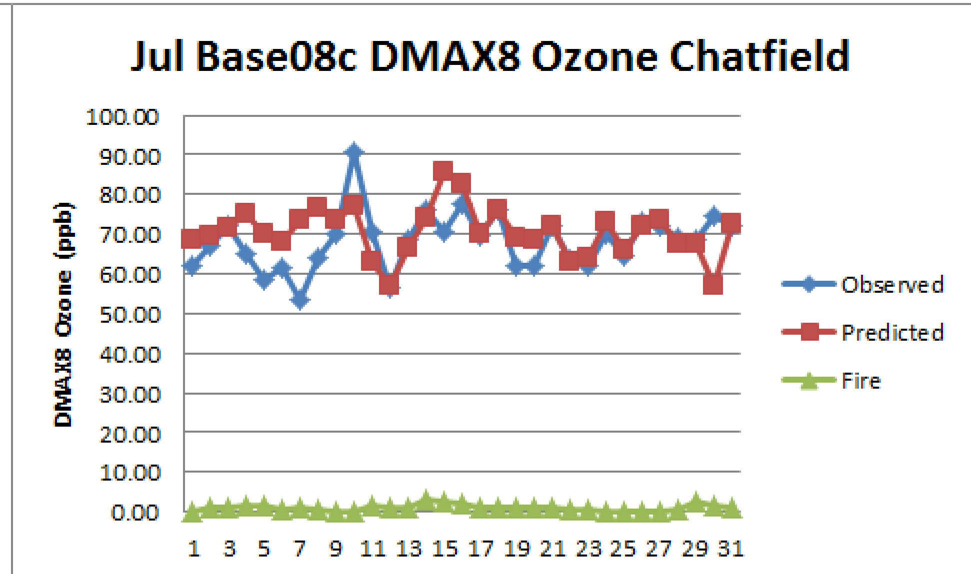


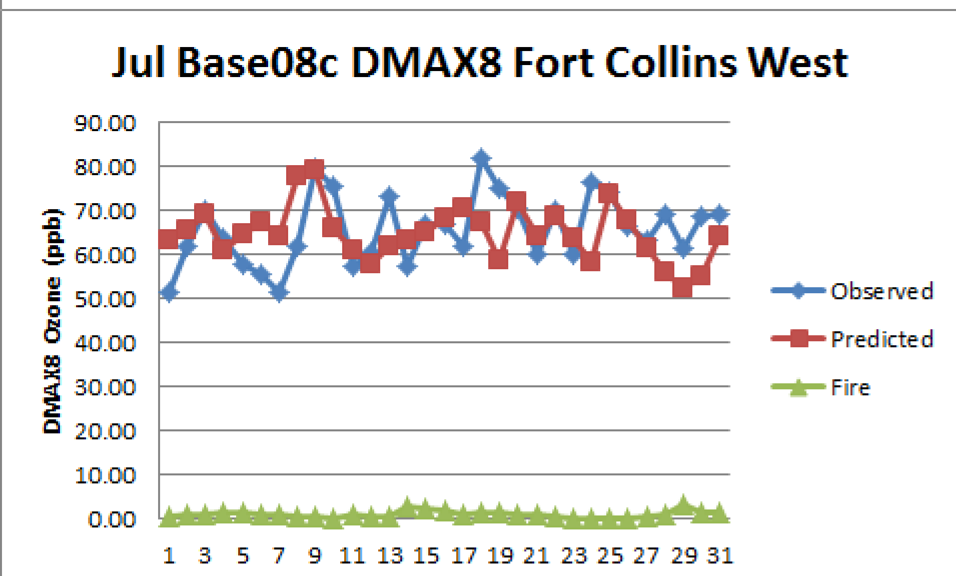


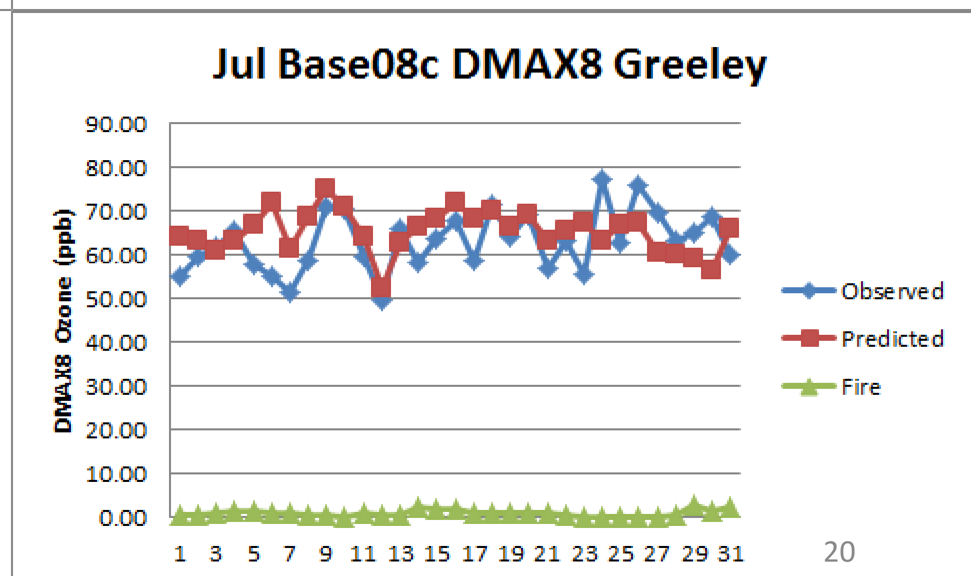


Denver Ozone Monitors July 2008









Particulate Matter Deterministic & Empirical Tagging & Assessment of Impacts on Levels (PMDETAIL)

- https://pmdetail.wraptools.org/
- 3-year project, JFSP-funded
  - Completion target Sept. 2015
  - Team = WESTAR/WRAP, Air Sciences, ENVIRON, CMU, and CSU
- Study Objectives
  - Quantify the impact of prescribed and other fire sources on particulate matter (characterized as $PM_{2.5}$ and PM_{10}) levels across the continental U.S.
  - Develop new fire emissions inventories and computational modules for chemical transport models to simulate the atmospheric transformations of these emissions
  - CAMx and PMCAMx models and inventories will be evaluated against field measurements for 2002, 2008, and 2011.
    - CAMx is a publicly available chemical transport model (CTM) used for regulatory purposes, while PMCAMx is its research version developed by the CMU team.
  - Based on leveraging and significant extending emission inventory development and CAMx modeling from the Deterministic and Empirical Assessment of Smoke's Contribution to Ozone ($DEASCO_3$) study completed in 2013.

FETS, Present and Future

- Developed and on-line in 2007
- Continuing processing / addition of each year's data from SMPs
  - Continuing to add new SMPs
  - Exploring additional sources of daily wildfire incidence data
- Leveraged JFSP projects have covered very limited FETS maintenance support
- Datasets from JFSP projects and ongoing FETS data collection converging on WRAPTools (https://wraptools.org/)
- High-priority, critical infrastructure maintenance tasks underway
- Outreach process to WRAP region SMPs to assess needs for additional functionality and identify collaboration activities

Case Studies –
Impact of Fires on Ozone in the Central and Midwest US

Welcome to the DEASCO$_3$ analysis tools

Link to May 20, 2013 demonstration webinar: MOV
Link to Tuesday, May 21, 2013 demonstration webinar: MOV

You may use this site to browse results of the DEASCO$_3$ study and start new investigation. The analysis environment was designed around a suite of Case Studies that were developed to characterize situations analogous to those that FLMs may face with current conditions and in the future. Five technical and policy hypotheses, listed below, were developed for the study proposal and guided the analyses. The hypotheses below are linked to the Case Studies relevant to that hypothesis.
From this page, you may choose an analysis "pathway" to examine Case Studies and other resources related to Exceptional Events, Fire Planning, and SIP Support, as well as build a new analysis for a time and place of your choosing.

https://deasco3.wraptools.org/

Exceptional Events Support

Assist with determining if fire contributed to an ozone NAAQS violation. Examine monitored air quality, modeling results, and fire emissions and activity for a selected date and area of interest.

Go to EE Support

Fire Planning for FLMs

Assist with various aspects of air quality analysis required for fire management plans, i.e., Fire Planning when it is time to plan for an upcoming burn or burn season. Review historical ozone data, nearby nonattainment areas, and modeling results for your area at different times of the year.

Go to Fire Planning

SIP Support

Assist with determining if and how planned and unplanned fire should be considered for ozone SIP planning and other air quality management program issues. Review model results, historical ozone data, and case studies relevant to your area.

Go to SIP Support

Hypotheses and Links to Associated Case Studies

Hypothesis	Type	Cases	Link to Studies
Ho1 – Mature and well-mixed smoke emissions from wildland fire do not titrate ambient ozone, but do	Technical	9	view

DEASCO$_3$ Home Analysis Maps Area Impacts Datasets Help Public Admin tmoore Comments

Start date

2008-04-20

End date

2008-04-27

Ozone - 40 to 75 ppb

Fire contribution - ≥ 1 ppb

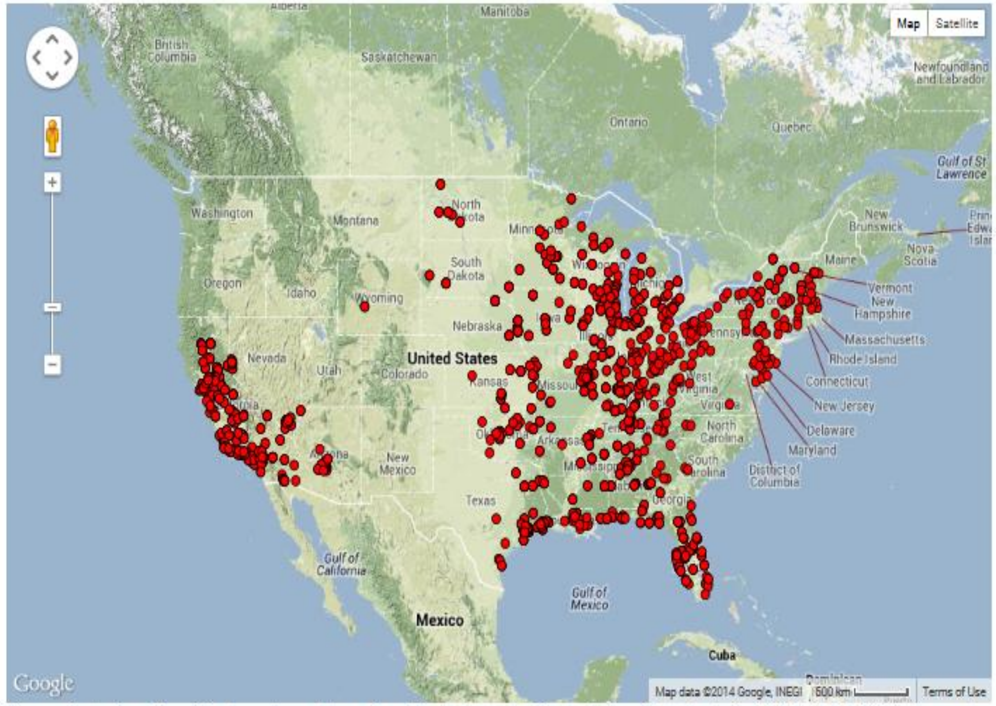
Error rate limit - ≤ 25% observed

Opacity - 100%

Points

Large points

Submit



Ozone monitor locations with max 8-hr observed ozone between 40 and 75 ppb, with a modeled fire contribution of at least 1 ppb, from 2008-04-20 to 2008-04-27. Ozone and predicted fire contribution from the FINN model. Non-attainment areas are shown as orange polygons and MTBS areas as red polygons. Ozone stations are shown in red with a black border; fire activity is shown in blue (agriculture), green (prescribed) and red (wildfires). Roll over map features to see more information and click on ozone sites to filter the table below.

Show 10 entries Search:

Site name	day	lat	lon	Observed O3 (ppb)	Modeled O3 (ppb)	Fire (%)	Modeled Fire (ppb)	Est. Observed Fire (ppb)	Error (%)
01_003_0010 - Baldwin County, AL	2008-04-23	30.498001	-87.881412	64.0	67.8	2.2	1.5	1.4	5.9
01_033_1002 - Colbert County, AL	2008-04-21	34.758781	-87.650562	57.5	65.2	2.1	1.4	1.2	13.5
01_033_1002 - Colbert County, AL	2008-04-22	34.758781	-87.650562	59.8	67.9	3.2	2.2	1.9	13.6
01_033_1002 - Colbert County, AL	2008-04-	34.758781	-87.650562	62.5	73.0	1.7	1.3	1.1	16.8

Managed fire in Louisiana, 2008

Early fall ozone episode near Baton Rouge Nonattainment Area (at or near 8-hr NAAQS)

- Fire stats for the region show fire activity dominated by prescribed burning
- Model source apportionment shows O_3 impact from Canadian wildfire on 9/27, otherwise Rx burning
- Similar data for other years shows consistent fire & O_3 signature

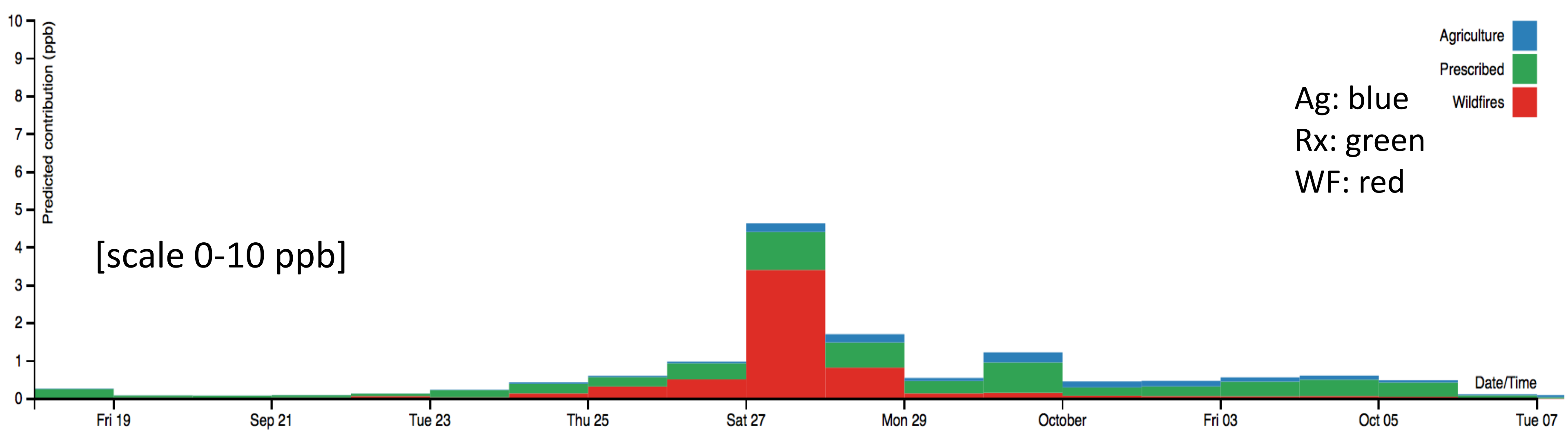
FETS Summary Fire Statistics 09/27/2008 to 09/30/2008

Emissions Totals Tons

Total NO_x: 79.7 Total VOC: 90.1 Total $PM_{2.5}$: 225.5

	Tons Consumed	Acres Burned	Tons NO_x	Tons $PM_{2.5}$
Wildfire	606	58	1.9	3.9
Prescribed Fire	23,003	2,390	71.4	205.2
Agricultural Fire	2,063	650	6.4	16.3

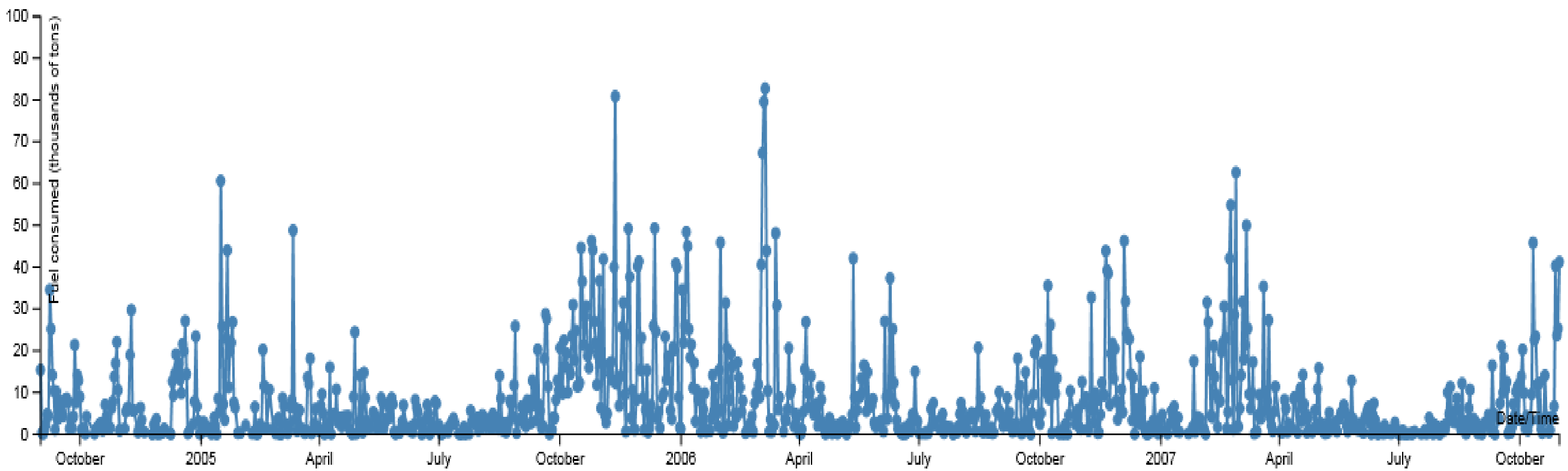
Modeled max 8-hour fire contribution by fire type, 09/18/2008 to 10/07/2008
Lafourche Parish, LA - 22_057_0004



Fall burning patterns in southern Louisiana, 2004-07

- 1 of 3 case studies looking at patterns of burning over several years.
- Managed burning in early Fall 2008 in southern Louisiana a separate case study analysis, showing potential for fire to contribute to elevated ozone in the shoulder season.
- This analysis used an ozone threshold of 70ppb, to see if similar patterns of burning occur in other years or if 2008 was unusual.
- Pairs of box plots and fire activity tables for each year from 2004 - 2007 are displayed.
- The data reveal a consistent pattern of managed burning (mostly prescribed fire) in the September-October time-frame, with a time series of tons consumed for the entire 4 year span show an annual pattern of burning mainly in the Spring and Fall.

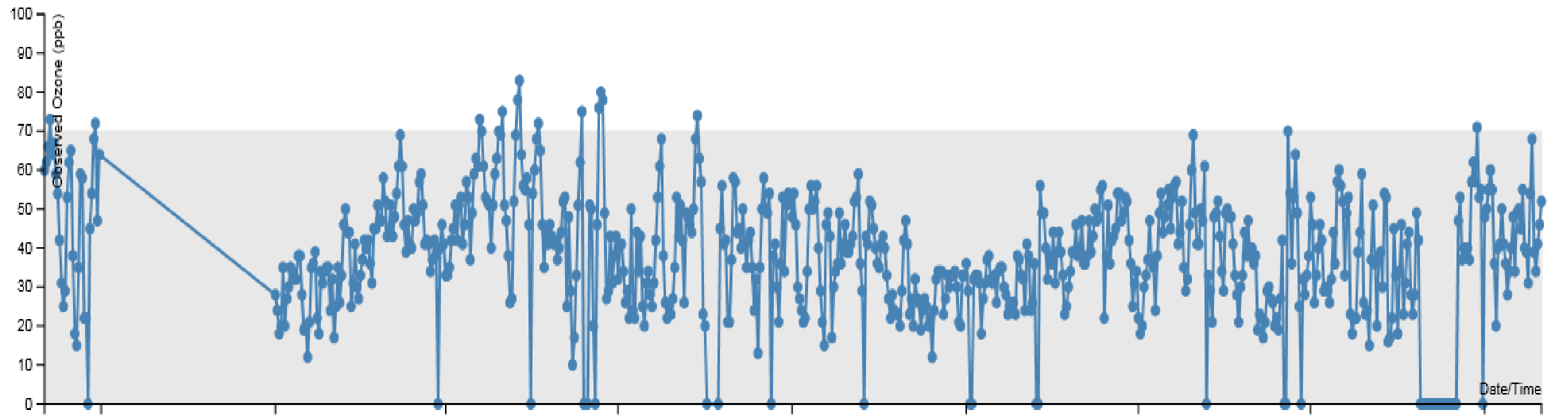
FETS estimated fuel consumed for all fire types 09/01/2004 to 10/31/2007 limited by geographic bounding box



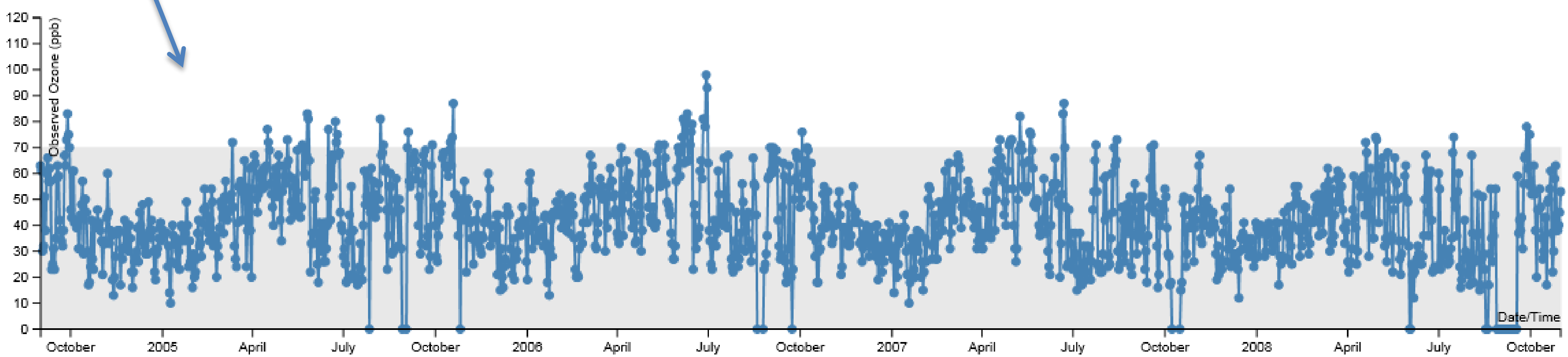
Fall burning patterns in southern Louisiana, 2004-07

- The ramp-up in burning in Sept.-Oct. coincides with sporadic instances of elevated ozone, whereas in the summer ozone is high with little burning occurring. Two years, 2005 and 2007, have several larger fires burning simultaneously for short periods but that do not show increased frequency of elevated ozone. Two monitoring sites from the area show instances of elevated ozone into October; the site at LaFourche Parish has a more consistent annual pattern.

St. Bernard 2006-08



La Fourche 2004-08

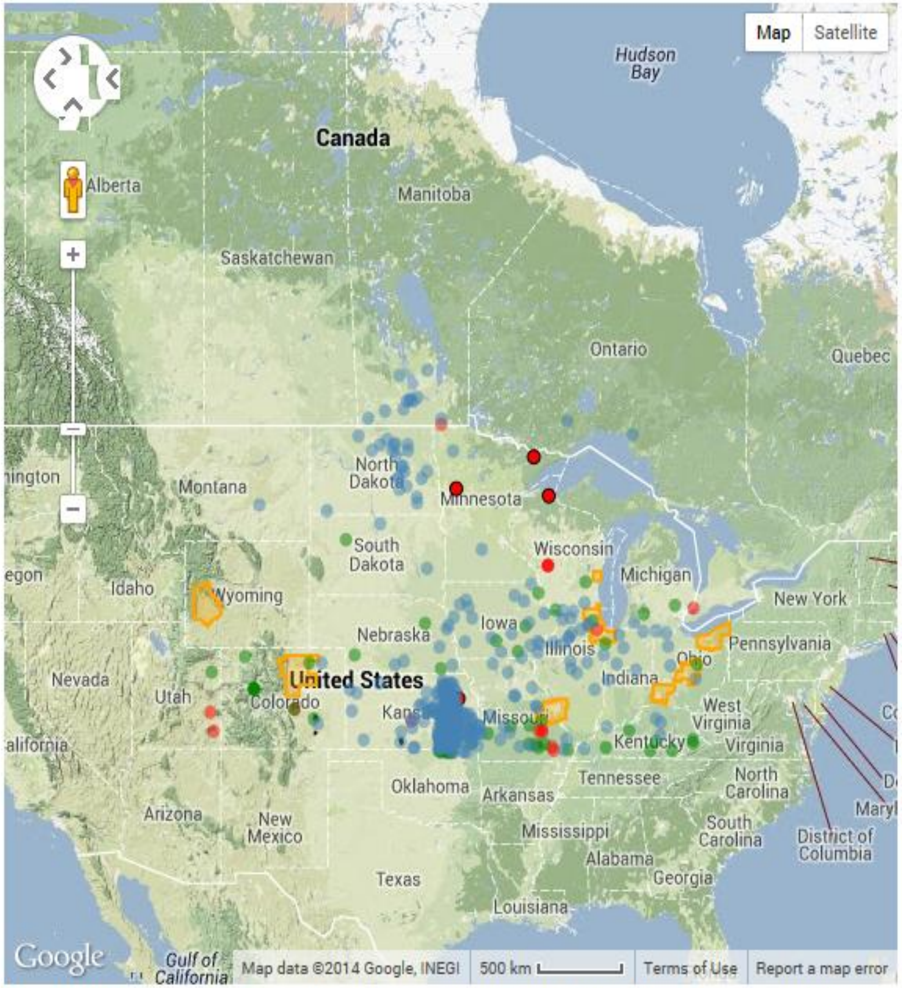


Agricultural fires' influence on ozone formation - MN Case Study

- April is a time of intense agricultural burning in the Midwest, especially in Kansas.
- Over a period of 2 days, April 14-15, 2008, an estimated 16,000 acres of agricultural land was burned. CAMx model results were interrogated to look for instances of fire contributing to ozone formation at ozone monitors in the Midwest during this period.
- Three monitors in Minnesota and Wisconsin were modeled to have a nearly 5ppb contribution from agricultural burning.
- The map following shows minimal burning in the vicinity of the western-most monitor in Minnesota, so presumably the influence is from the burning in Kansas to the south.
- Measured ozone concentrations, while not exceeding the current 8-hour ozone standard, were elevated enough such that a lowered standard could cause greater concern about smoke transport to this region in the Spring.

Agricultural fires' influence on ozone formation - MN Case Study

DEASCO$_3$ Home Analysis Maps Area Impacts Datasets Help Public Admin tmoore Defaults



Ozone monitor locations with max 8-hr observed ozone between 65 and 200 ppb, with a modeled fire contribution of at least 3 ppb, from 2008-04-14 to 2008-04-15. Ozone and predicted fire contribution from the DEASCO$_3$ model. Non-attainment areas are shown as orange polygons and MTBS areas as red polygons. Ozone stations are shown in red with a black border; fire activity is shown in blue (agriculture), green (prescribed) and red (wildfires).

FETS Summary Fire Statistics 04/14/2008 to 04/15/2008

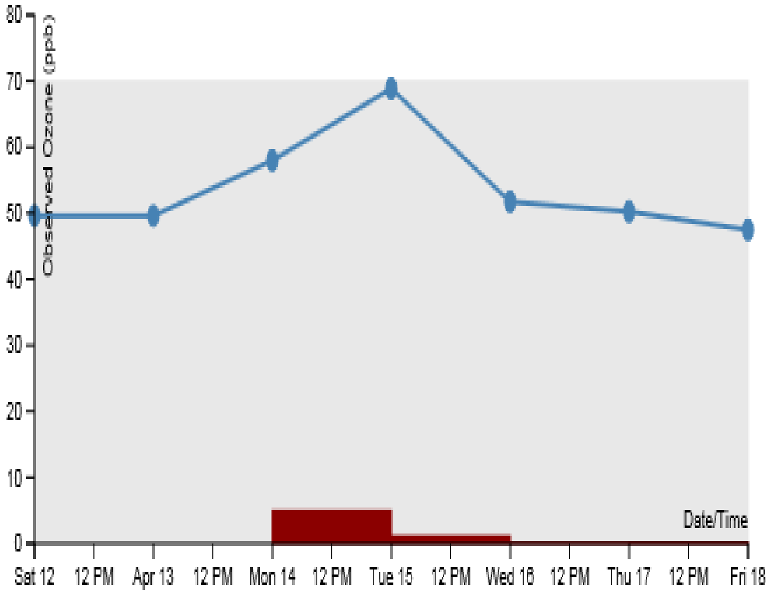
Emissions Totals Tons

Total NO_x: 146.4 Total VOC: 307.6 Total $PM_{2.5}$: 432.8

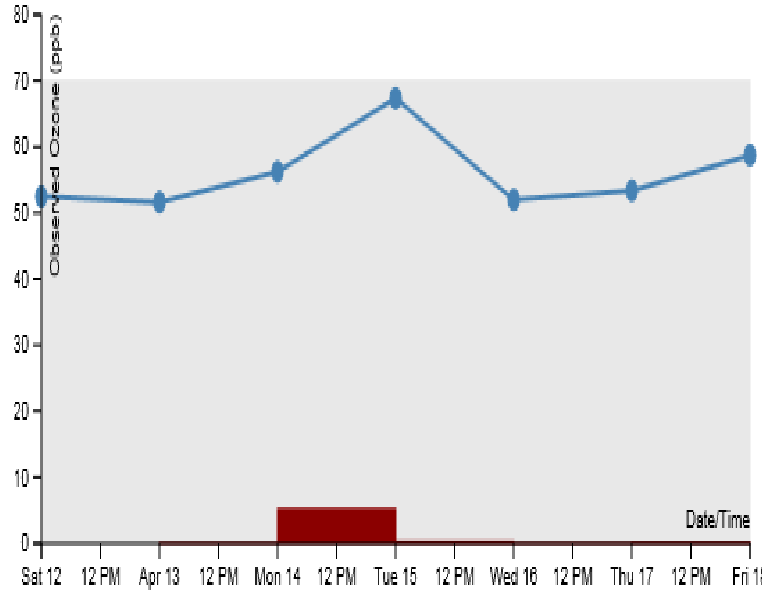
	Tons Consumed	Acres Burned	Tons NO_x	Tons $PM_{2.5}$
Wildfire	14,705	2,819	45.6	119.9
Prescribed Fire	6,127	848	19.0	50.5
Agricultural Fire	26,344	16,225	81.8	262.4

Agricultural fires' influence on ozone formation - MN Case Study

Observed Ozone paired with modeled max 8-hour fire contribution, mid-April 2008

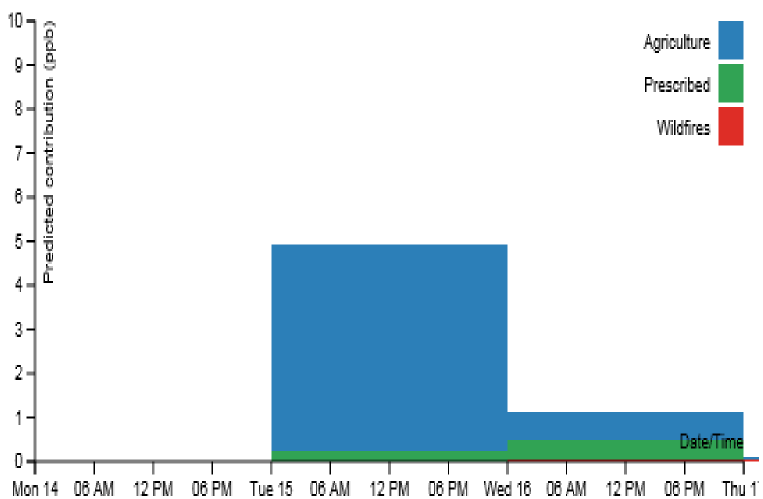


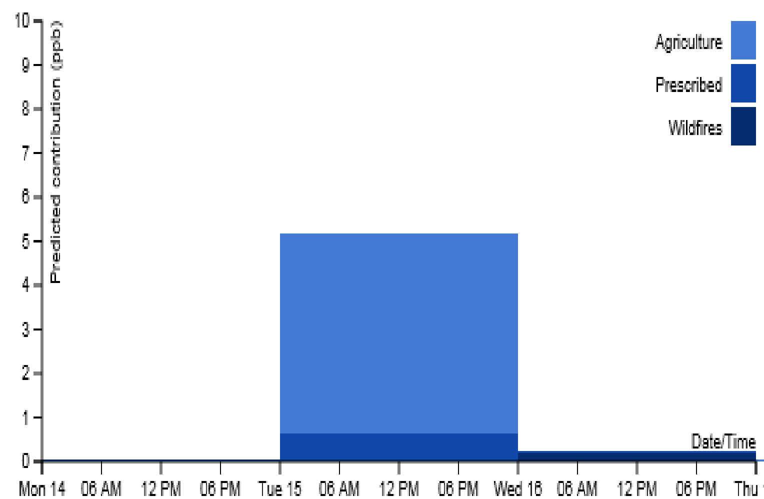
Lake County, MN - 27_075_0005



Becker County, MN - 27_005_2013

Modeled max 8-hour fire contribution by fire type, mid-April 2008



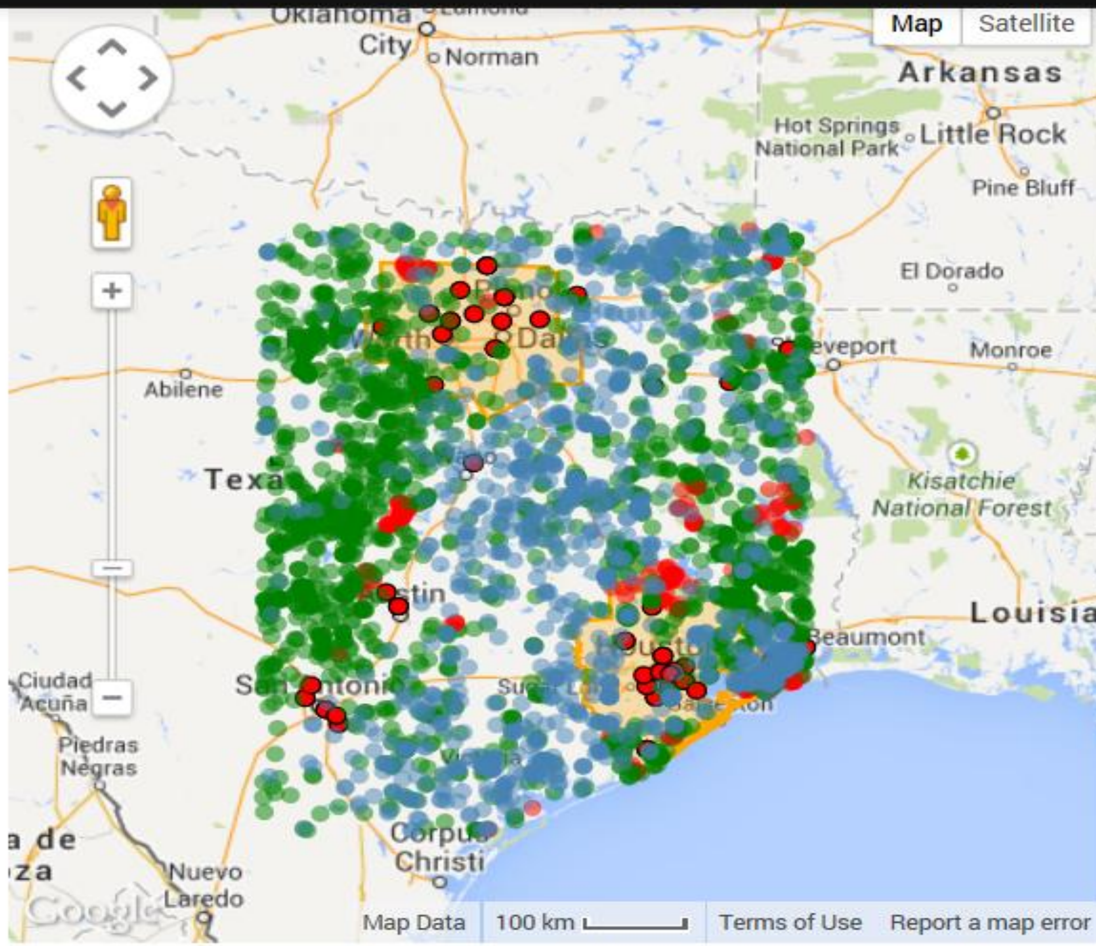


Managed burning proximate to Non-Attainment Areas Case Study

- The fire emissions inventory developed for 2008 revealed several ozone nonattainment areas (NAAs) that have planned fires inside or near the NAA boundary at certain times of the year. Burning proximate to NAAs has the potential to affect ozone formation in areas already prone to elevated ozone.
- Three NAAs were isolated and observed 8-hour ozone concentrations were compared to CAMx modeling results that predict the contribution by 3 types of burning to ozone formation. Three NAAs were chosen by ranking the total tons consumed by agricultural and prescribed burning (together referred to as 'planned fires') within 100km of the NAA boundary between April and October, 2008.
  - Atlanta, GA metro area
  - Phoenix-Mesa, AZ metro area
  - Dallas-Fort Worth/Austin/San Antonio/Houston metro areas
- Example following for Texas metro areas:
  - Reference map
  - Timeseries plot of one ozone monitor representative of each area
  - Modeled fire contributions at ozone monitor site
- The modeled fire contribution plots show that the majority of impacts from fires at each ozone monitor is caused by wildfire in the summer months, and by planned burning in the spring and fall.
  - The monitor in Arizona has a distinct annual trend such that spring and fall ozone concentrations do not approach 70ppb
  - Polk County, Texas and Dawson County, Georgia both see periods of elevated ozone in the Spring and Fall coincident with planned burns.

Managed burning proximate to Non-Attainment Areas Case Study

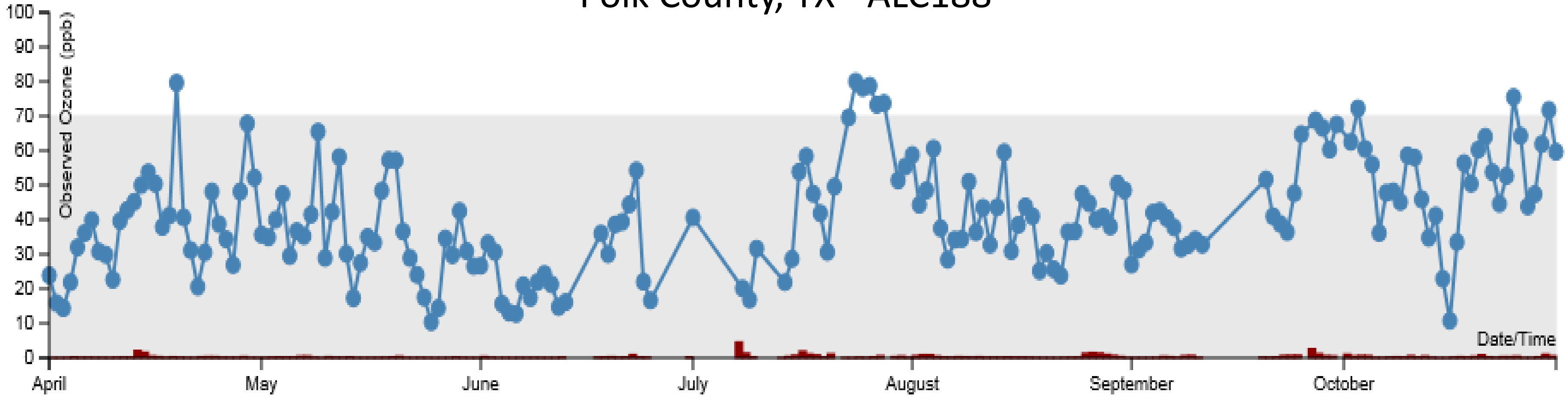
DEASCO$_3$ Home Analysis Maps Area Impacts Datasets Help Public A



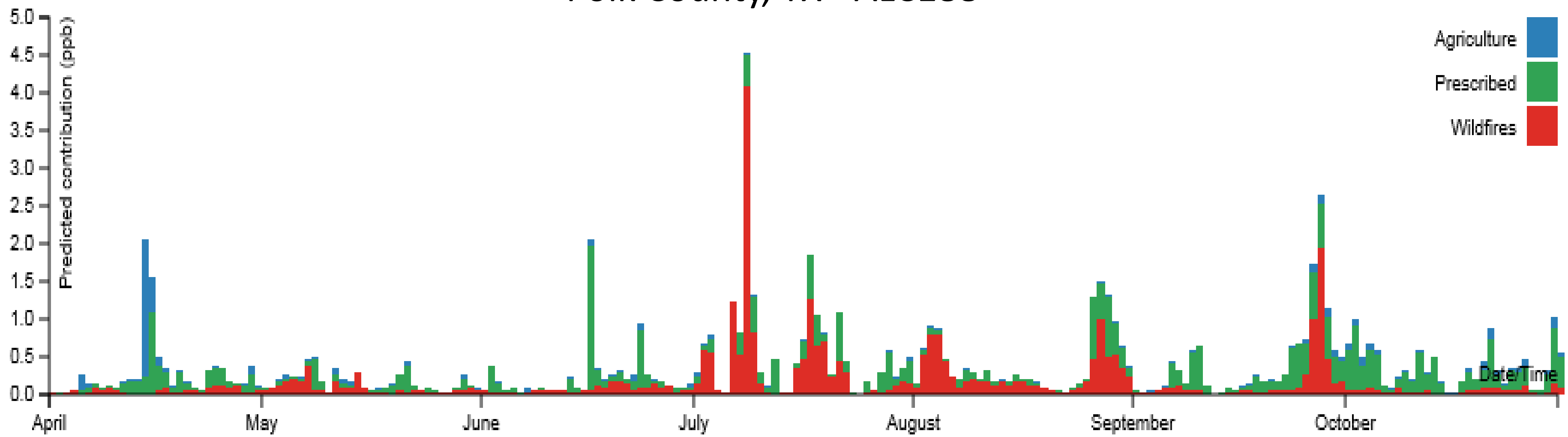
Ozone monitor locations with max 8-hr observed ozone between 70 and 200 ppb, with a modeled fire contribution of at least 1 ppb, from 2008-04-01 to 2008-10-31. Ozone and predicted fire contribution from the DEASCO$_3$ model. Non-attainment areas are shown as orange polygons and MTBS areas as red polygons. Ozone stations are shown in red with a black border; fire activity is shown in blue (agriculture), green (prescribed) and red (wildfires).

Managed burning proximate to Non-Attainment Areas Case Study

Observed Ozone paired with modeled max 8-hour fire contribution 4/01/2008 to 10/31/2008
Polk County, TX - ALC188



Modeled max 8-hour fire contribution by fire type, 4/01/2008 to 10/31/2008
Polk County, TX - ALC188



Thanks –

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