Emissions from Prescribed Burning and the Effects on Air Quality in the Tahoe Basin

Tom Malamakal

L.W Antony Chen, Xiaoliang Wang, Mark Green, Steven Gronstal

Desert Research Institute

University of Nevada, Reno

Overview

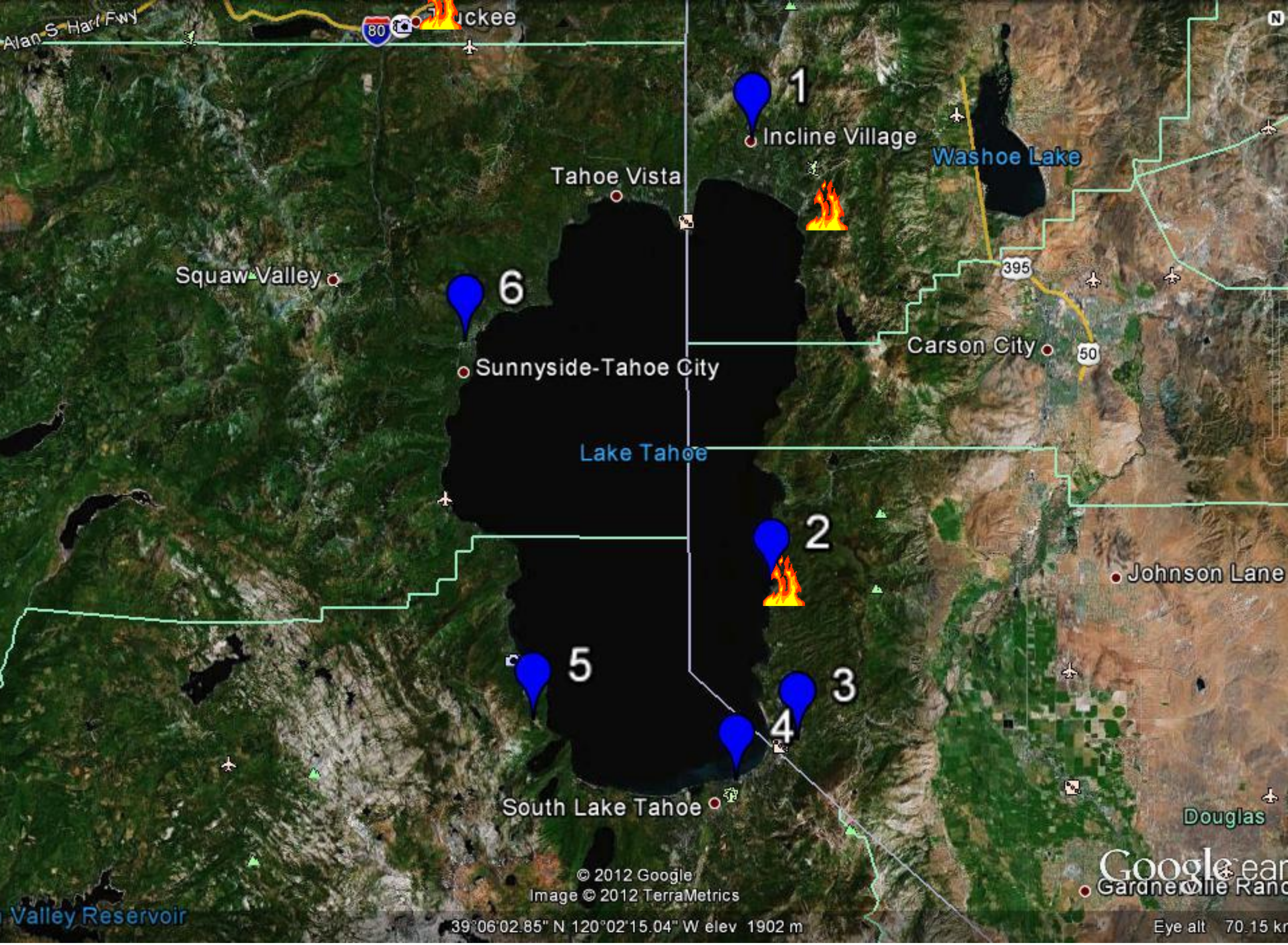
- Background/history of burning around Tahoe
- Our objectives/goals
- Description of method
- Preliminary Data
  - Time series, emission factors, chemical composition
- Future Directions
  - modeling transport
  - Spring monitoring, seasonal differences

Lake Tahoe Basin

- Lake is 22 miles long north to south, 12 miles wide.
- Roughly same size for last million years
- Forest landscape has evolved over last 10,000 years.
- Development in basin has altered natural wildfire cycle - large buildup of fuels.

Project Objectives

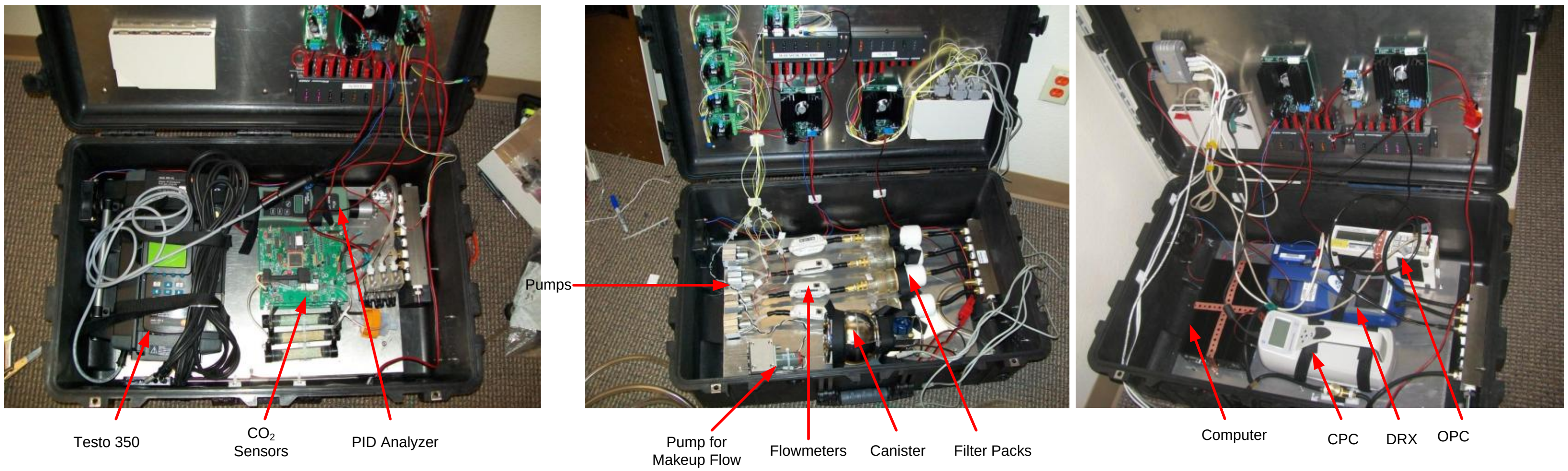
- Characterize particles and gases associated with prescribed burn
- Develop source profiles
- Develop continuous and time integrated emissions factors for different burn types, fuel loading and environmental conditions (moisture content, carbon and nitrogen content)
- Assess burn emissions transport by satellite remote sensing and five air monitoring sites representative of community exposure.

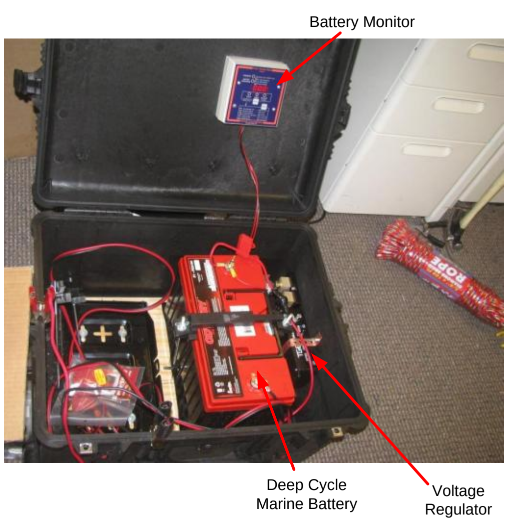


Alan S. Hart Fwy
80
Truckee
1
Incline Village
Washoe Lake
Tahoe Vista
395
Squaw Valley
6
Sunnyside-Tahoe City
Carson City
50
Lake Tahoe
2
Johnson Lane
5
3
4
South Lake Tahoe
Douglas
© 2012 Google
Image © 2012 TerraMetrics
Valley Reservoir
39°06'02.85" N 120°02'15.04" W elev 1902 m
Eye alt 70.15 km

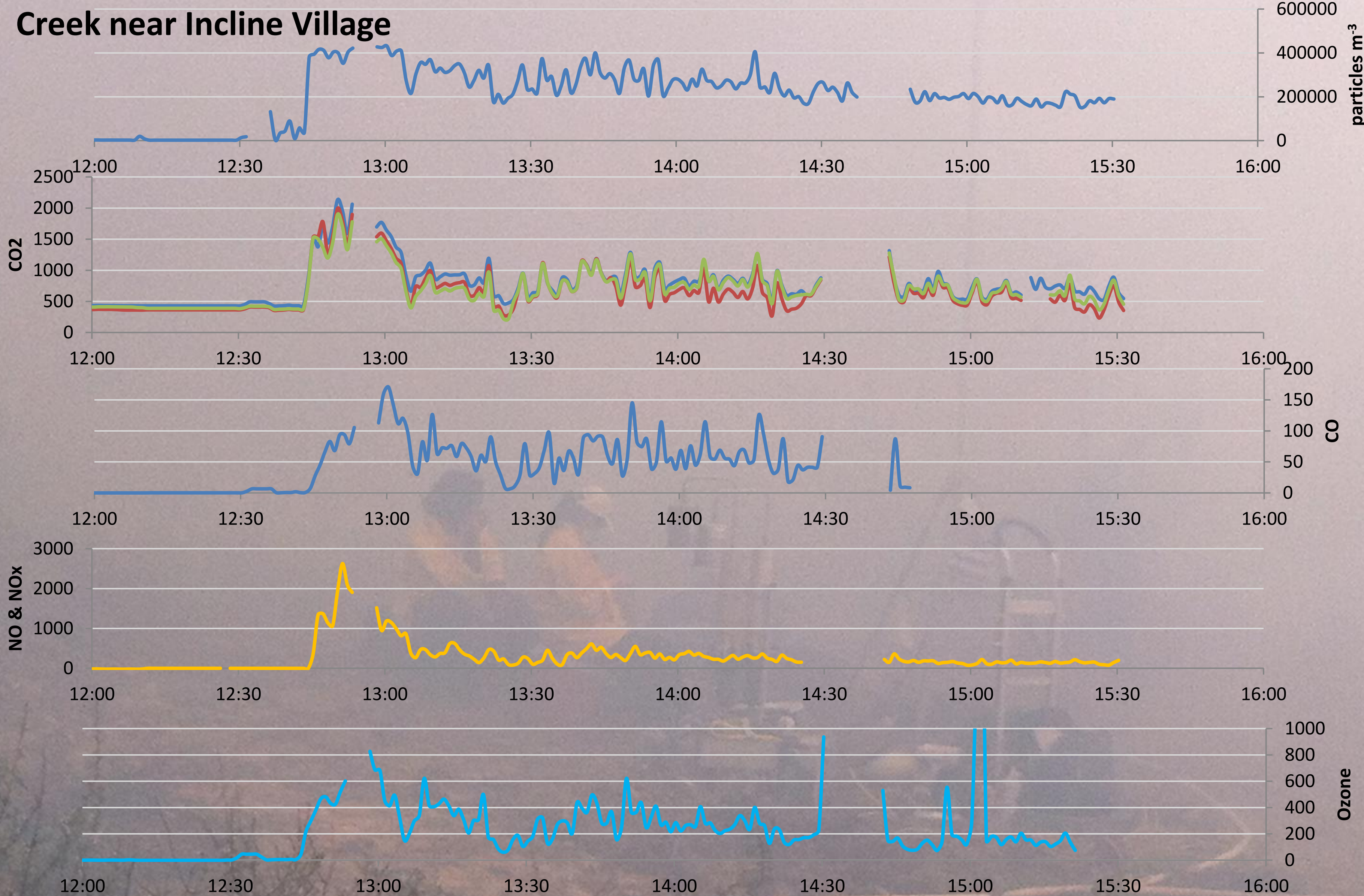
Method

In-Plume System





7 acre prescribed burn - source measurements taken at Tunnel Creek near Incline Village



Calculation Method

Emission Factor

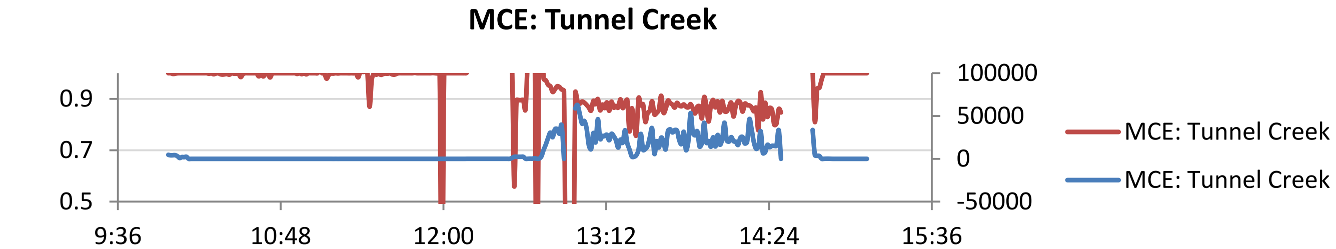
$$EF_j = \frac{M_j}{M_{fuel}} = \frac{M_j}{C_{ash} + \sum_i C_i} x_{c,fuel} = \frac{M_j}{\sum_i C_i}\left(\frac{\sum_i C_i}{C_{ash} + \sum_i C_i}\right) x_{c,fuel} = \frac{M_j}{\sum_i C_i}\left(x_{c,fuel} - \frac{M_{ash}}{M_{fuel}} x_{c,ash}\right)$$

EF_j: emission factor of species j
M_{fuel}: mass of the fuel burned
M_j: mass of the species j emitted
C_{ash}: carbon mass in ash
C_i: carbon mass in every combustion product i (CO_2, CO, etc., including species j)
$x_{c,fuel}$ and $x_{c,ash}$: carbon mass fraction in fuel and ash, respectively

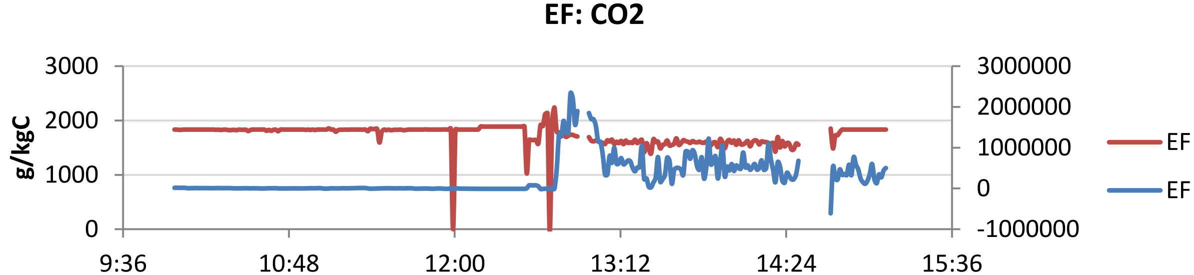
Combustion Efficiency

$$CE = \frac{C_{CO_2}}{\sum_i C_i} = \frac{C_{CO_2}}{C_{CO_2} + C_{CO} + C_{HC} + C_{VOC} + C_{PM}}$$

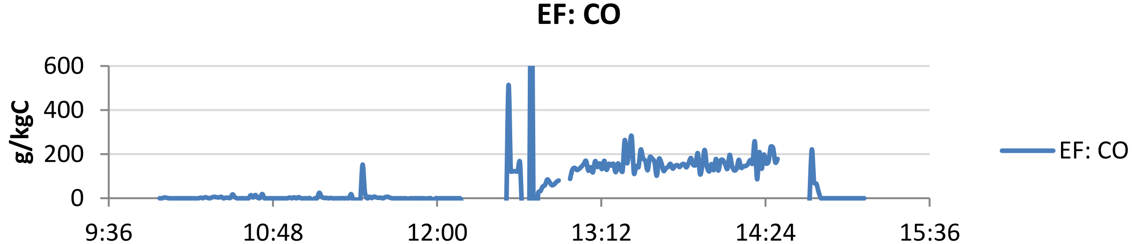
(Chen et al., 2007)



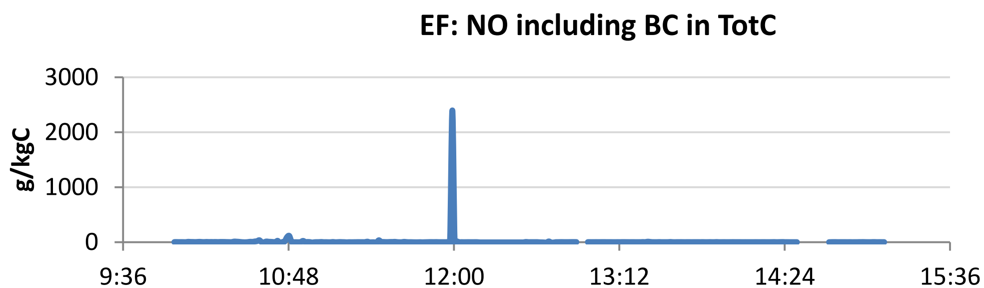
MCE: Tunnel Creek
0.9
0.7
0.5
100000
50000
0
-50000
9:36
10:48
12:00
13:12
14:24
15:36
MCE: Tunnel Creek
MCE: Tunnel Creek



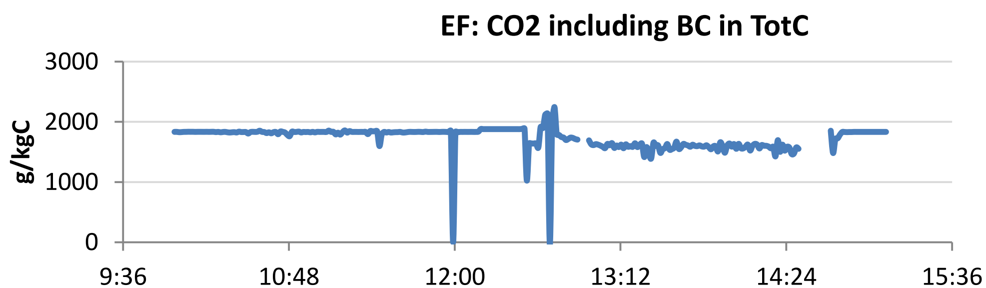
EF: CO2
g/kgC
3000
2000
1000
0
3000000
2000000
1000000
0
-1000000
9:36
10:48
12:00
13:12
14:24
15:36
EF
EF



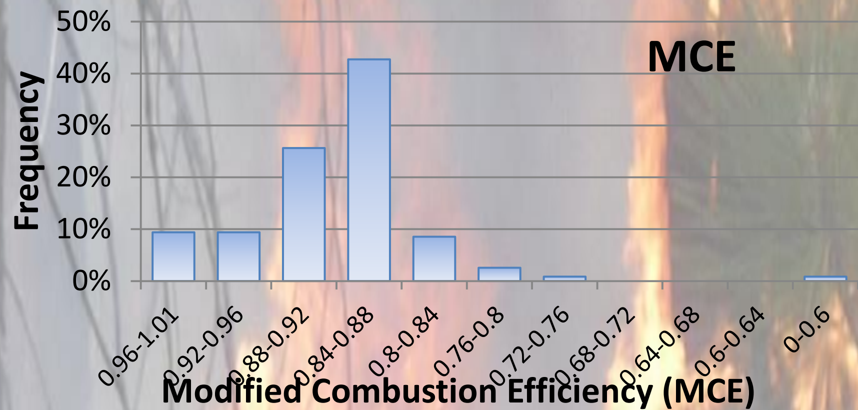
EF: CO
g/kgC
600
400
200
0
9:36
10:48
12:00
13:12
14:24
15:36
EF: CO

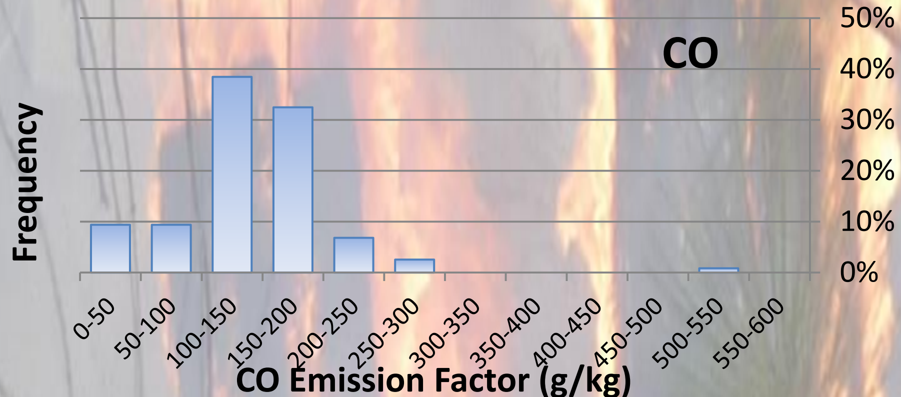


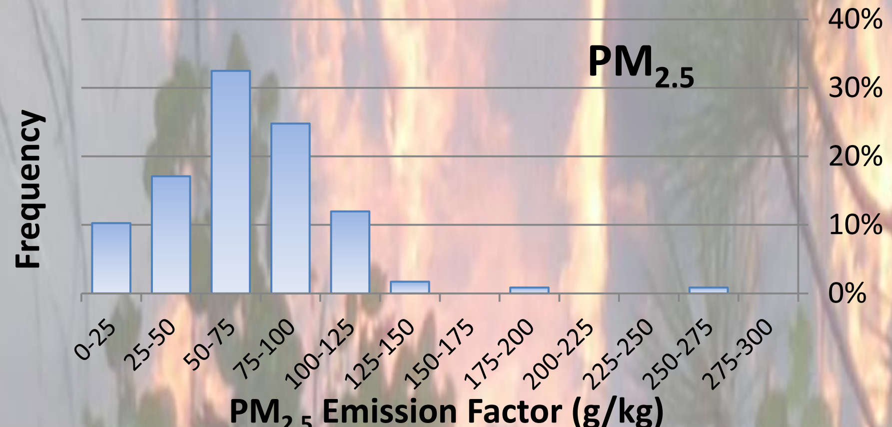
EF: NO including BC in TotC
g/kgC
3000
2000
1000
0
9:36
10:48
12:00
13:12
14:24
15:36

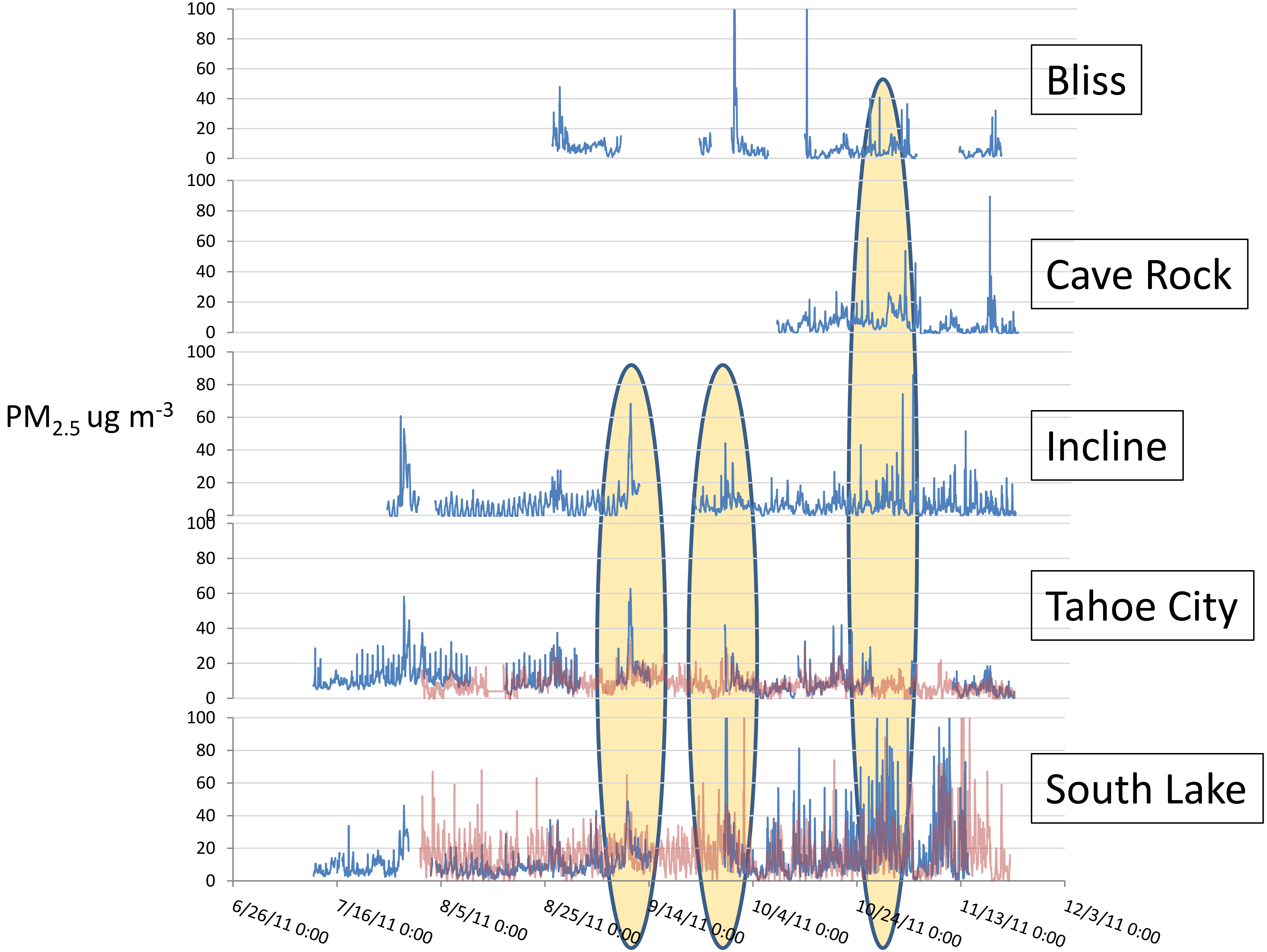


EF: CO2 including BC in TotC
g/kgC
3000
2000
1000
0
9:36
10:48
12:00
13:12
14:24
15:36

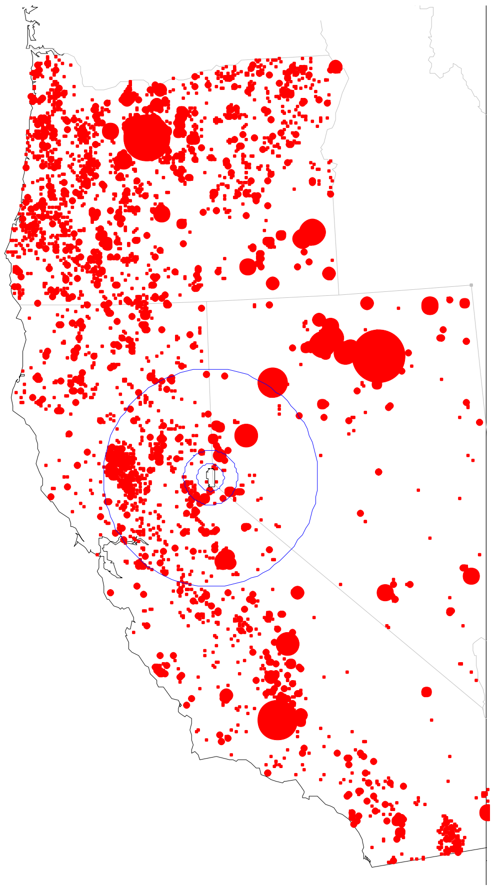

MCE
Frequency
50%
40%
30%
20%
10%
0%
0.96-1.01
0.92-0.96
0.88-0.92
0.84-0.88
0.8-0.84
0.76-0.8
0.72-0.76
0.68-0.72
0.64-0.68
0.6-0.64
0-0.6
Modified Combustion Efficiency (MCE)


CO
Frequency
50%
40%
30%
20%
10%
0%
0-50
50-100
100-150
150-200
200-250
250-300
300-350
350-400
400-450
450-500
500-550
550-600
CO Emission Factor (g/kg)

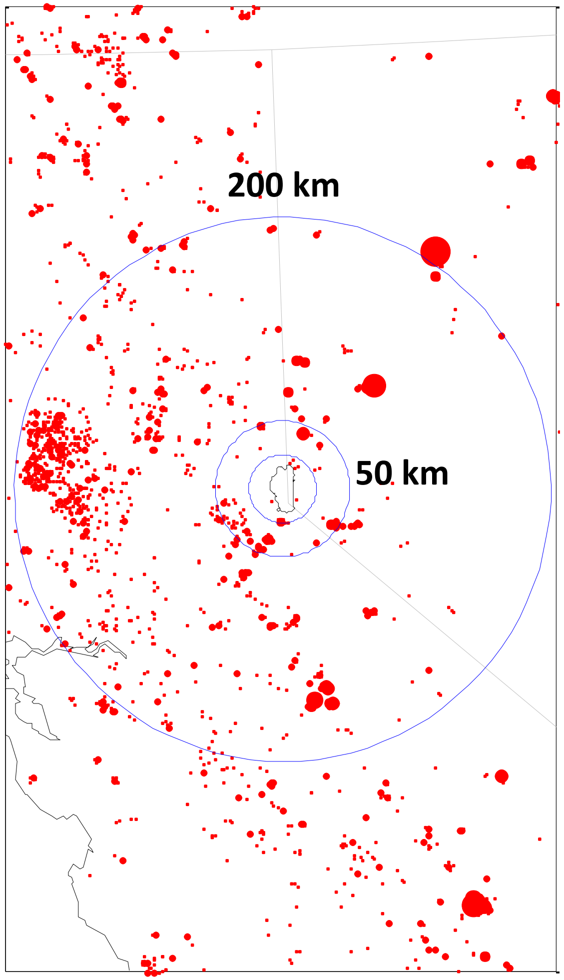

$PM_{2.5}$
Frequency
40%
30%
20%
10%
0%
0-25
25-50
50-75
75-100
100-125
125-150
150-175
175-200
200-225
225-250
250-275
275-300
$PM_{2.5}$ Emission Factor (g/kg)



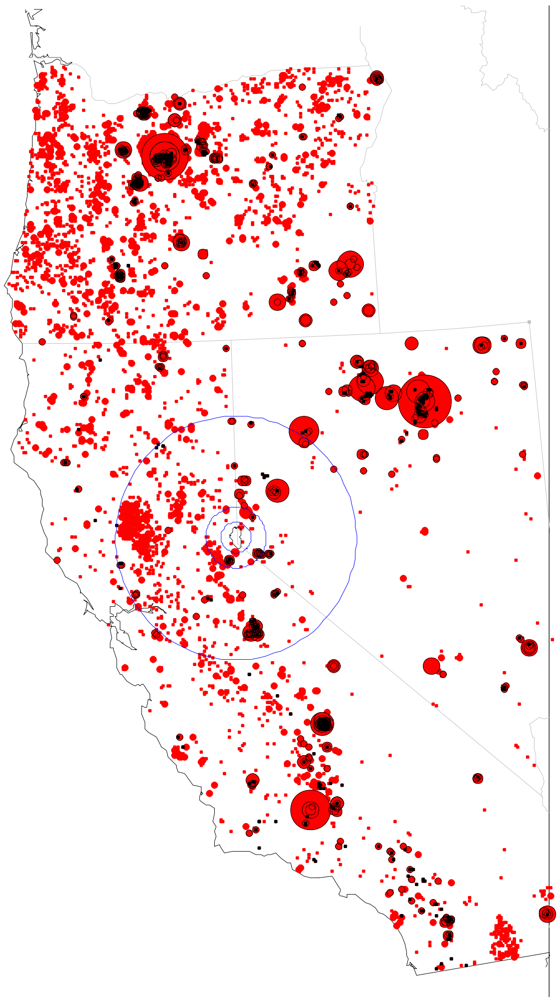
Bliss
Cave Rock
Incline
Tahoe City
South Lake
PM2.5 ug m-3
6/26/11 0:00
7/16/11 0:00
8/5/11 0:00
8/25/11 0:00
9/14/11 0:00
10/4/11 0:00
10/24/11 0:00
11/13/11 0:00
12/3/11 0:00

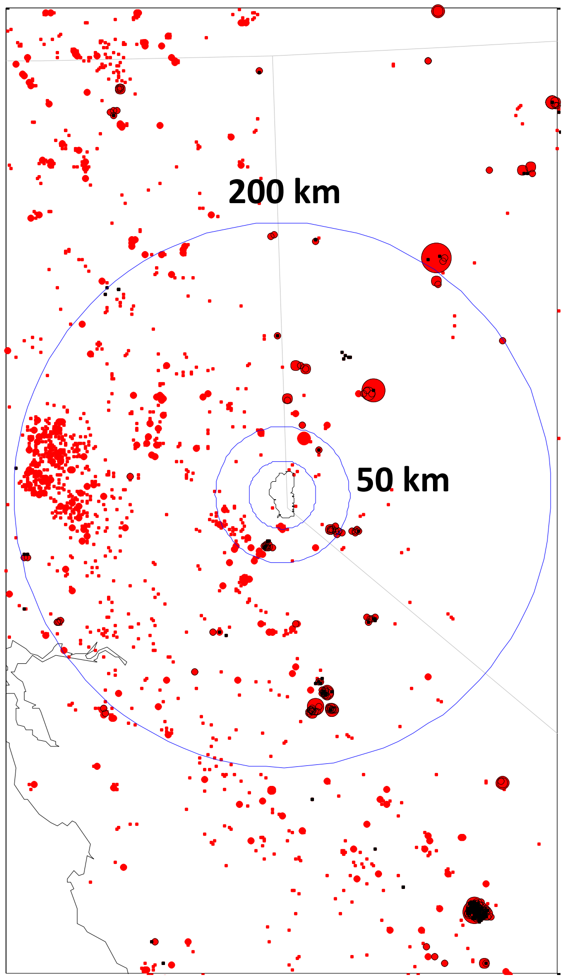


Open burning in Oregon, Nevada, and California recorded by SMARTFIRE for June – November, 2011

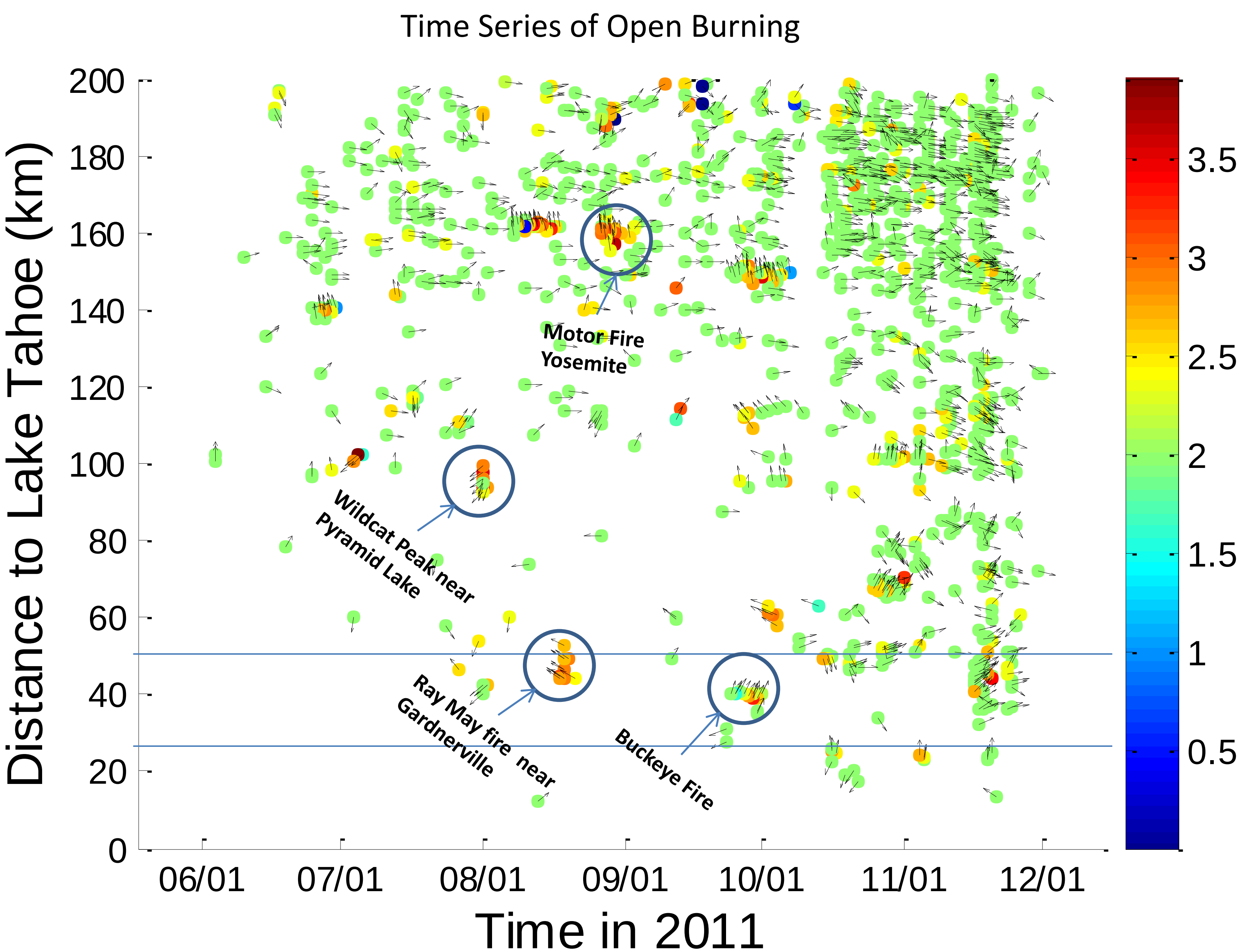


Fires within the 25, 50, and 250 km domain. The largest circle represents of a burn area of 14,288 acres.

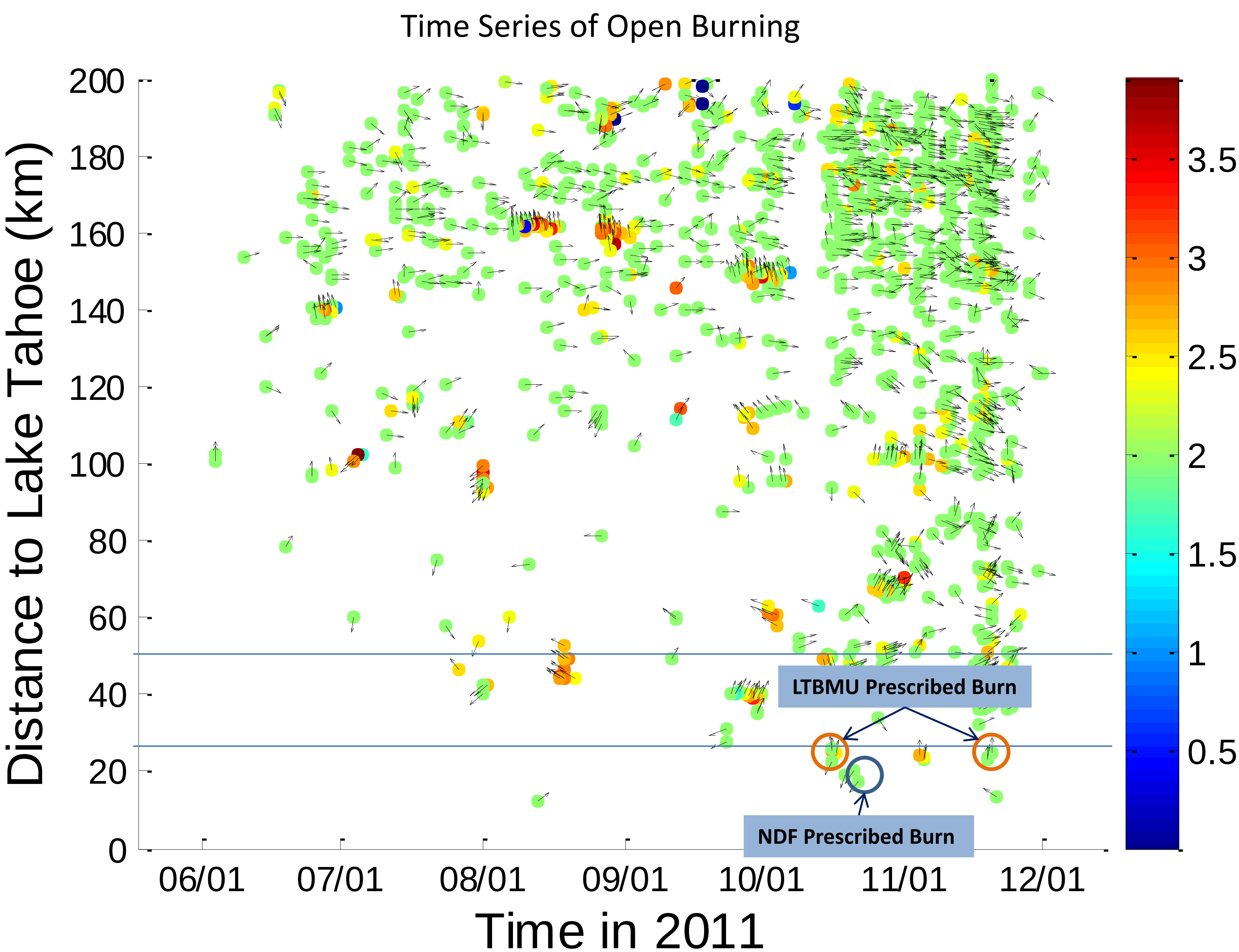




Known wildfires are circled in black



Time Series of Open Burning
Distance to Lake Tahoe (km)
200
180
160
140
120
100
80
60
40
20
0
06/01
07/01
08/01
09/01
10/01
11/01
12/01
Time in 2011
3.5
3
2.5
2
1.5
1
0.5
Motor Fire Yosemite
Wildcat Peak near Pyramid Lake
Ray May fire near Gardnerville
Buckeye Fire


Time Series of Open Burning
Distance to Lake Tahoe (km)
200
180
160
140
120
100
80
60
40
20
0
06/01
07/01
08/01
09/01
10/01
11/01
12/01
Time in 2011
LTBMU Prescribed Burn
NDF Prescribed Burn
3.5
3
2.5
2
1.5
1
0.5

Challenges and Future Directions

- Source profiles difficult to obtain.
  - meteorology
  - access
  - coordination between multiple agencies
- Sample through spring, look at seasonal difference in burns
- Model emissions transport

to: 2300 UTC OCT 20 2011
10/20/2011 3:19:04 pm
NOAA
>5.3E+02 ug/m3
>3.0E+02 ug/m3
>1.4E+02 ug/m3
>8.8E+01 ug/m3
>3.9E+01 ug/m3
>1.0E+00 ug/m3
Maximum: 1.4E+01 ug/m3
(identified as a square)
Minimum: 6.8E-08 ug/m3
Reno
80
Truckee
Storey
Lahontan R
Source Location
Squaw Valley
395
Carson City
50
Lake Tahoe
South Lake Tahoe
Douglas
Lyon
Wellington
© 2012 Google
Image © 2012 TerraMetrics
Google earth
39°10'12.74" N 119°46'32.52" W elev 6014 ft
Eye alt 62.63 mi

Thank You

- Tahoe Regional Planning Agency
- Washoe County Air Quality Management Division
- Placer County Air Pollution Control District
- California Air Resources Board
- Nevada Division of Forestry
- California State Parks
- Lake Tahoe Basin Management Unit