

# AIRPACT Using BlueSky Framework with SMARTFIRE for Wildfire Emissions

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NW-AIRQUEST Annual Meeting  
Washington State University  
June 6-8, 2012

# Outline

- Background on BlueSky Framework
- AIRPACT implementation of BSF
- WRAP Plume Rise approach
- Results from September 2011
- Results comparing old and new BlueSky for AIRPACT-3 for 2007

# Background

***Since 2001, AIRPACT has been building toward a one-atmosphere AQ decision-support system for the Pacific Northwest region of the U.SA.***

*In 2008, the USDA Forest Service AIRFire Lab provided wildfire emissions from their BlueSky model to AIRPACT-3. (terminated with system failure)*

*Subsequently BlueSky system was redesigned as a 'framework', with the addition of options for using SMARTFIRE.*

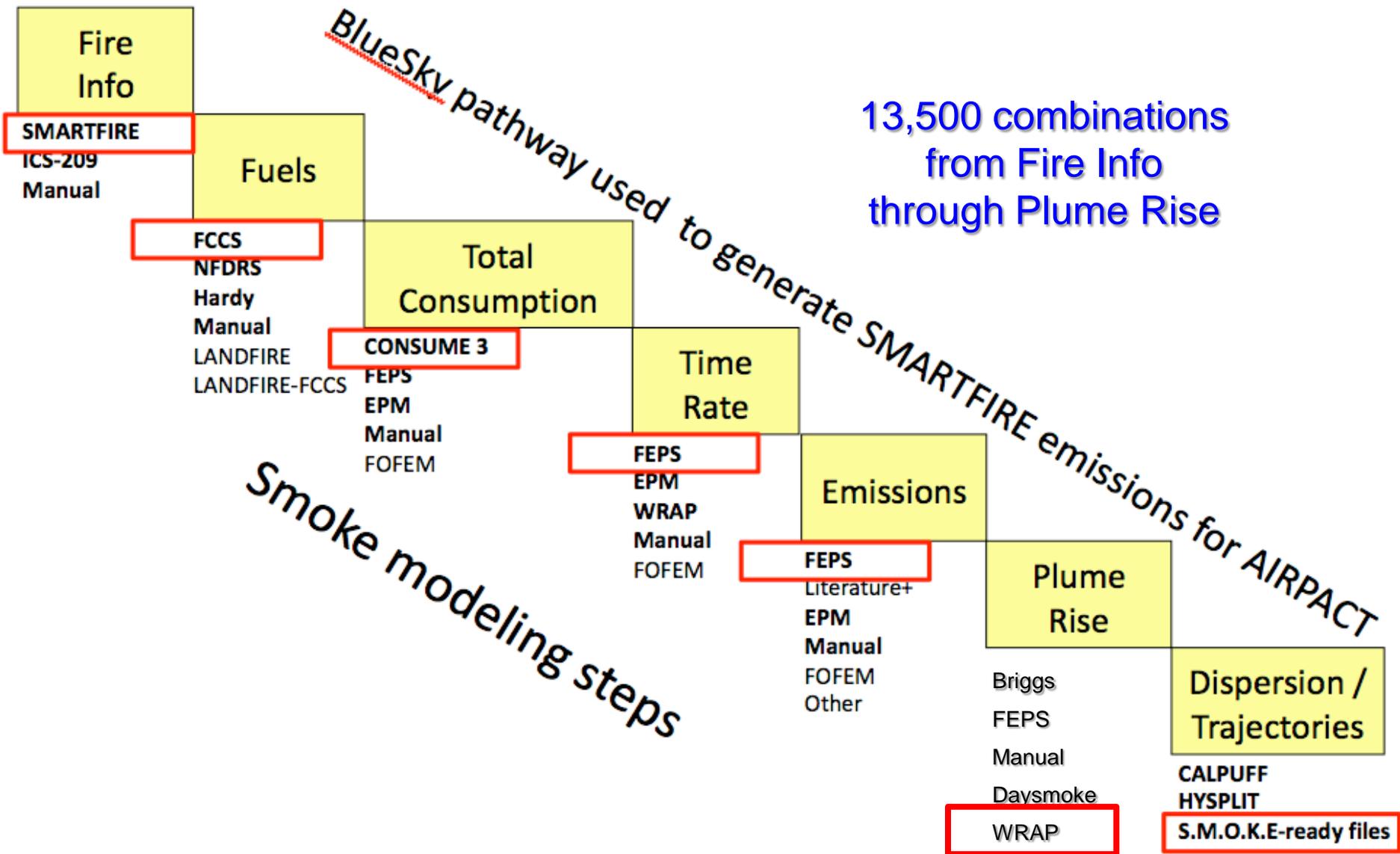
# Background (2)

*BlueSky FRAMEWORK offers SMARTFIRE as an option for fire identification and,*

*Options for models of Fuels, Fuel Consumption, Temporal Behavior, Emissions and Plume Rise.*

*SMARTFIRE:*

- *Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation*
- *Expert human system determines fire activity by using the NOAA Hazard Mapping System to reconcile satellite and ground reports.*

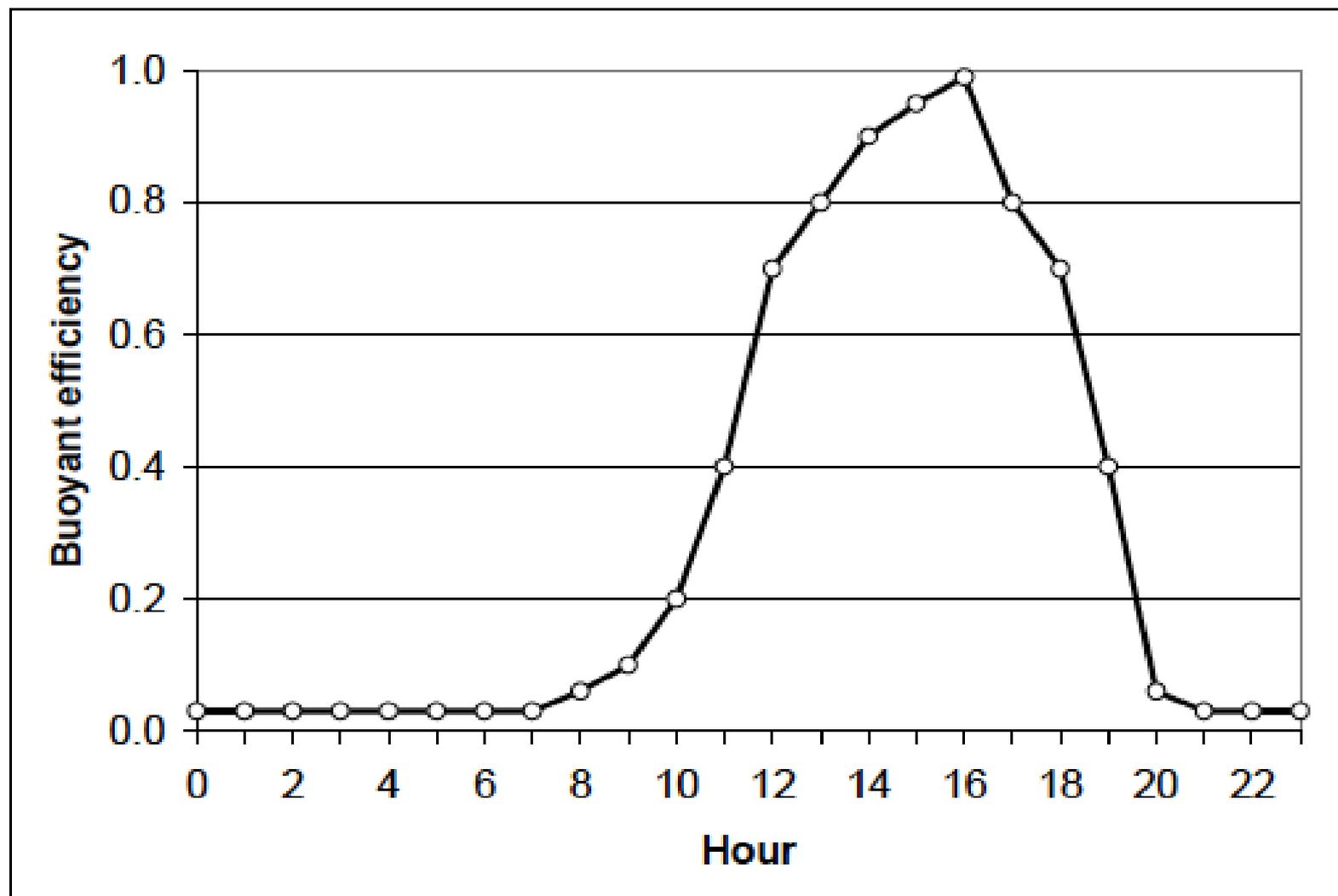


# WRAP Plume Rise Approach

- Five categories of wildfire size by 'acreage':
  - 1-10,
  - 10-100,
  - 100-1000,
  - 1000-5000,
  - $\geq 5000$
- Daily profile of Buoyant Efficiency (BE)
- Expert-based plume rise by category and BE, by hour.

**Figure 1: Buoyant Efficiency**

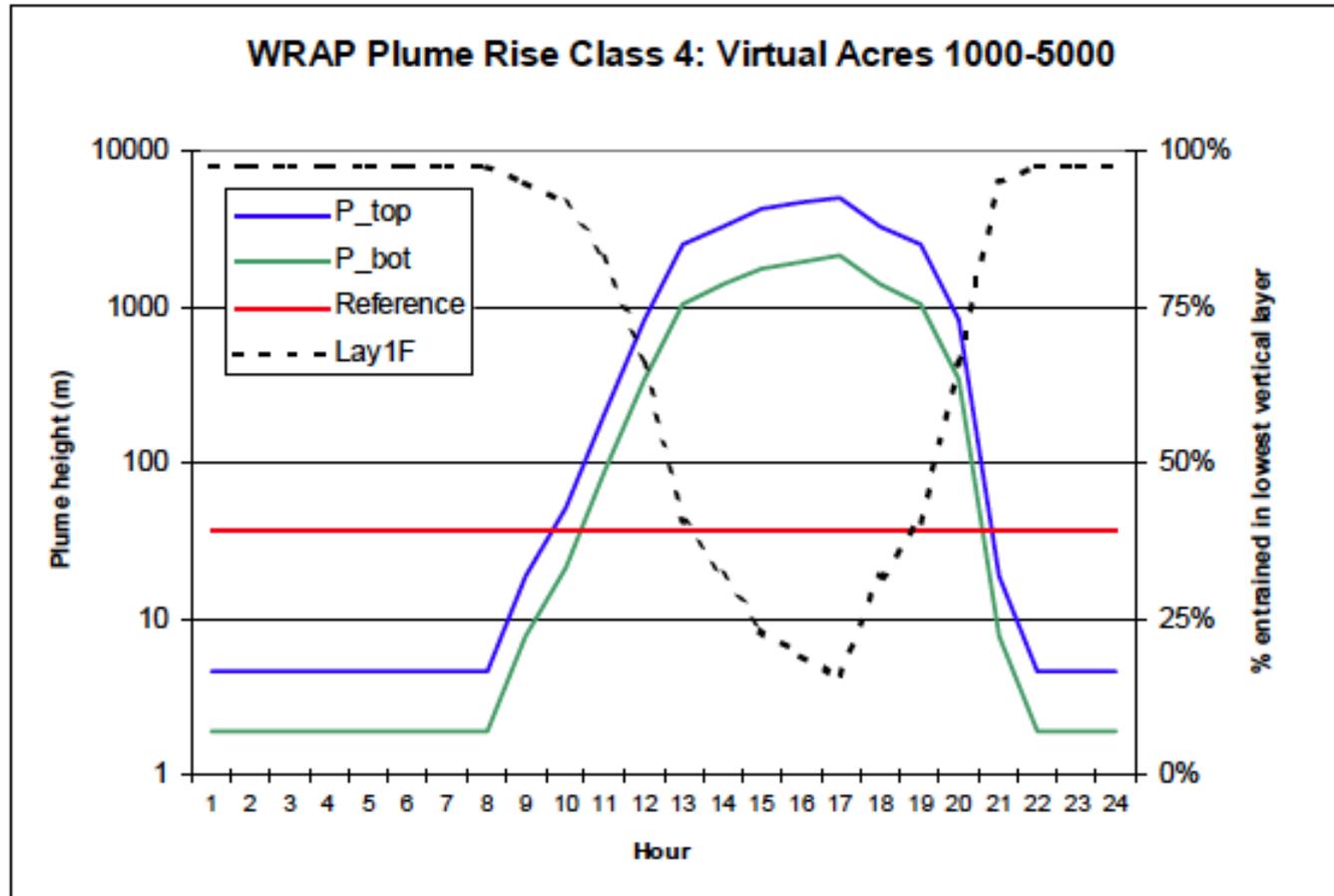
The relationship between buoyant efficiency and time of day.



WRAP 2002 Phil EI Report\_20050722.doc

### Figure 8: Fire Size Class 4 Plume Characteristics

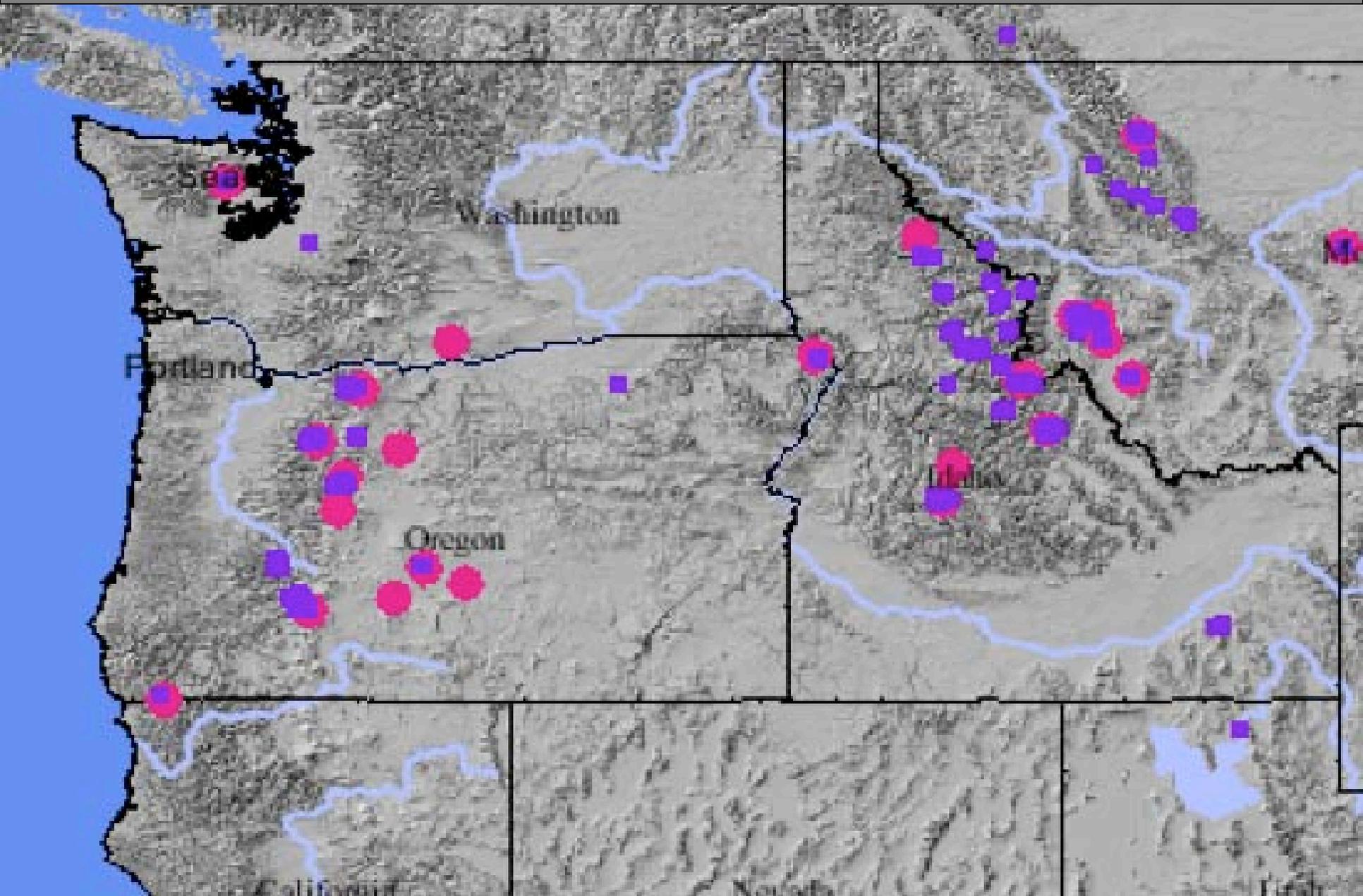
This figure shows plume characteristics (P<sub>top</sub>, B<sub>bot</sub>, and Lay1F) for Class 4 fires for each hour. Plume height in meters is shown on the left Y-axis (in log-scale), and Lay1F in percent entrained into the lowest vertical layer is shown on the right Y-axis. For reference, the height of the lowest vertical layer (38 m) is shown in red.



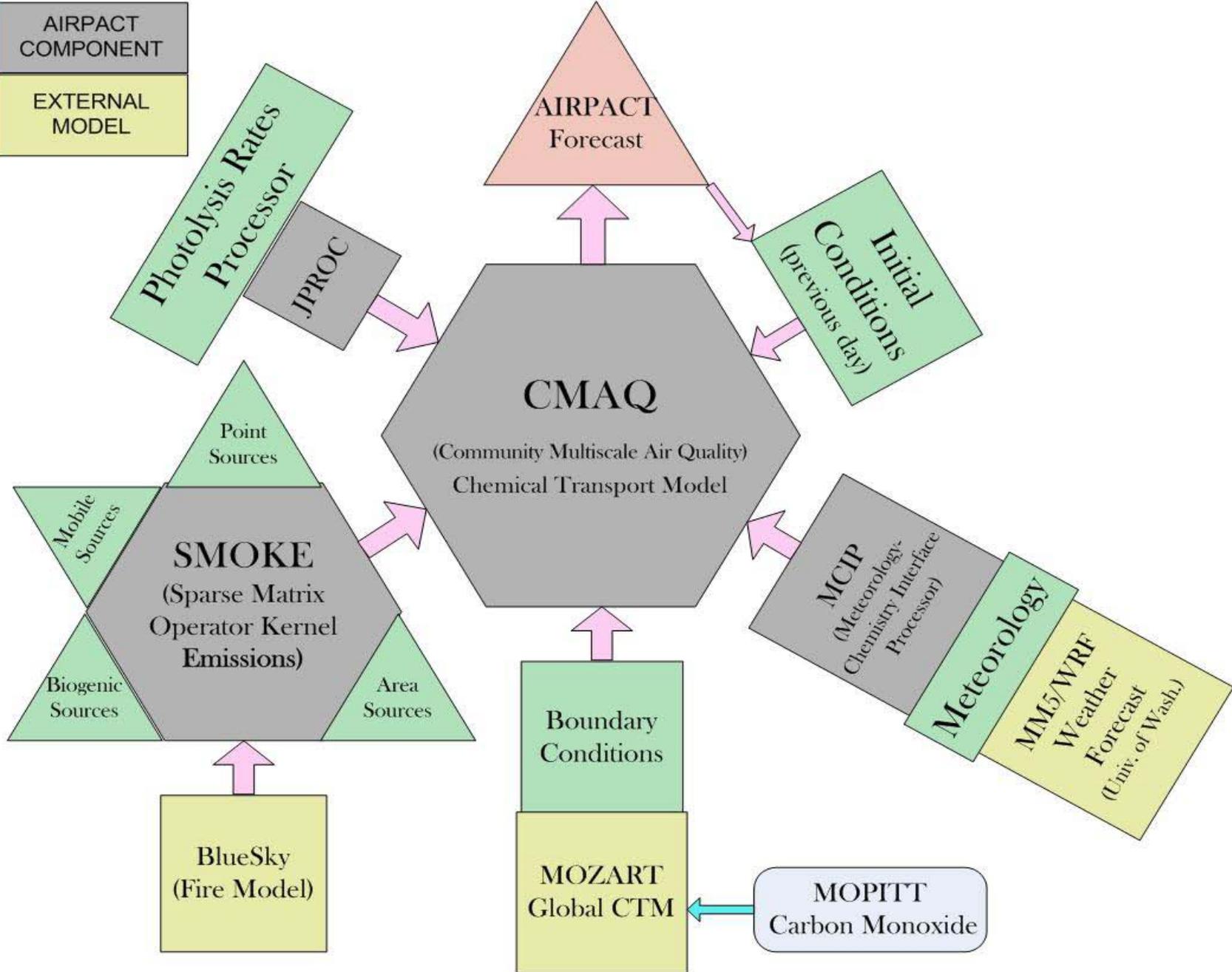
Source: 2002 Fire Emission Inventory for the WRAP Region – Phase II, Air Sciences, 2005.

# Fire activity from SMARTFIRE for Sept 10, 2011.

HMS fires shown in purple; ICS209 ground reports shown in pink.



OUTPUT	AIRPACT COMPONENT
Standard INPUT	EXTERNAL MODEL



# SMOKE Programs and versions used to process BlueSky Framework emissions from SMARTFIRE

SMKINVEN	SMOKE v3.0
GRDMAT	SMOKE v2.7
SPCMAT	SMOKE v2.7
TEMPORAL	SMOKE v2.7
LAYPOINT	SMOKE v3.0
SMKMERGE	SMOKE v2.7

## Pave 'Curtain-Max' Quick-look plots

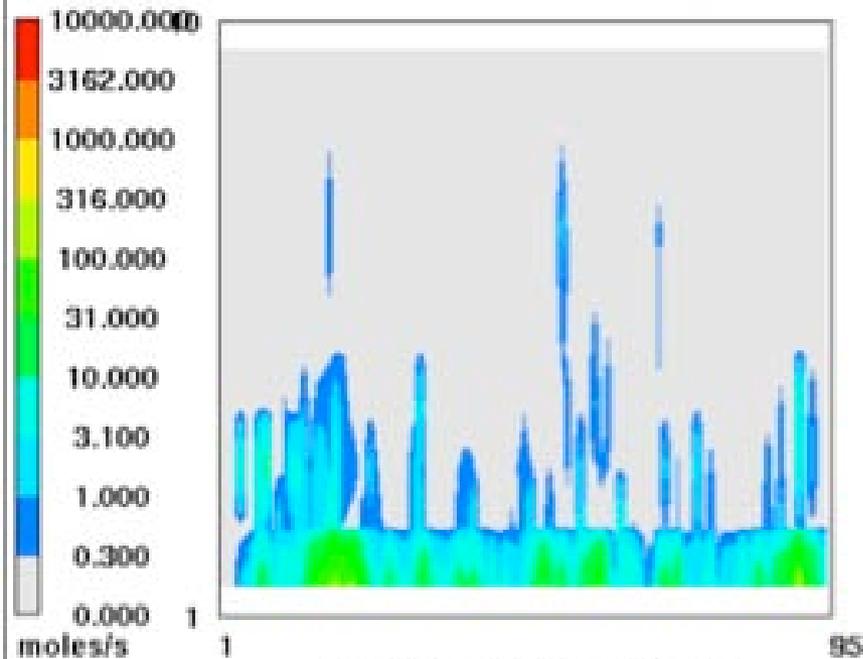
'CURTAIN-MAX' plots show, for all model domain grid columns, and for all layers, the maximum value for a species as found across all the cells in single North-South rank.

These Curtain-Max plots allow for a quick review of 3-D data. Only showing first 10 layers – up to ~750 meters.

# CO Emissions

## Non-Wildfire CO emissions

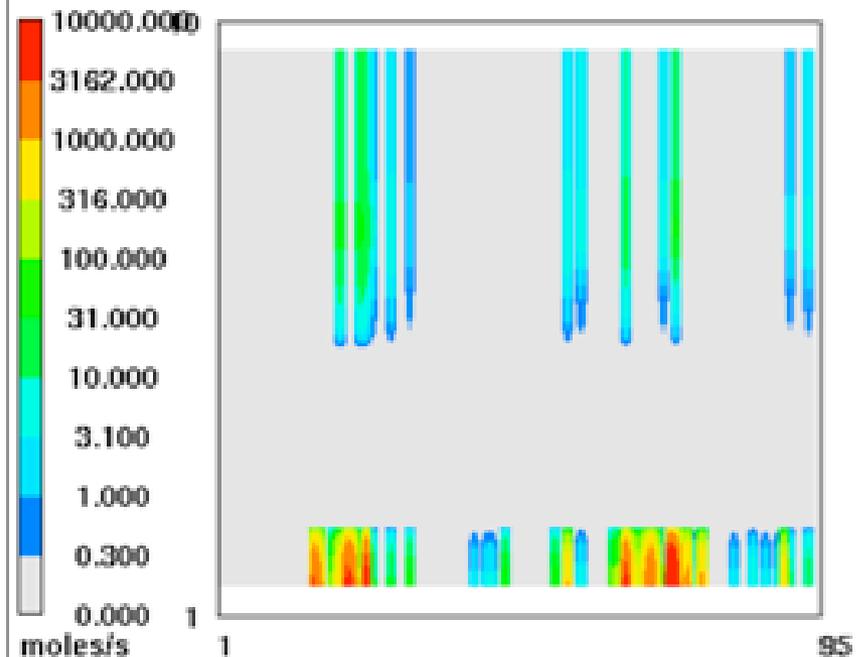
Curtain-Max to South Wall  
max over all Y for all X & Z



September 9, 2011 22:00:00  
Min= 0.000 at (1,1), Max= 141.837 at (91,1)

## Wildfire CO emissions

Curtain-Max to South Wall  
max over all Y for all X & Z

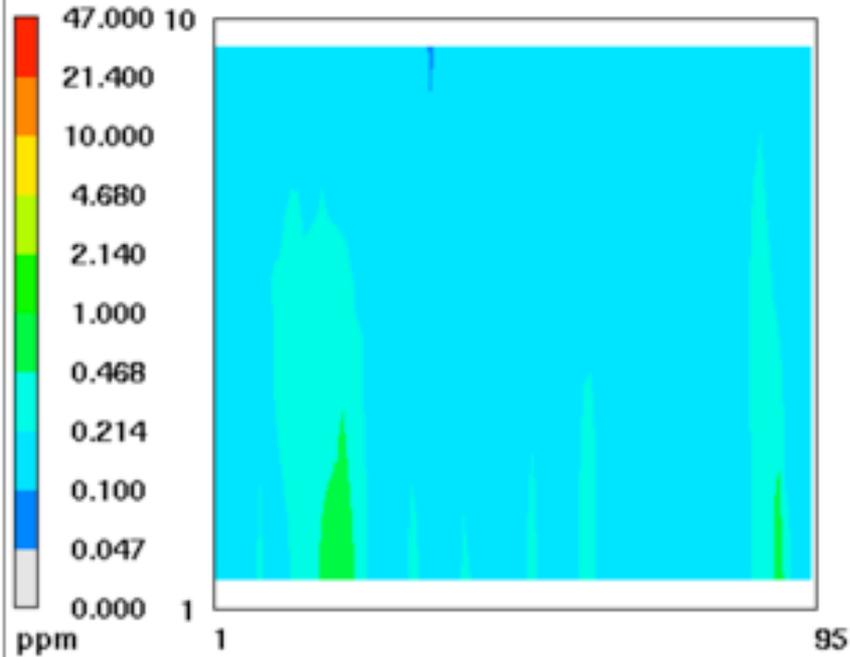


September 9, 2011 22:00:00  
Min= 0.000 at (1,1), Max= 12299.908 at (72,1)

# CMAQ CO Results

## Non-Wildfire CMAQ CO

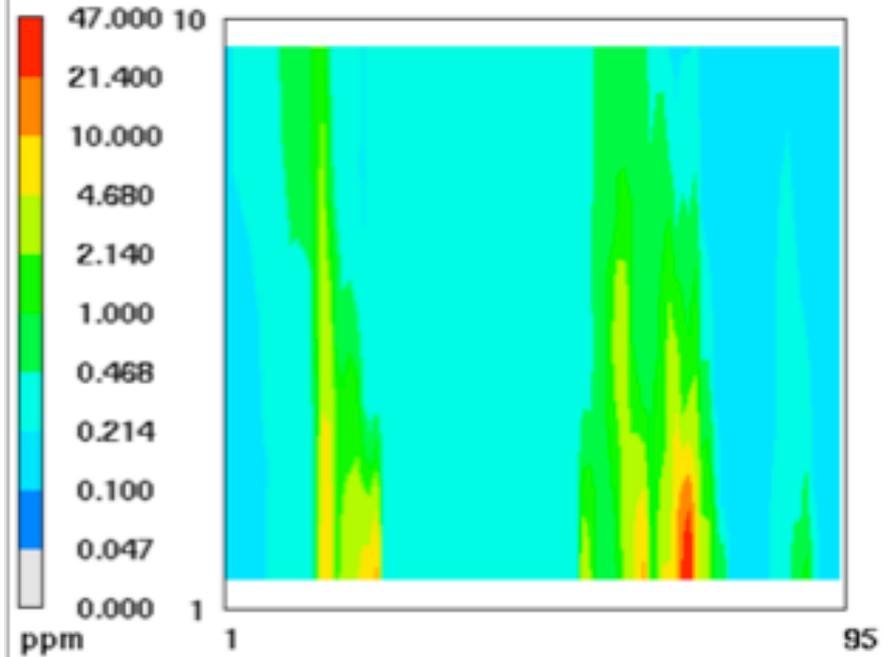
Curtain-Max to South Wall  
max over all Y for all X & Z



September 10, 2011 4:00:00  
Min= 0.099 at (35,10), Max= 0.882 at (21,1)

## With-Wildfire CMAQ CO

Curtain-Max to South Wall  
a=CONC\_CO\_XY\_MAX.ncf

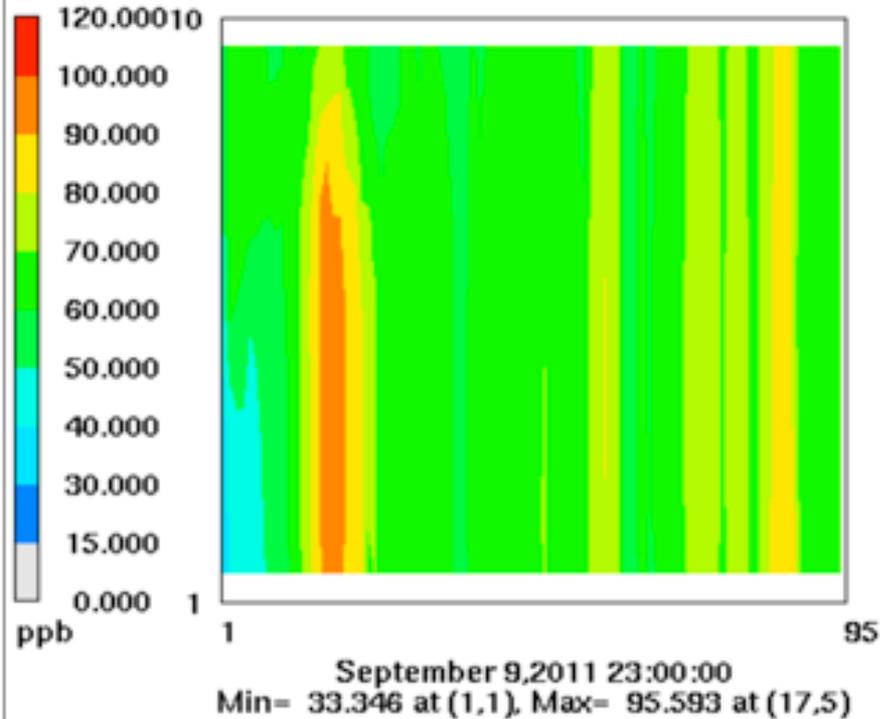


September 10, 2011 4:00:00  
Min= 0.113 at (1,1), Max= 46.265 at (72,1)

# CMAQ O3 Results

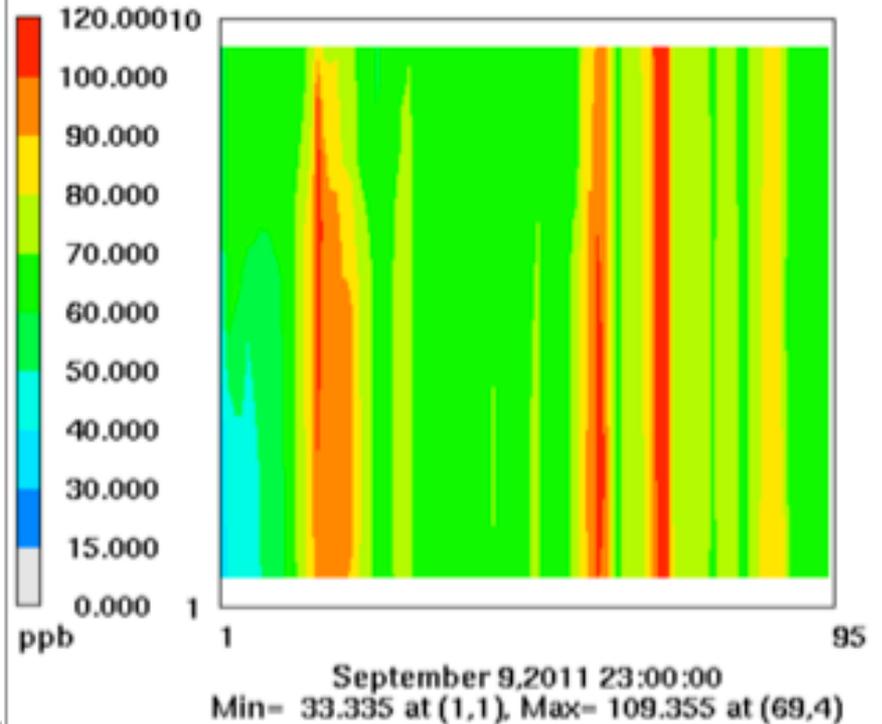
## Non-Wildfire CMAQ O3

Curtain-Max to South Wall  
max over all Y for all X & Z

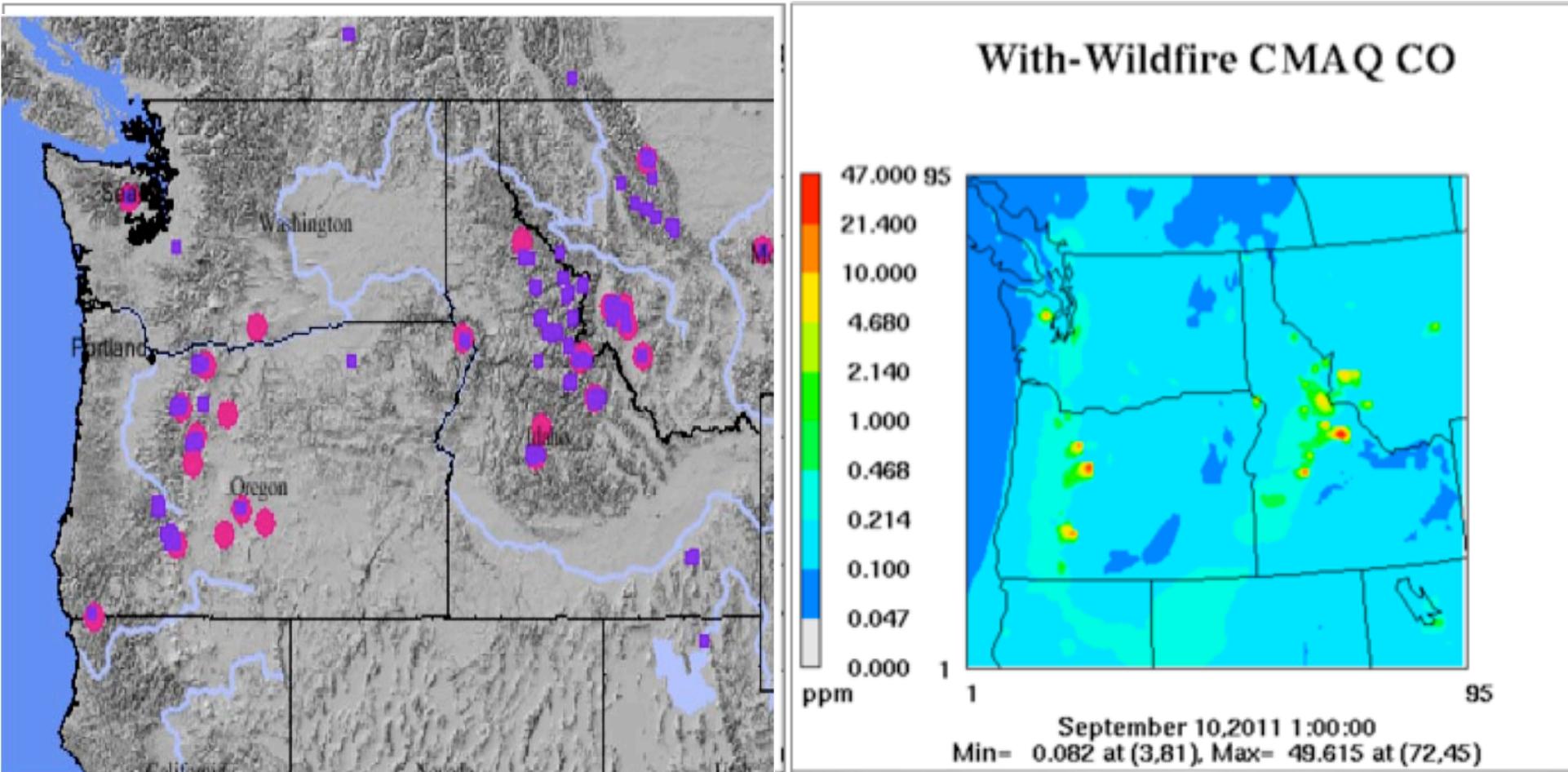


## With-Wildfire CMAQ O3

Curtain-Max to South Wall  
max over all Y for all X & Z

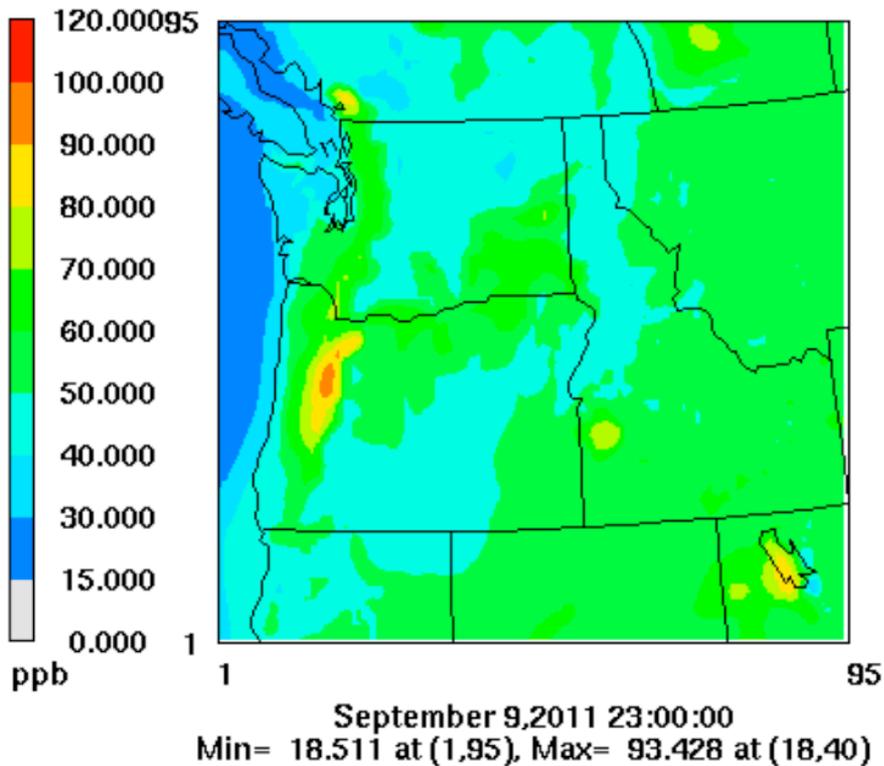


# CMAQ CO Results

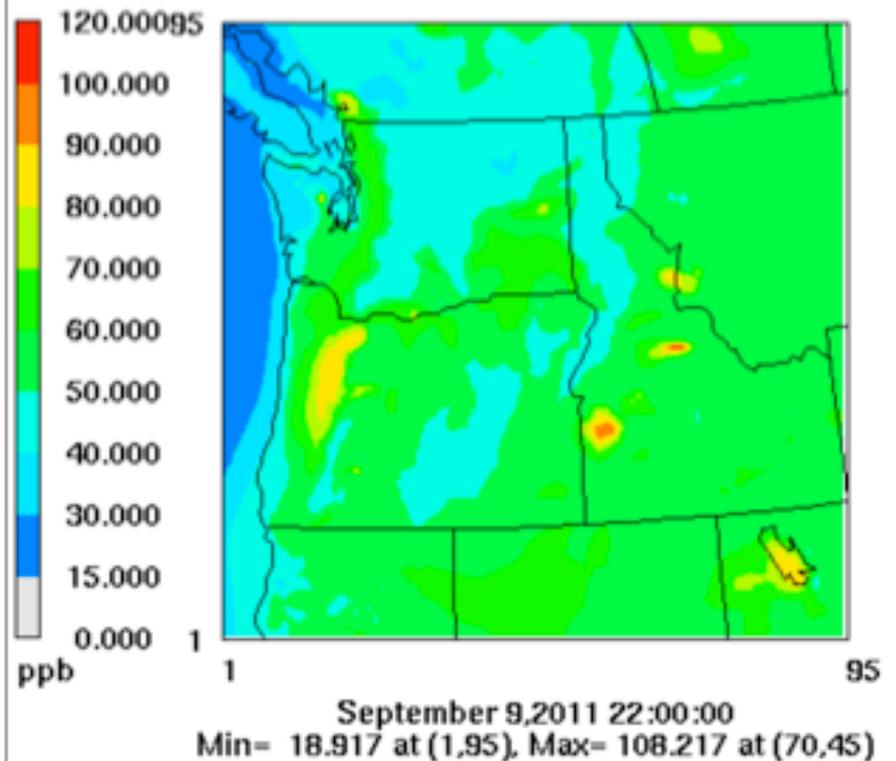


# CMAQ O3 Results

## Non-Wildfire CMAQ O3



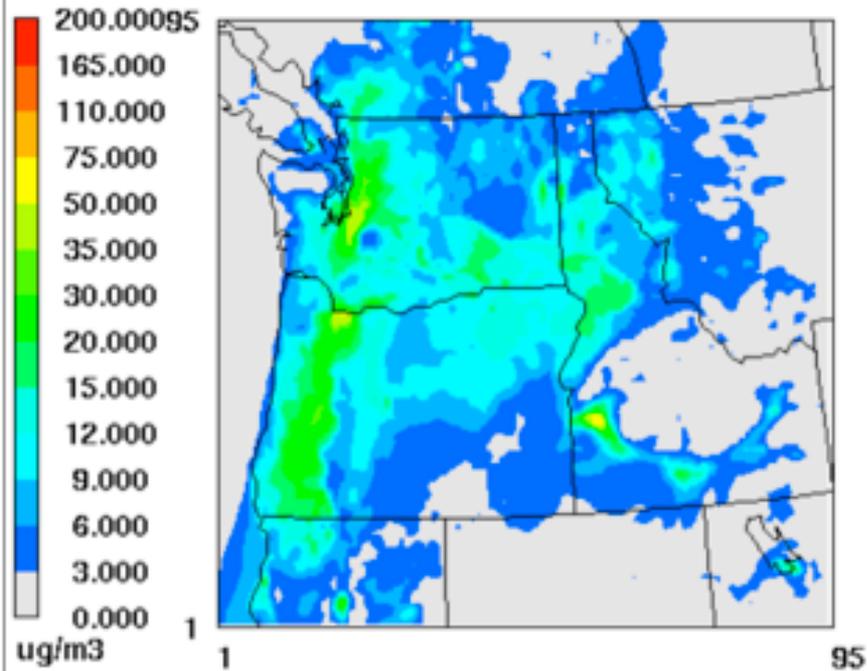
## With-Wildfire CMAQ O3



# CMAQ PM2.5 Results

## Non-Wildfire CMAQ PM2.5

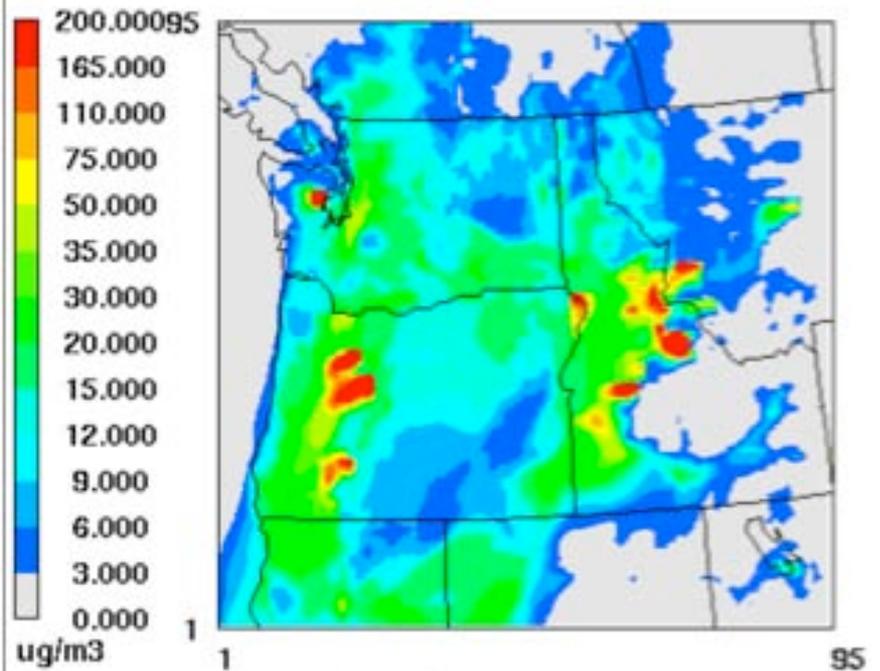
Surface Layer



September 10, 2011 4:00:00  
Min= 0.104 at (4,72), Max= 71.515 at (59,33)

## With-Wildfire CMAQ PM2.5

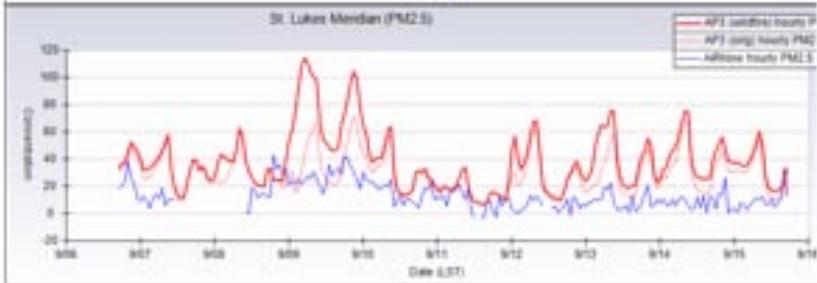
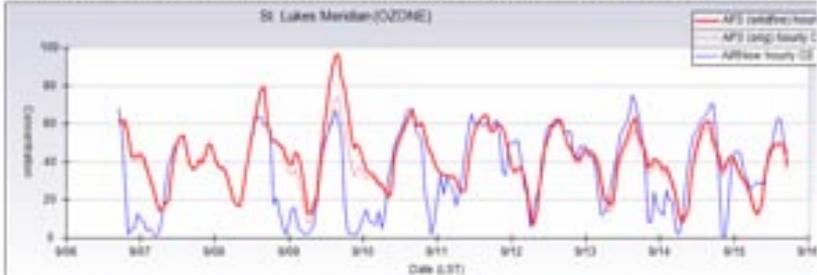
Surface Layer



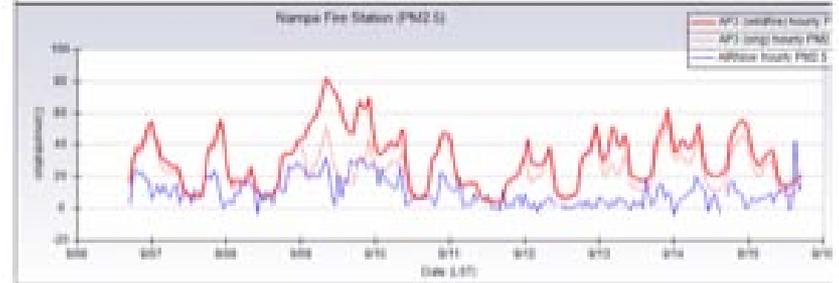
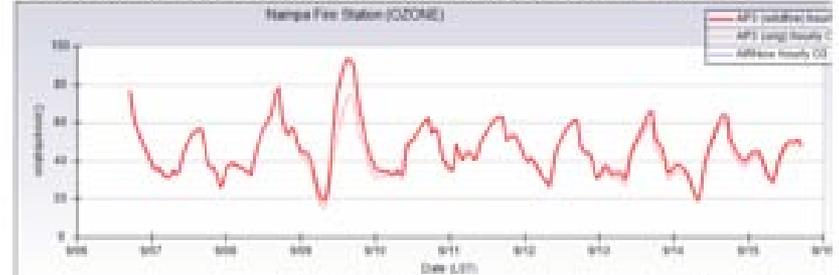
September 10, 2011 4:00:00  
Min= 0.104 at (4,72), Max=3491.735 at (72,45)

# AIRPACT online performance charts show ozone and PM2.5 predictions vs. AIRNow observations (St Luke's Meridian, and Nampa Fire Station)

2011-Sept, Wildfire AP3 vs. Standard AP3 vs. AIRNow Hourly Performance [Jul 2011 dataset]



2011-Sept, Wildfire AP3 vs. Standard AP3 vs. AIRNow Hourly Performance [Jul 2011 dataset]



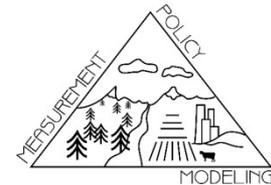
# NO/CO emissions ratios from field studies, from 2008 BlueSky, and from 2011 BlueSky w/ SMARTFIRE

<i>How do emission ratios compare?</i> (molar emission rate ratios)	NO/CO % flaming	NO/CO % smoldering	NO/CO % mixed
<b>North Carolina Rx Fires</b>	<b>2.6</b>	<b>1.1</b>	<b>1.9</b>
<b>Alaska Wildfires Obs (Goode et al., 2003)</b>			<b>1.6</b>
<b>BlueSky/AIRPACT Wildfire 2008</b>			<b>1.9</b>
<b>BlueSky/SMARTFIRE/SMOKE</b>	<b>Aloft: 2.0</b>	<b>Surface: 0.3</b>	<b>0.7</b>

# Comparison of Fire Emissions review for August 2007 runs for BlueSky vs. BlueSky Framework with Smartfire



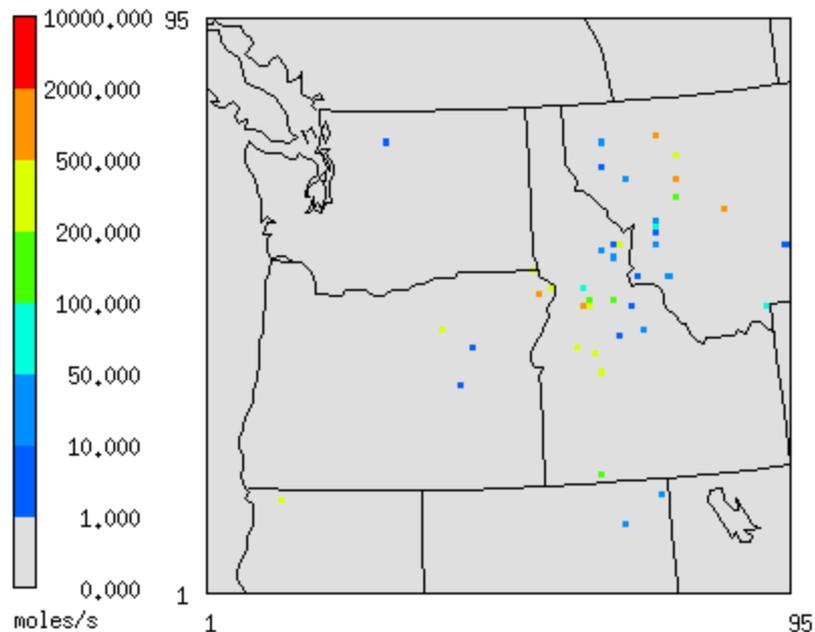
Prepared by: Farren L. Herron-Thorpe



Laboratory for Atmospheric Research

Original BlueSky

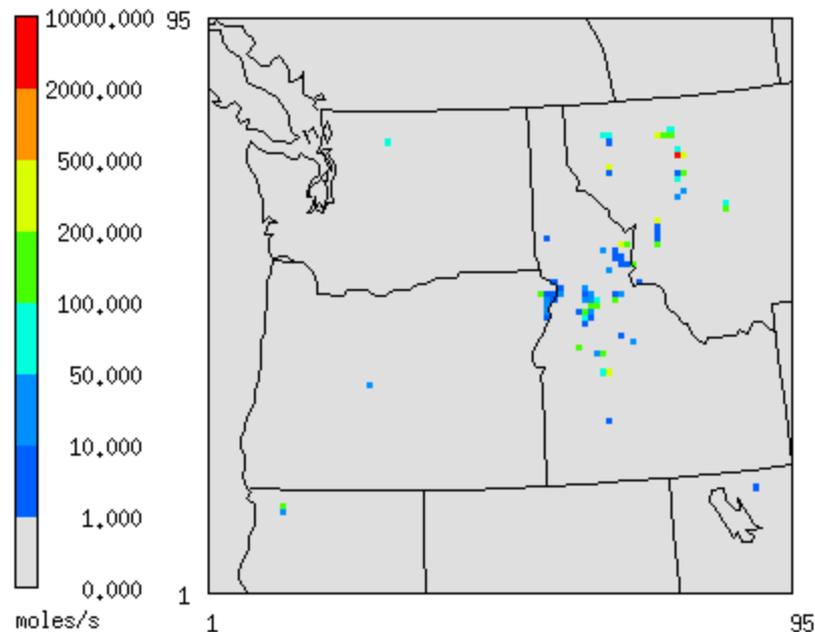
CO Emissions  
Layers Collapsed



August 1,2007 1:00:00 (PST)  
Min= 0,000 at (1,1), Max=1400,596 at (77,69)

New BlueSky-SMARTFIRE

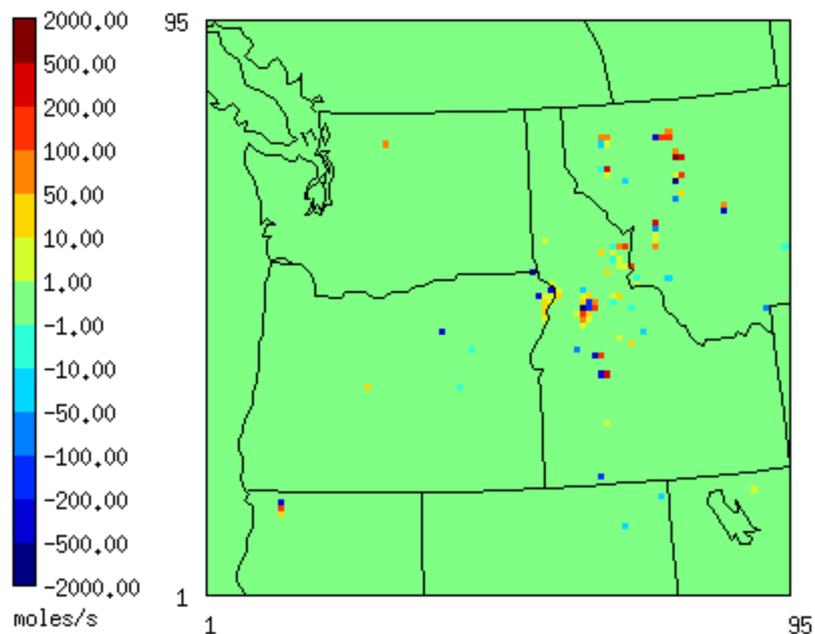
CO Emissions  
Layers Collapsed



August 1,2007 1:00:00 (PST)  
Min= 0,000 at (1,1), Max=2079,818 at (77,73)

Difference of CO Emissions

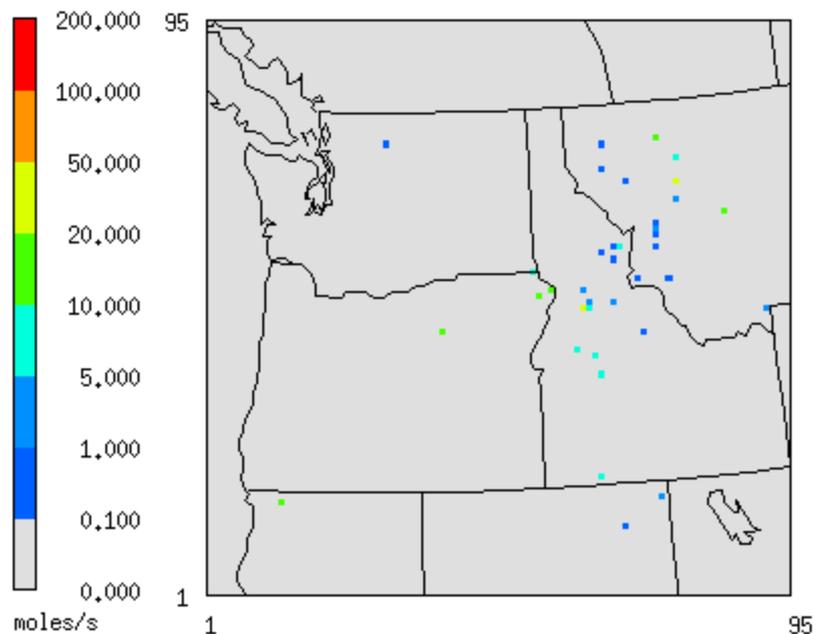
New BlueSky Emissions minus Original:  
Layers Collapsed



August 1, 2007 1:00:00 (PST)  
Min=-1346.97 at (77,69), Max=1706.26 at (77,73)

Original BlueSky

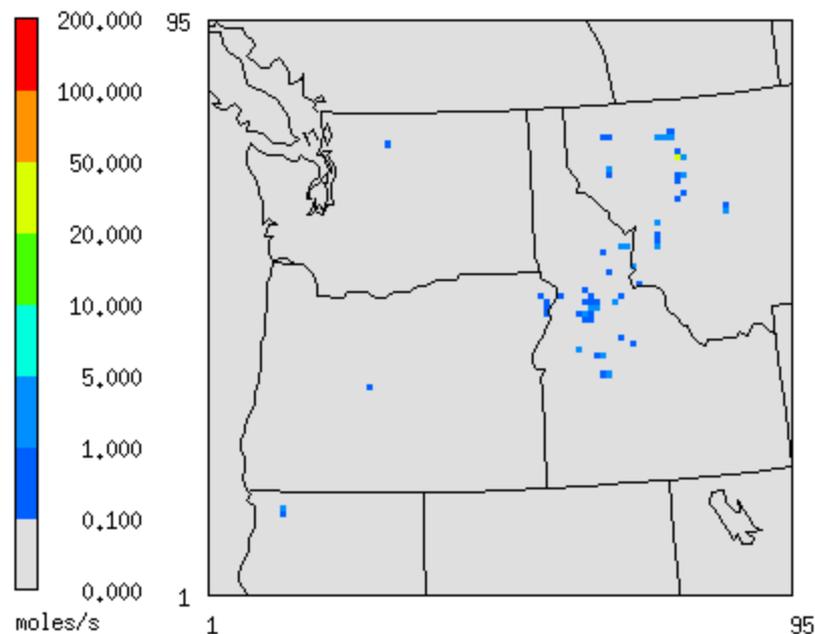
NOx Emissions  
Layers Collapsed



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (1,1), Max= 25,149 at (77,69)

New BlueSky-SMARTFIRE

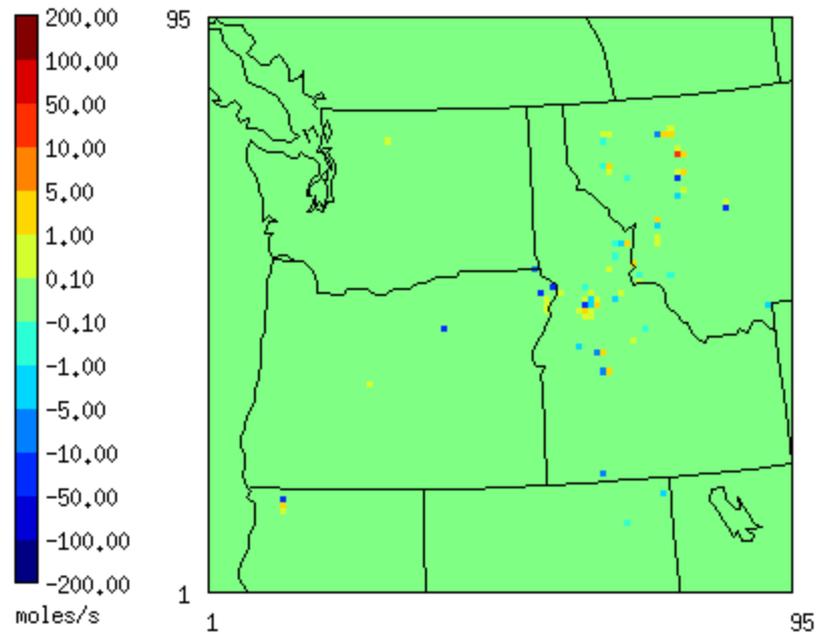
NOx Emissions  
Layers Collapsed



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (1,1), Max= 22,729 at (77,73)

Difference of NOx Emissions

New BlueSky Emissions minus Original:  
Layers Collapsed

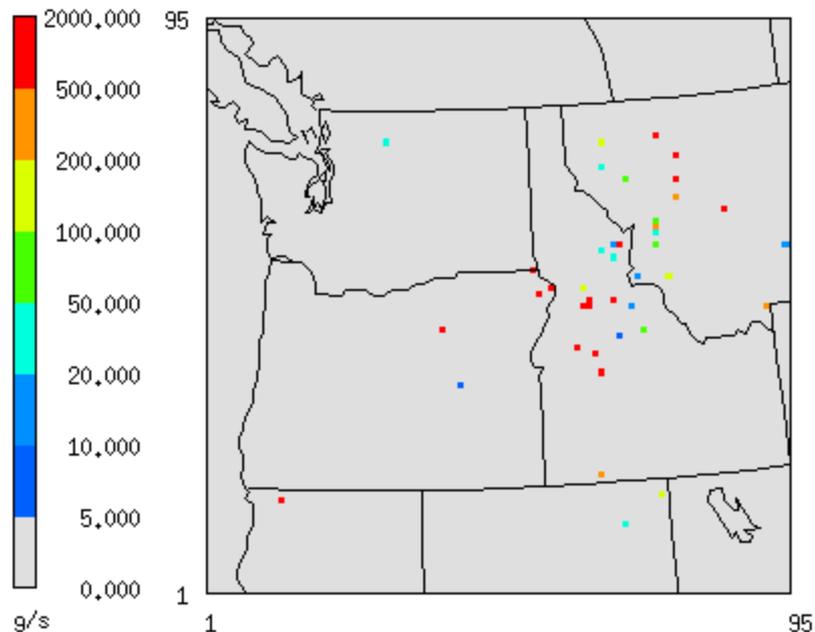


August 1, 2007 1:00:00 (PST)

Min=-24,57 at (77,69), Max=14,69 at (77,73)

Original BlueSky

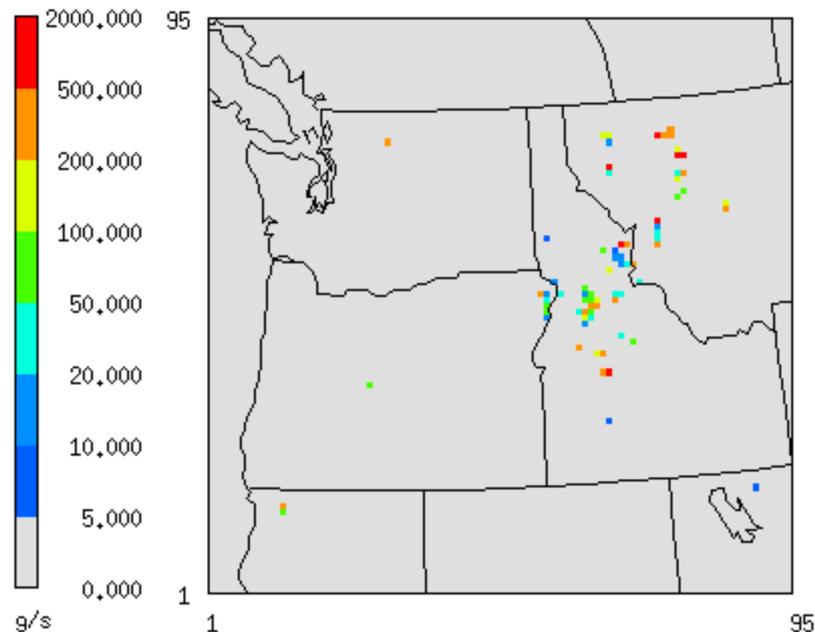
PM2.5 Emissions  
Layers Collapsed



August 1,2007 1:00:00 (PST)  
Min= 0,000 at (1,1), Max=4660,749 at (77,69)

New BlueSky-SMARTFIRE

PM2.5 Emissions  
Layers Collapsed

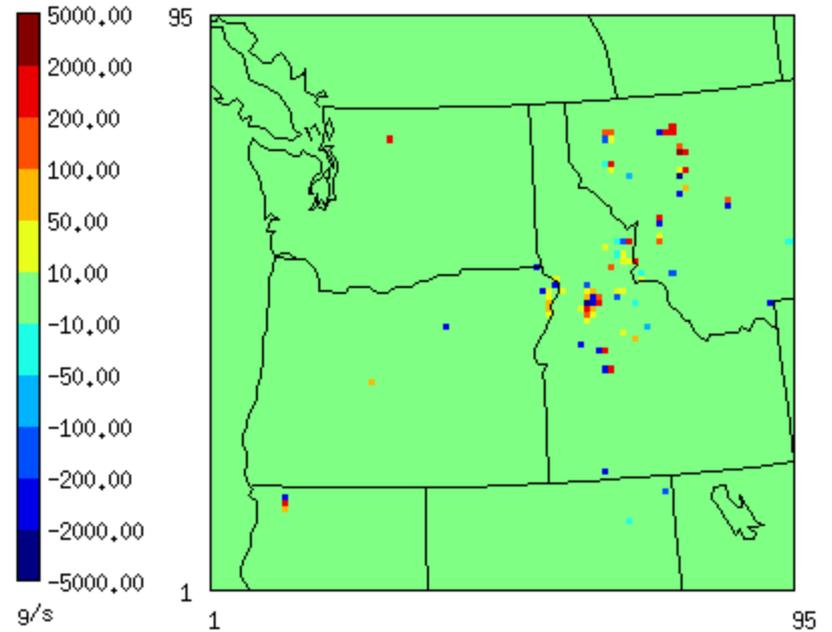


August 1,2007 1:00:00 (PST)  
Min= 0,000 at (1,1), Max=5209,887 at (77,73)

PM 2.5 = P(FINE)+P(NO3) +P(IEC)+P(SO4) +POA

Difference of PM2.5 Emissions

New BlueSky Emissions minus Original:  
Layers Collapsed

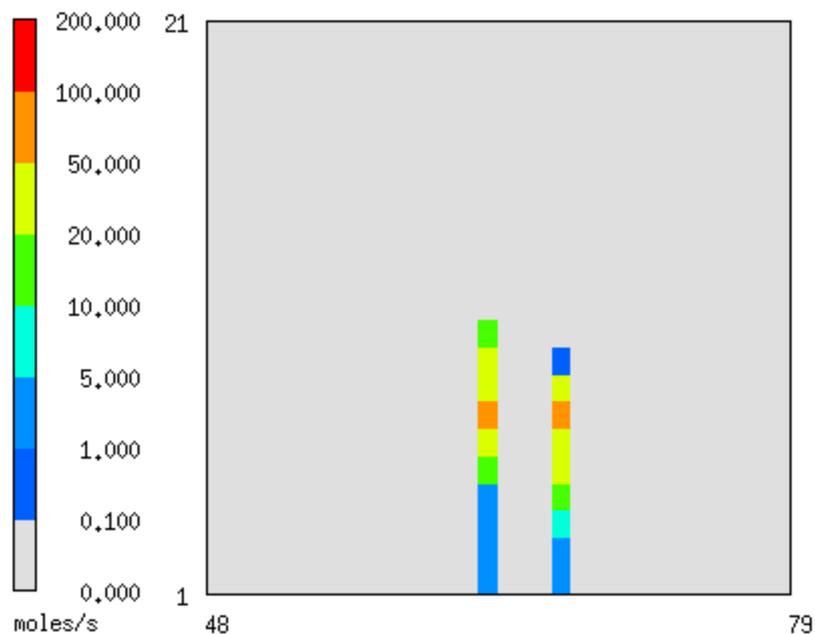


August 1, 2007 1:00:00 (PST)

Min=-4526.64 at (77,69), Max=3976.36 at (77,73)

Original BlueSky

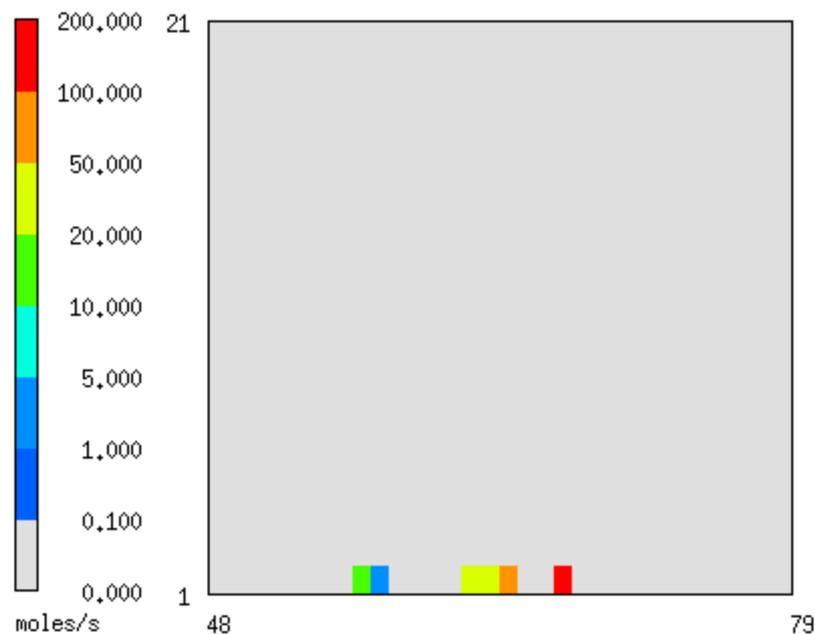
CO Emissions  
Idaho Fires



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (48,1), Max= 52,353 at (67,7)

New BlueSky-SMARTFIRE

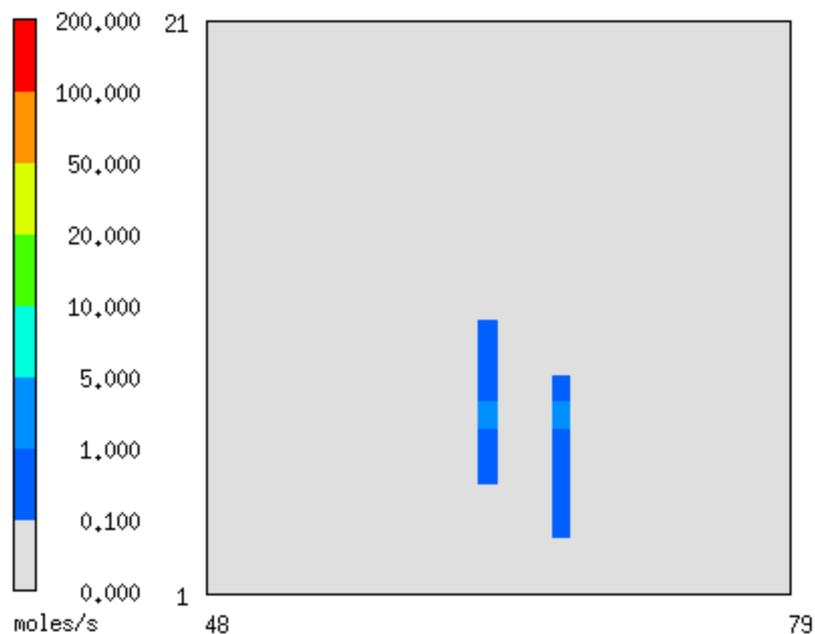
CO Emissions  
Idaho Fires



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (48,1), Max= 144,403 at (67,1)

Original BlueSky

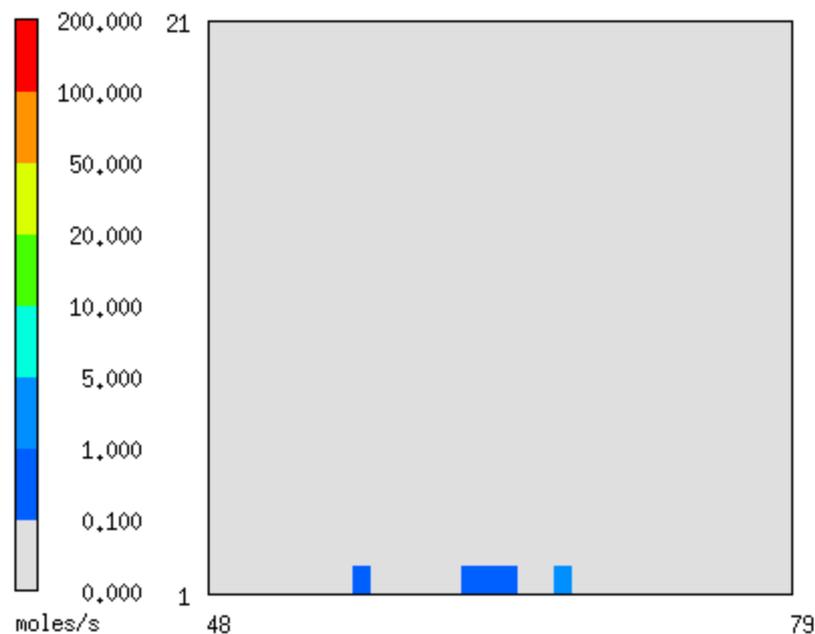
NOx Emissions  
Idaho Fires



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (48,1), Max= 1,075 at (67,7)

New BlueSky-SMARTFIRE

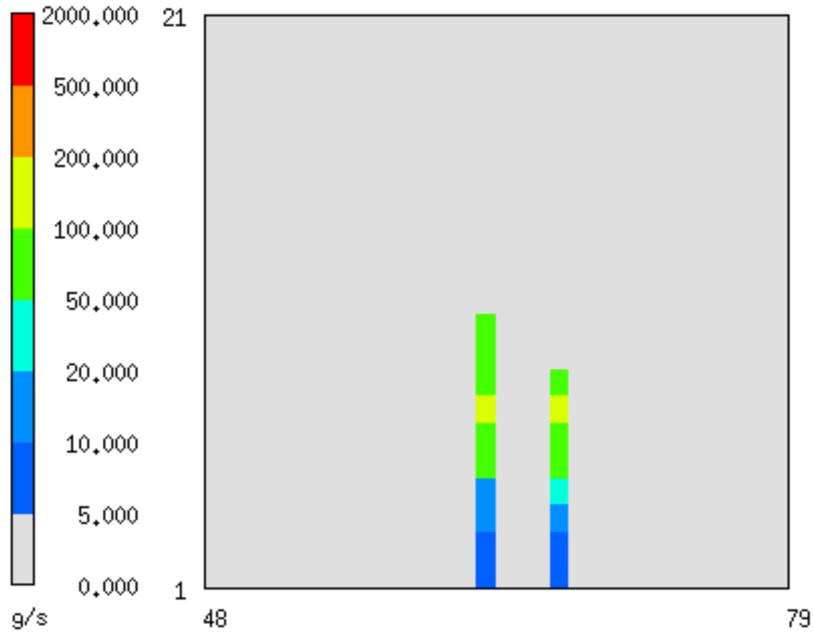
NOx Emissions  
Idaho Fires



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (48,1), Max= 1,057 at (67,1)

Original BlueSky

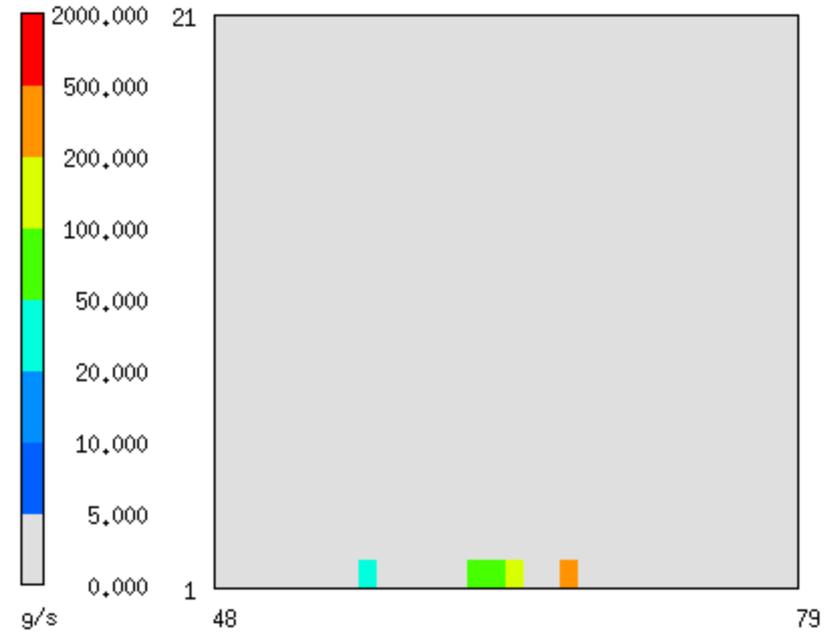
PM2.5 Emissions  
Idaho Fires



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (48,1), Max= 173,250 at (67,7)

New BlueSky-SMARTFIRE

PM2.5 Emissions  
Idaho Fires



August 1, 2007 1:00:00 (PST)  
Min= 0,000 at (48,1), Max= 343,621 at (67,1)

# One mid-day time-step collapsed emissions (Aug 1, 2007)

## Mean Emissions Per Grid Cell (including pixels w/o fires)

	<u>Old BlueSky</u>	<u>New BlueSky</u>		<u>Old BlueSky</u>	<u>New BlueSky</u>
ACET	NONE	0.05	MEOH	NONE	0.09
ALK1	<b>0.22</b>	0.15	MGLY	NONE	0.0006
ALK2	0.21	<b>0.25</b>	NH3	0.35	<b>0.84</b>
ALK3	0.004	<b>0.22</b>	NO	<b>0.56</b>	0.23
ALK4	0.008	<b>0.18</b>	NO2	<b>0.03</b>	0.01
ALK5	NONE	0.38	NR	<b>0.33</b>	0.22
ARO1	NONE	0.12	OLE1	0.07	<b>0.17</b>
ARO2	NONE	0.07	OLE2	0.02	<b>0.07</b>
BALD	NONE	NONE	PEC	<b>15</b>	10
CCHO	NONE	0.04	PHEN	NONE	0.01
CCO_OH	NONE	0.02	PM10	DNE	88
CH4	0.39	<b>0.94</b>	PM2_5	NONE	DNE
CO	28	<b>31</b>	PMC	8.4	NONE
CRES	NONE	0.01	PMFINE	4.4	<b>15</b>
ETHENE	<b>0.44</b>	0.21	PNO3	<b>0.18</b>	0.13
GLY	NONE	0.0007	POA	<b>71</b>	49
HCHO	NONE	0.11	PROD2	NONE	0.01
HCN	NONE	DNE	PSO4	<b>1.8</b>	1.3
HCOOH	NONE	0.02	RCHO	NONE	0.05
IPROD	NONE	NONE	RCO_OH	NONE	0.03
ISOPRENE	NONE	0.01	SO2	<b>0.14</b>	0.1
MACR	NONE	0.03	SULF	NONE	NONE
MEK	NONE	0.02	TRP1	NONE	0.01

Bolded numbers indicate larger value (where both have non-zero)

DNE = Variable DOES NOT EXIST

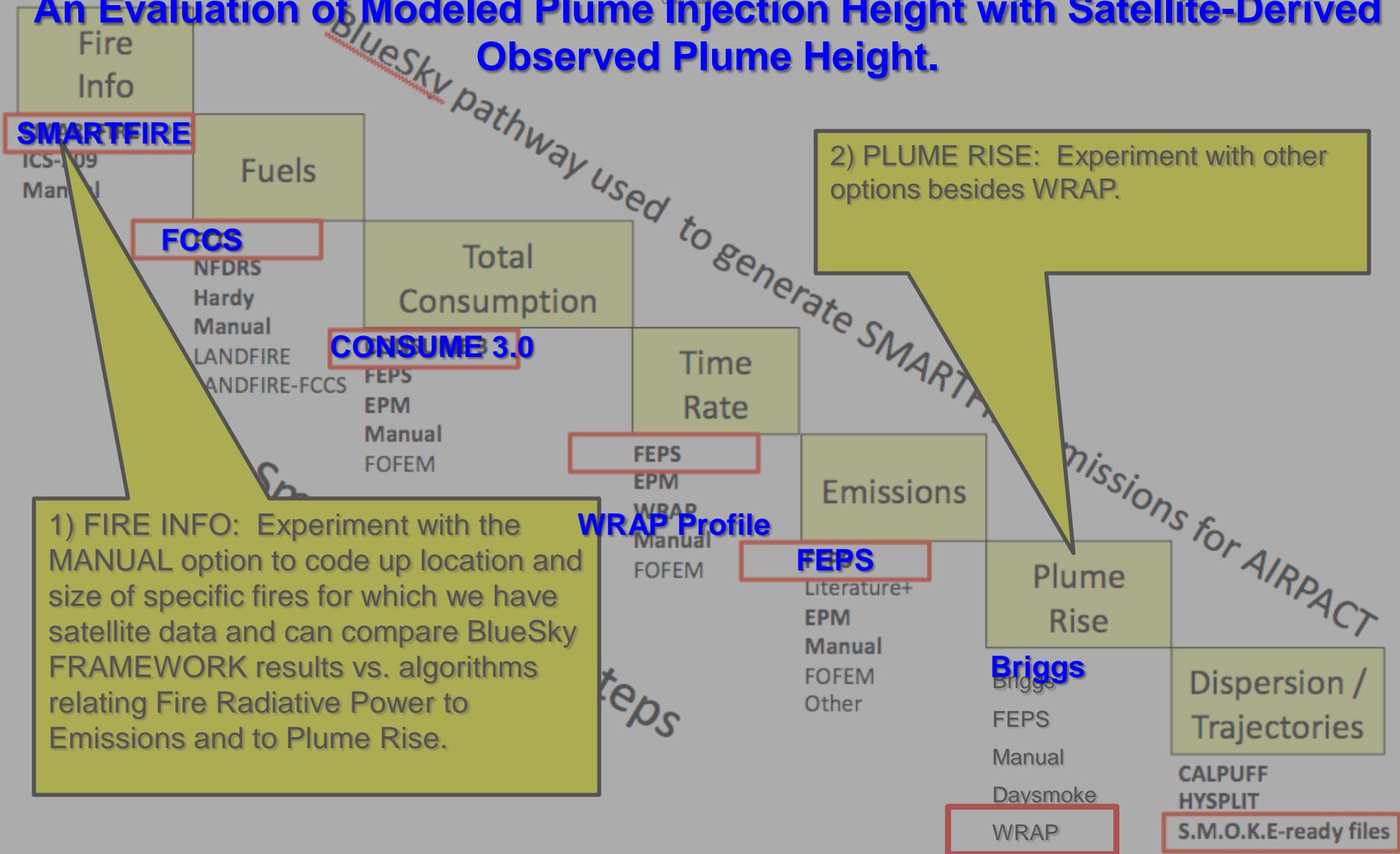
Units are moles/s for gases and g/s for particles

# Summary

- New Bluesky has significantly larger number of species with emissions factors
- New BlueSky has bulk of emissions in the surface layer with significant plume rise in daytime hours. This contrasts to Old BlueSky where bulk emissions are aloft.
- New BlueSky has significantly larger fire locations and growth dynamics. However, some fires that were identified with Old BlueSky Model (ICS-209 based) do not appear at with the new BlueSky using (SMARTFIRE).

Raffuse et al., 2012,

# An Evaluation of Modeled Plume Injection Height with Satellite-Derived Observed Plume Height.



1) FIRE INFO: Experiment with the MANUAL option to code up location and size of specific fires for which we have satellite data and can compare BlueSky FRAMEWORK results vs. algorithms relating Fire Radiative Power to Emissions and to Plume Rise.

2) PLUME RISE: Experiment with other options besides WRAP.

CONSUME 3.0

FCCS

SMARTFIRE

WRAP Profile

FEPS

Briggs

S.M.O.K.E-ready files

WRAP

CALPUFF  
HYSPLIT

steps

emissions for AIRPACT

BlueSky pathway used to generate SMARTFIRE

# Discussion