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Smoke from Western Wildfires & Particulate Matter Concentrations

Presentation for: ASHRAE Project Committee GPC 44P – Protecting Building Occupants from Smoke During Wildfire and Prescribed Burn Events

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What do the smoke data from large wildfires show?

3 large western wildfire events studied:

1. 2020 Labor Day fires: burned over 330,000 acres across Washington, smoke affected Seattle, Puget Sound, and southern British Columbia; multiple large fires burning in CA as well (i.e., Creek, LNU Complex, SCU Complex, August Complex)
2. 2018 Summer Fires: Mendocino Complex (7/27, burned 459,123 acres) and Carr Fire (7/23, burned 229,651 acres)
3. 2018 Camp Fire: 11/8, burned 153,336 acres, destroyed 18,804 structures

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$PM_{2.5}$ Data

24-hour average $PM_{2.5}$ (ug/m^3) from EPA Air Quality System (AQS) database

The level of 24-hour National Ambient Air Quality Standards (NAAQS) is: **35 ug/m³**

Air Quality Index (AQI) Category	AQI Range	$PM_{2.5}$ Range
Good/Moderate	0-100	0-35 ug/m³
Unhealthy for sensitive groups	100-150	35-55 ug/m³
Unhealthy	151-200	55-150 ug/m³
Very Unhealthy	201-300	150-250 ug/m³
Hazardous	301 and higher	250-500 ug/m³
Above the AQI		500+ ug/m³

* This is a simplified version of the EPA AQI

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Questions addressed:

How long did the smoke event last?

- Days above 35 ug/m^3 and consecutive days above 35 ug/m^3

During the smoke event, what was the average $PM_{2.5}$ concentration?

- Mean concentration for days above 35 ug/m^3

How long were $PM_{2.5}$ concentrations at unhealthy levels?

- Consecutive days > 55 ug/m^3
- Consecutive days > 150 ug/m^3

What was the peak concentration?

- Maximum

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Highlighted stations (for plots):

All stations were analyzed, but only certain stations were shown for presentation purposes

The stations chosen for presentation were selected as stations that saw large impacts from smoke – no specific threshold was used

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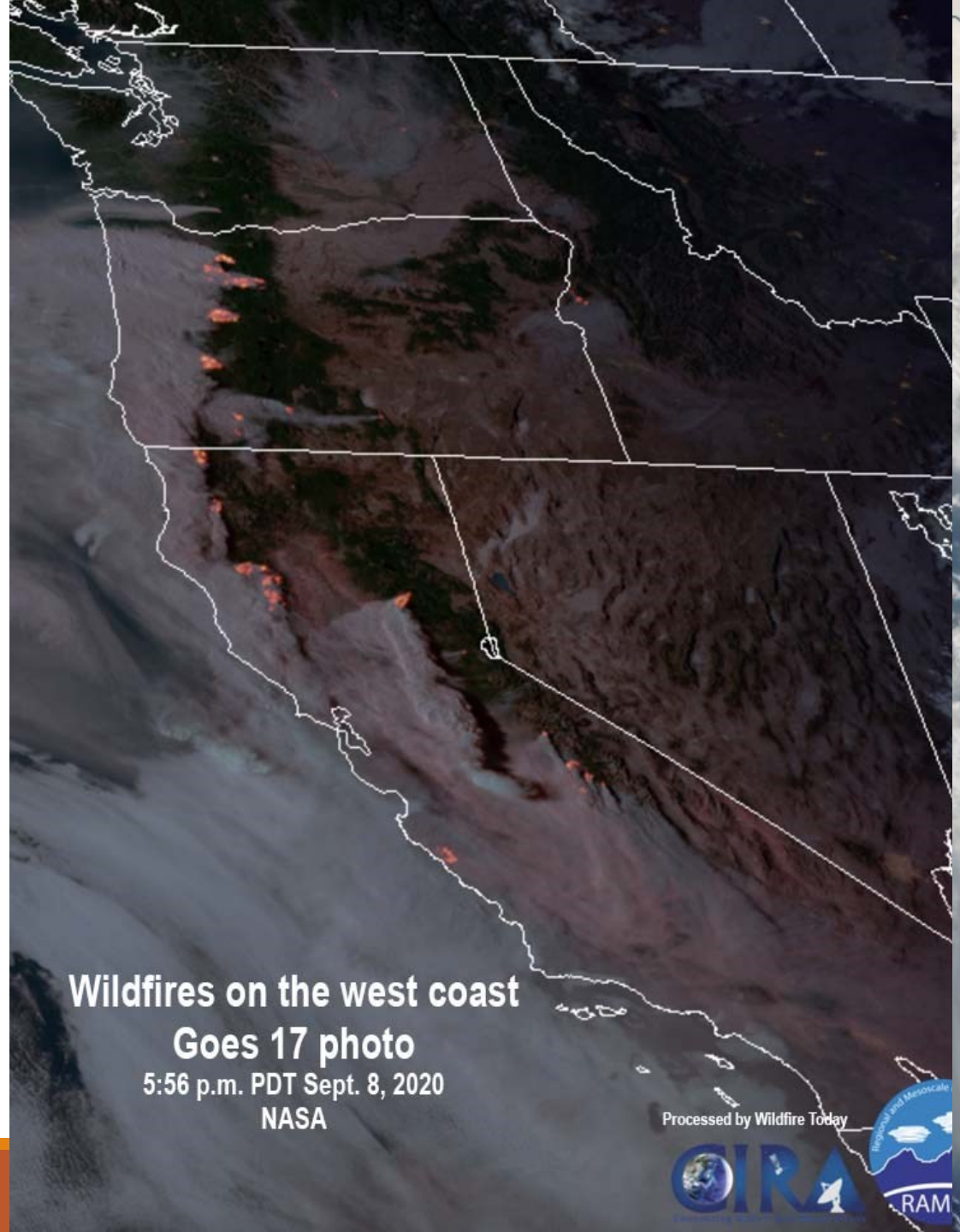
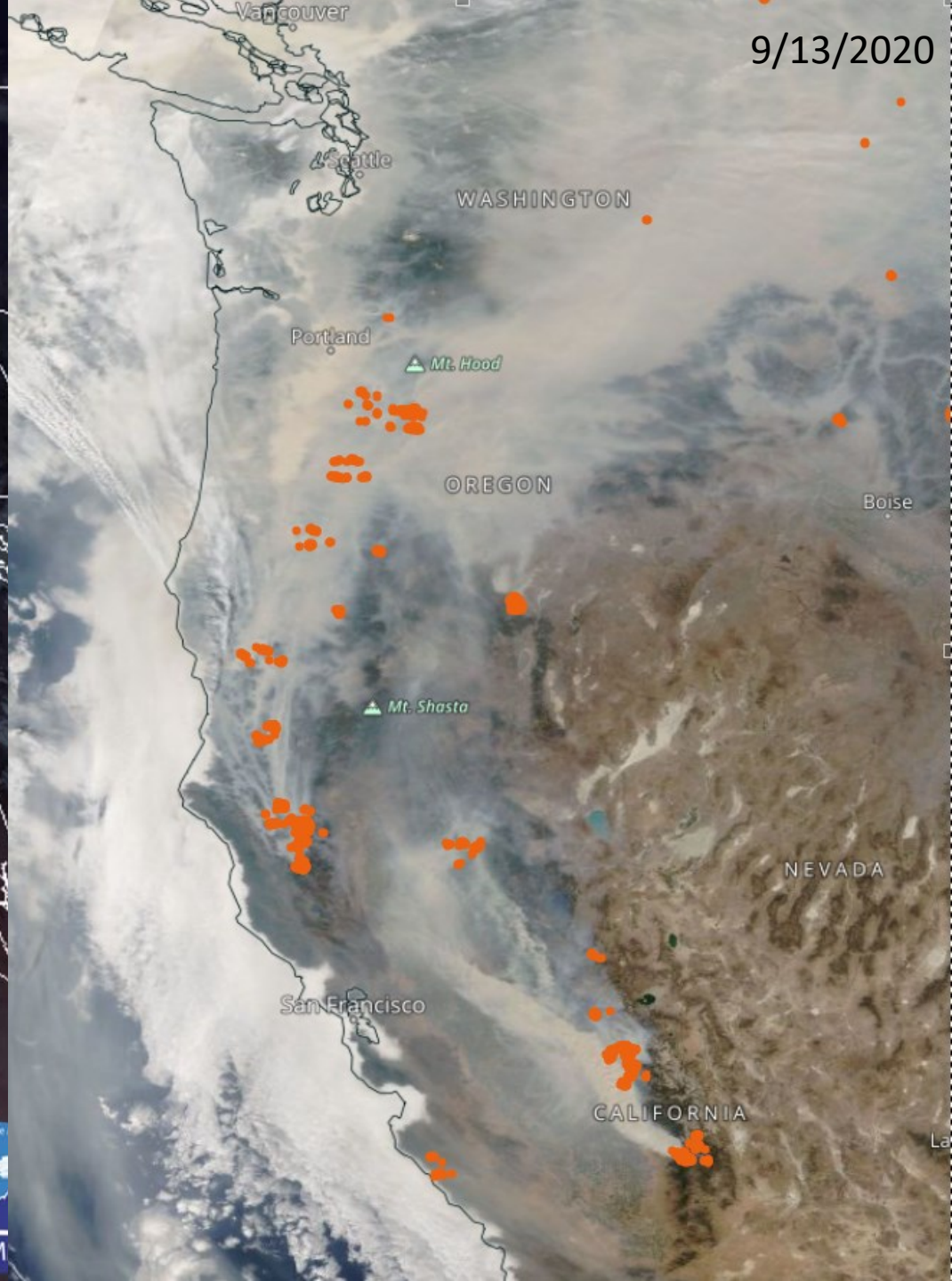
Labor Day Fires





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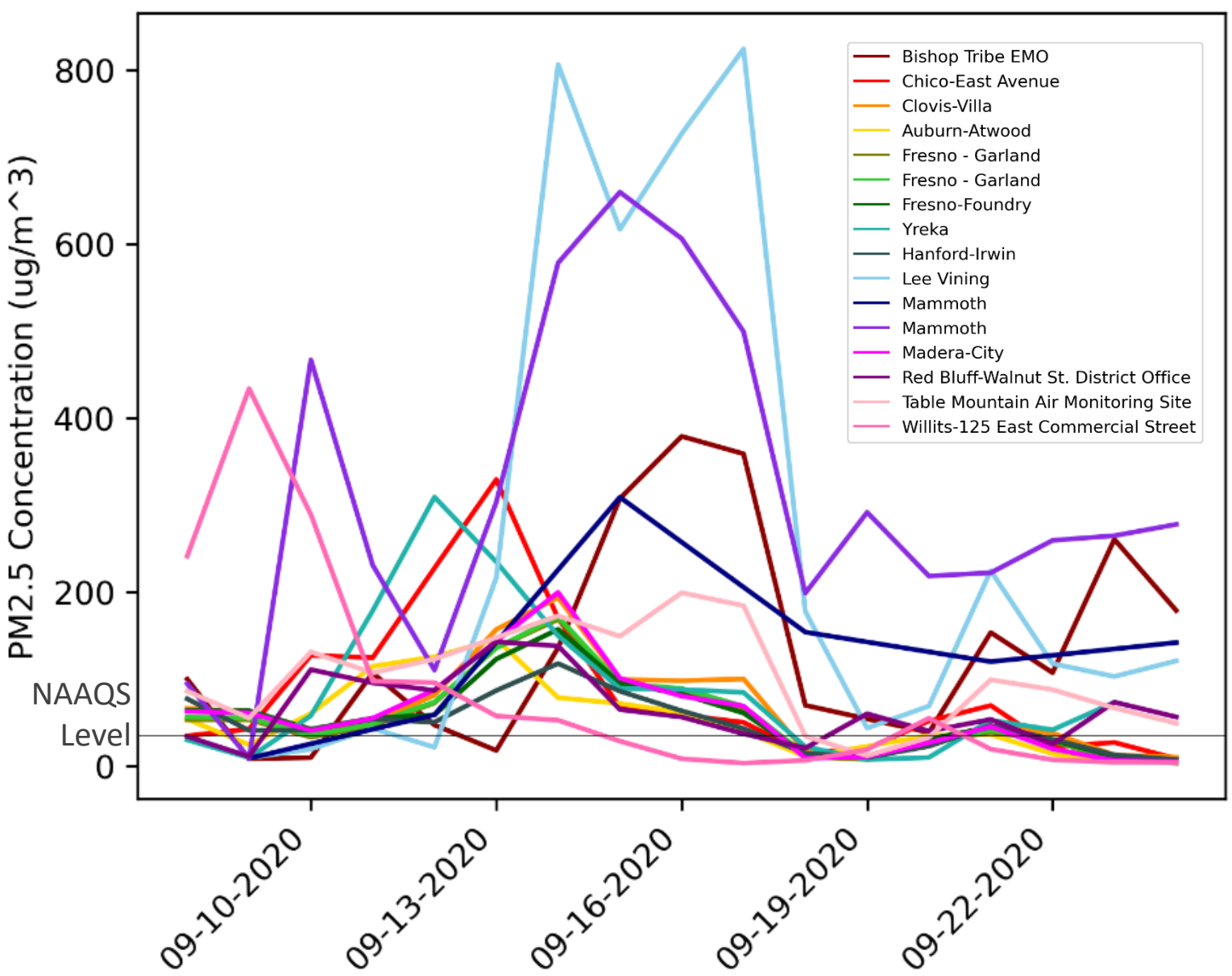
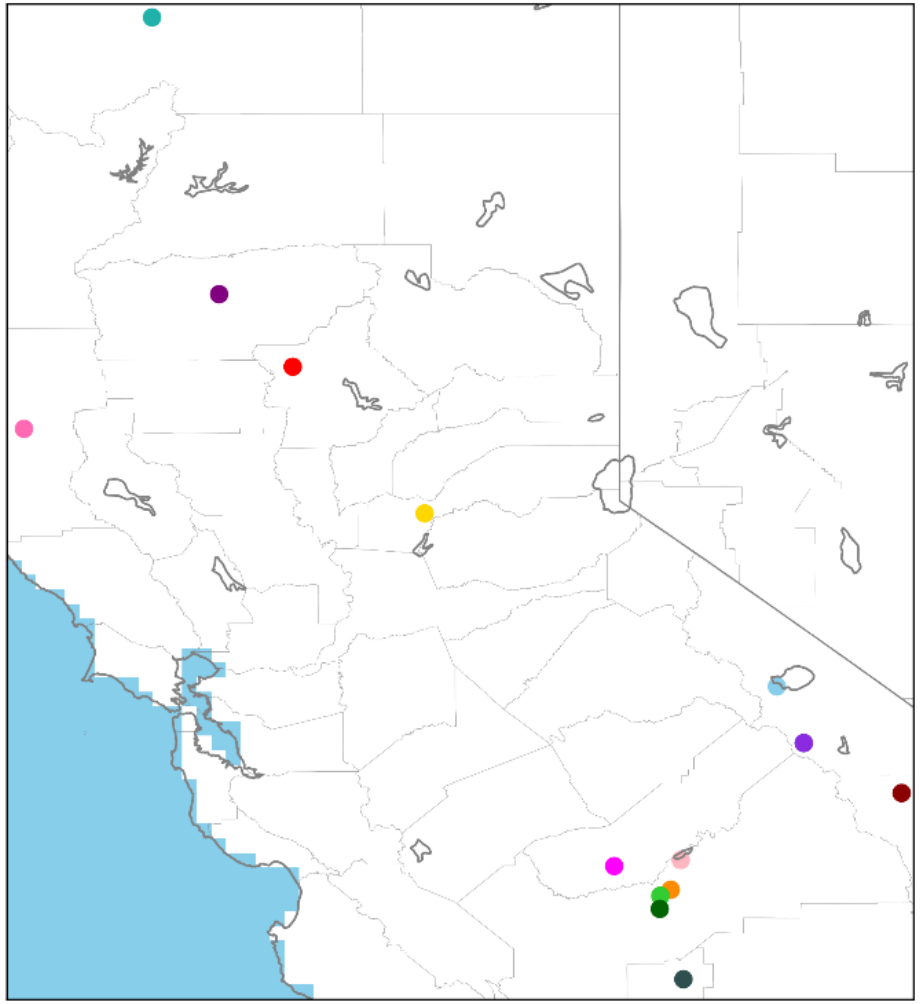
Labor Day fires (2020) (CA)





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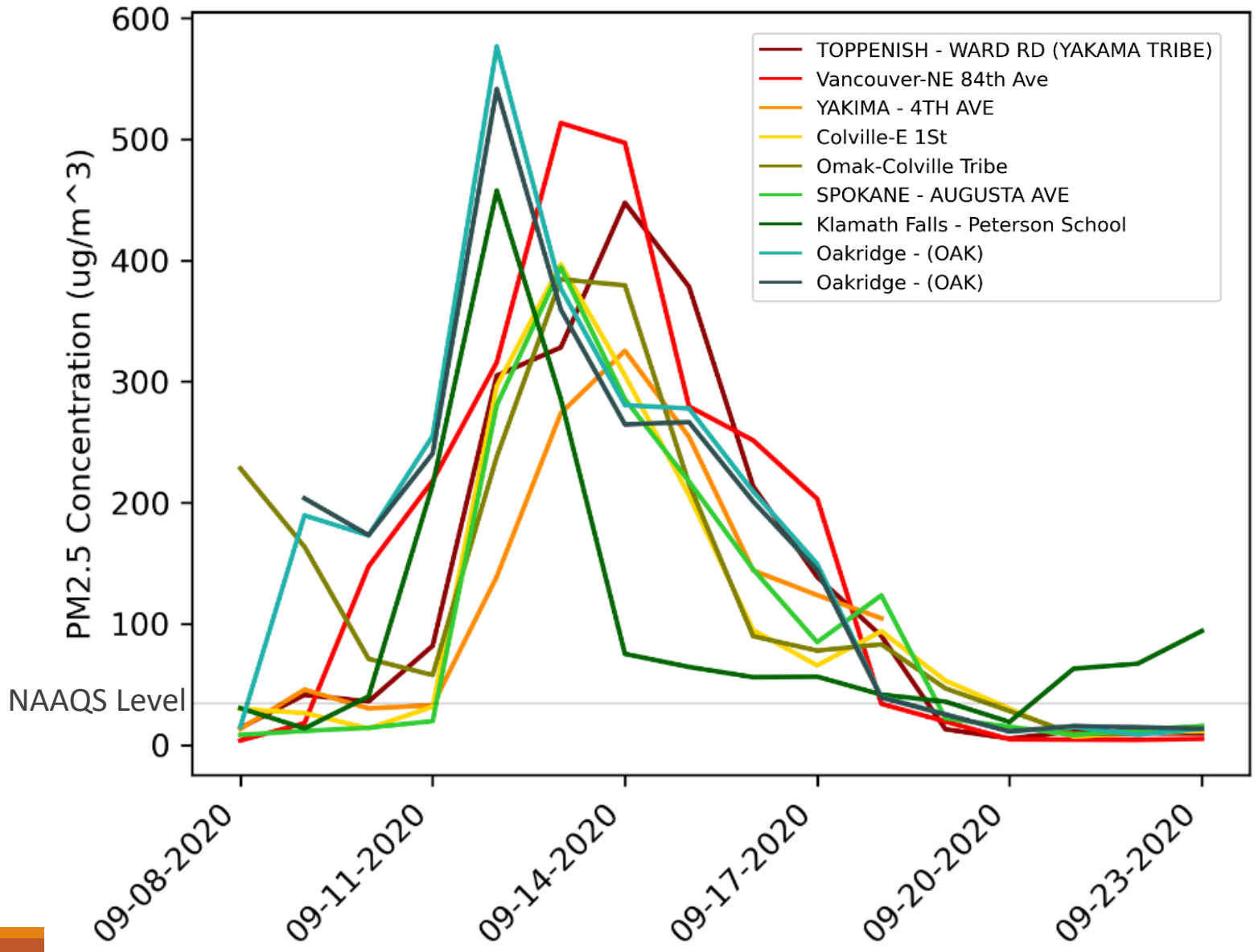
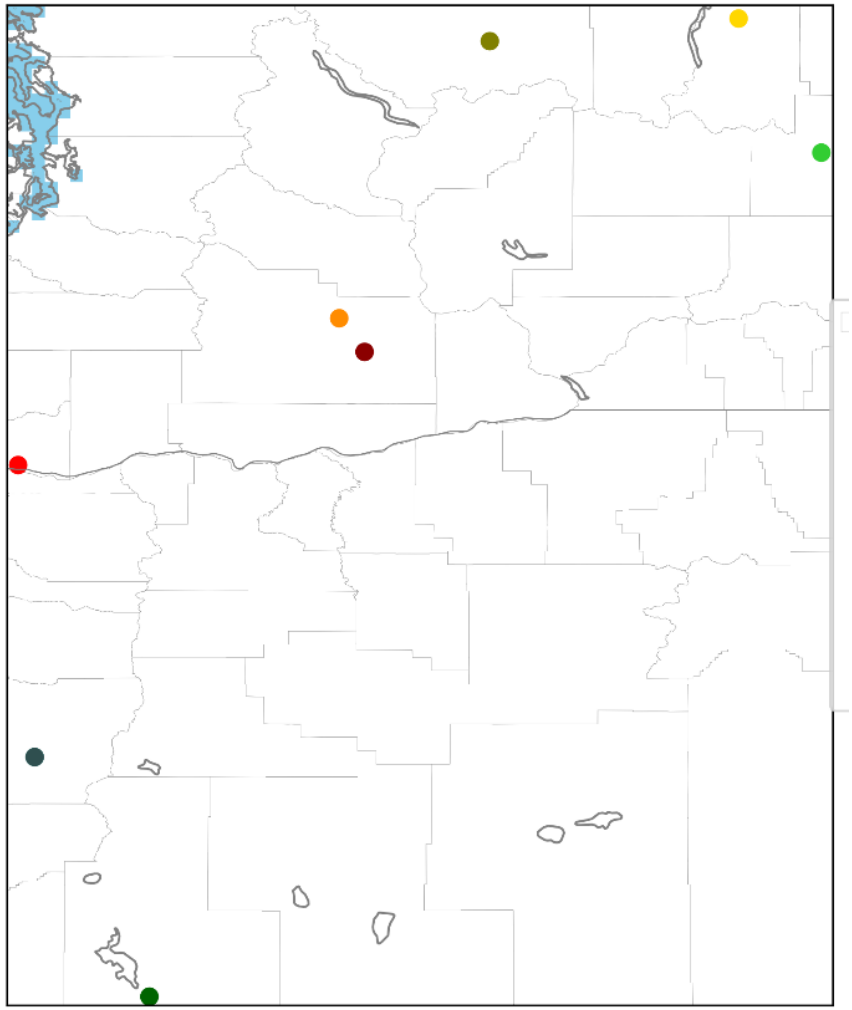
Data for Labor Day Fires (CA)

	Mammoth	Bishop Tribe EMO	Table Mountain Air Monitoring Site	Red Bluff-Walnut St. District Office	Lee Vining	Clovis-Villa	Chico-East Avenue	Madera-City	Fresno - Garland	Fresno - Garland	Fresno-Foundry	Hanford-Irwin	Auburn - Atwood
Days above 35 (out of 18):	17	15	14	14	13	13	12	12	12	12	12	12	11
Consecutive days > 35:	15	11	6	8	12	11	9	11	11	11	11	11	8
Mean (above 35):	315.07	161.47	115.77	75.74	314.68	83.55	114.17	83.87	76.04	74.39	74.17	62.86	74.96
Consecutive days > 150:	12	3	2	0	6	2	3	1	1	1	1	0	0
Consecutive days > 55:	15	5	6	7	6	6	7	7	6	6	7	4	7
Maximum:	659.6	379	199.3	142.9	824.1	193.7	329.3	199.7	171.8	163.2	157.2	117.9	146
Median:	262.1	107.25	99.3	56.45	119.35	51	51.15	57.25	45.15	44.05	50.1	44.55	38.25

Labor Day fires (2020) (OR and WA)





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Data for Labor Day Fires (OR and WA)

	Klamath Falls - Peterson School	Omak-Colville Tribe	Oakridge - (OAK)	Oakridge - (OAK)	TOPPENISH - WARD RD (YAKAMA TRIBE)	Vancouver-NE 84th Ave	Colville-E 1St	YAKIMA - 4TH AVE	SPOKANE - AUGUSTA AVE
Days above 35 (out of 18):	14	13	11	11	10	9	8	8	7
Consecutive days > 35:	10	13	10	10	10	8	8	7	7
Mean (above 35):	114.21	161.84	233.71	224.69	206.04	273.76	188.95	176.34	218.73
Consecutive days > 150:	3	4	8	8	5	7	4	3	4
Consecutive days > 55:	7	12	9	9	8	8	7	7	7
Maximum:	457.6	384.4	576.6	541.5	447.6	513.4	396.8	325.4	394.1
Median:	56.2	74.5	96.25	158.75	38.65	36	30.7	114.15	17.7

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2018 Summer Fires

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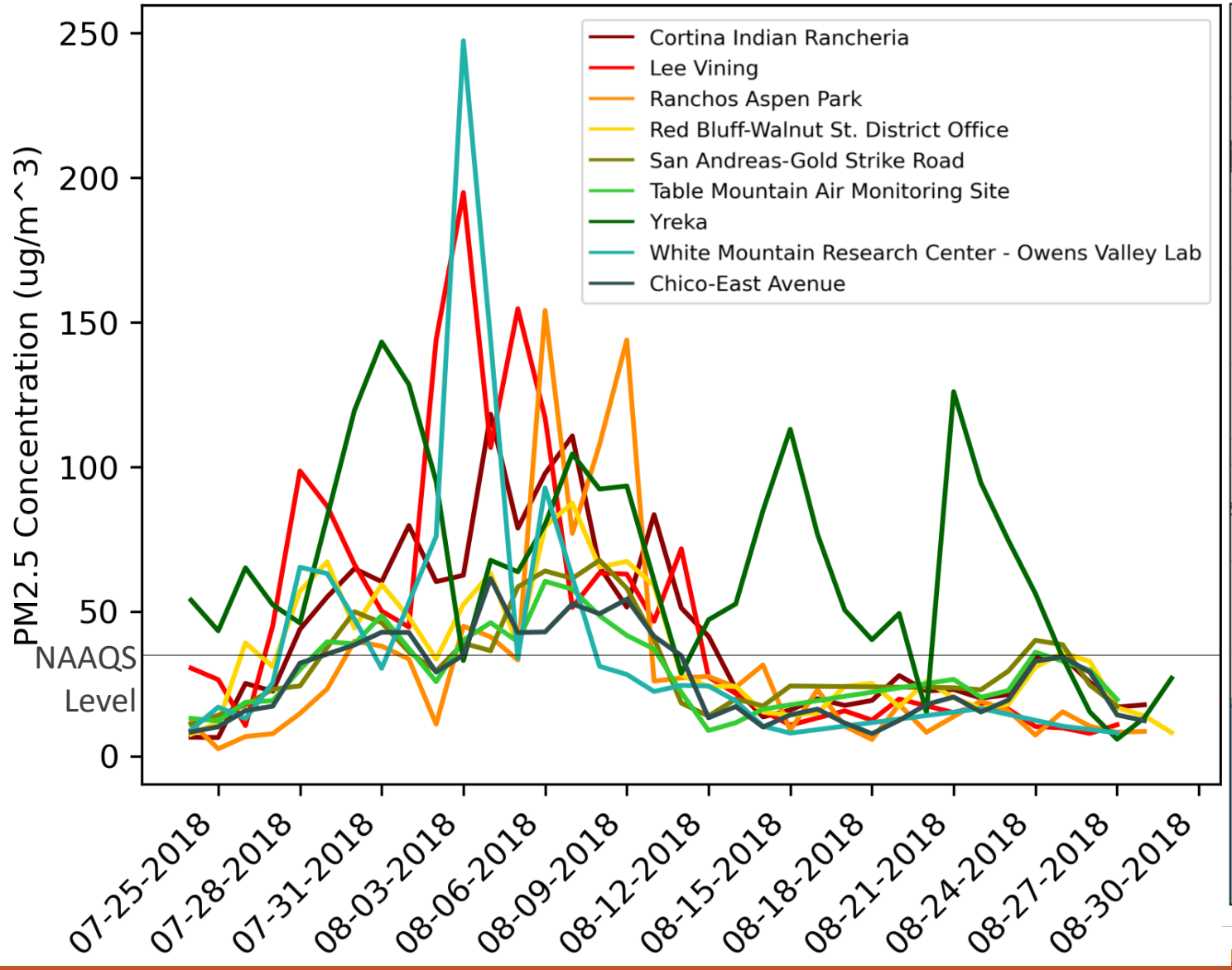
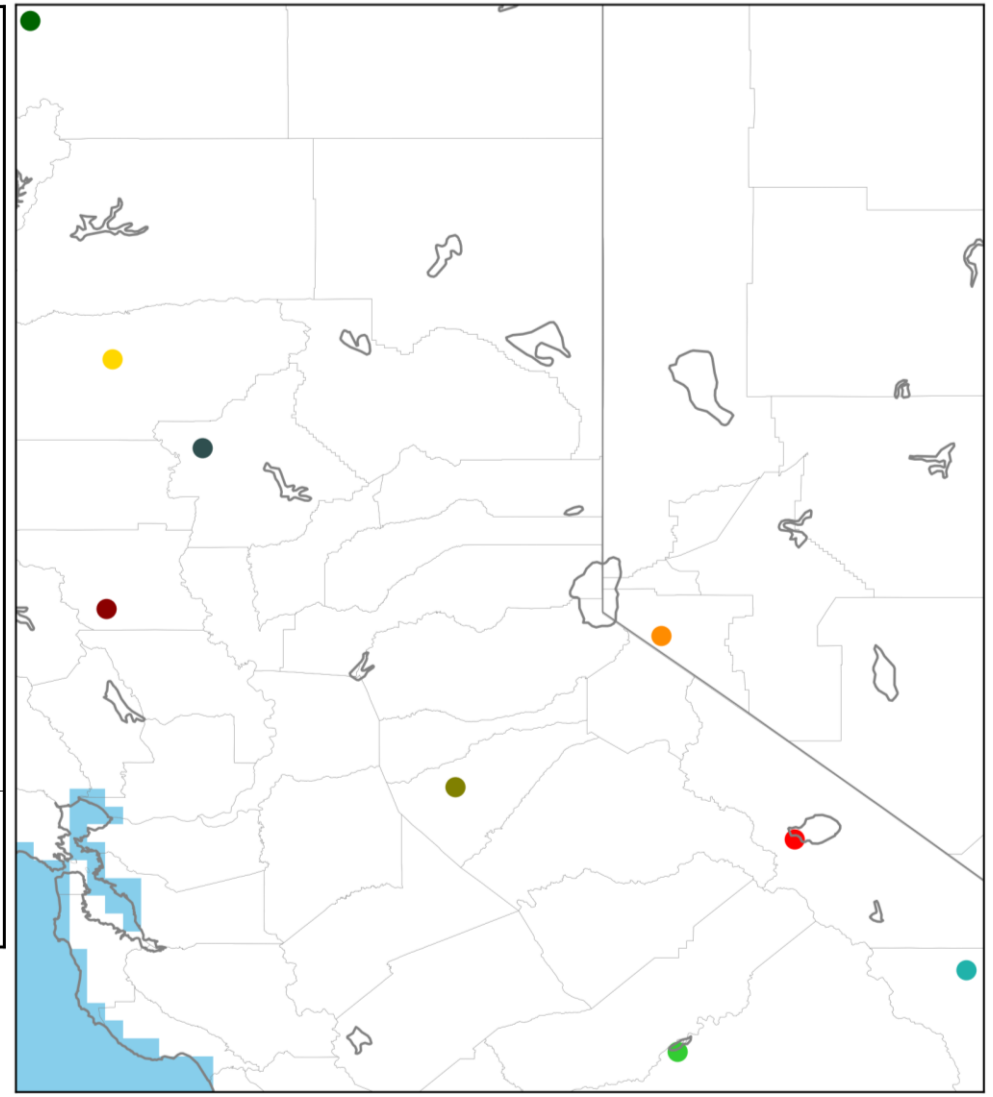
Summer Fires (2018) (CA and NV)





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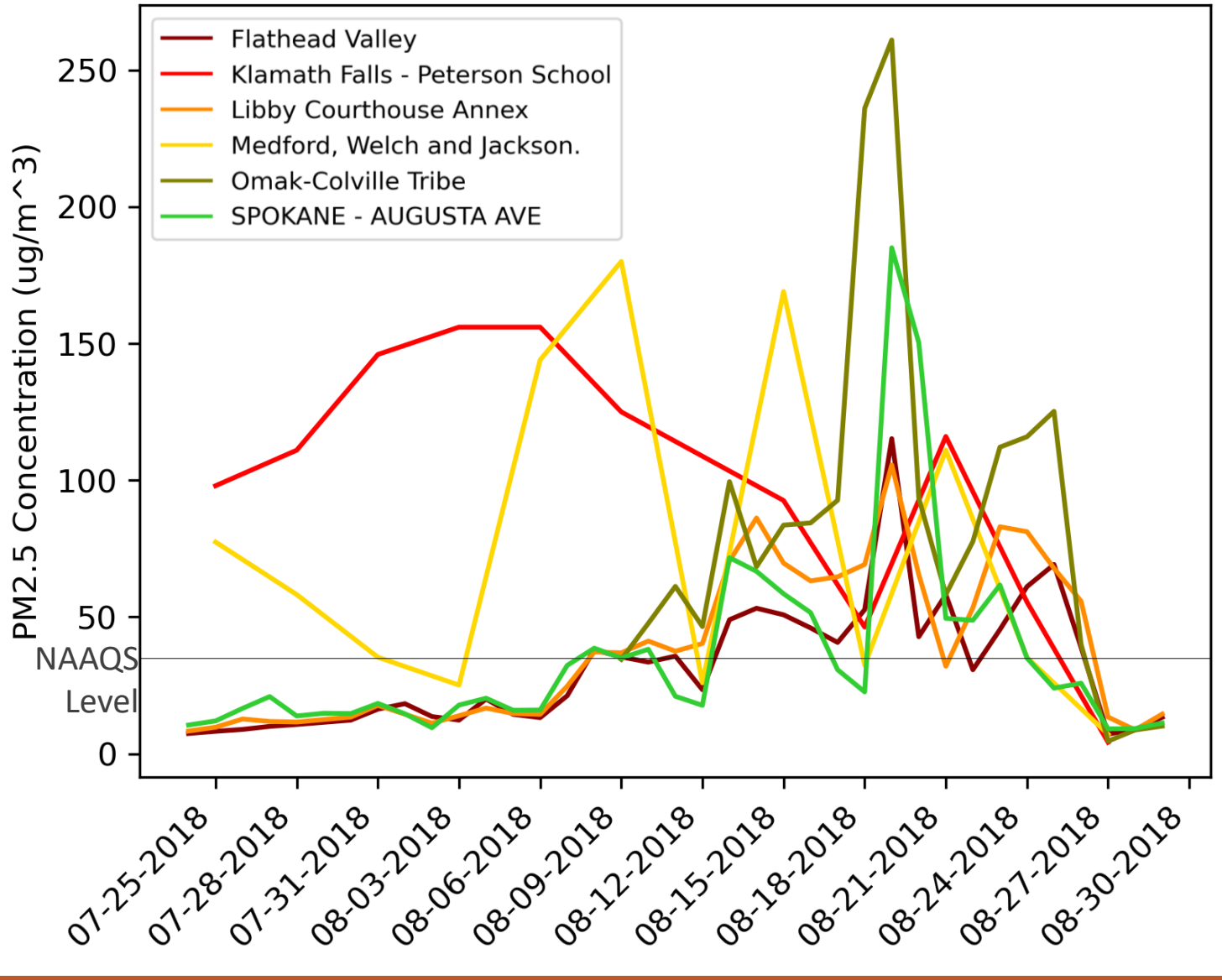
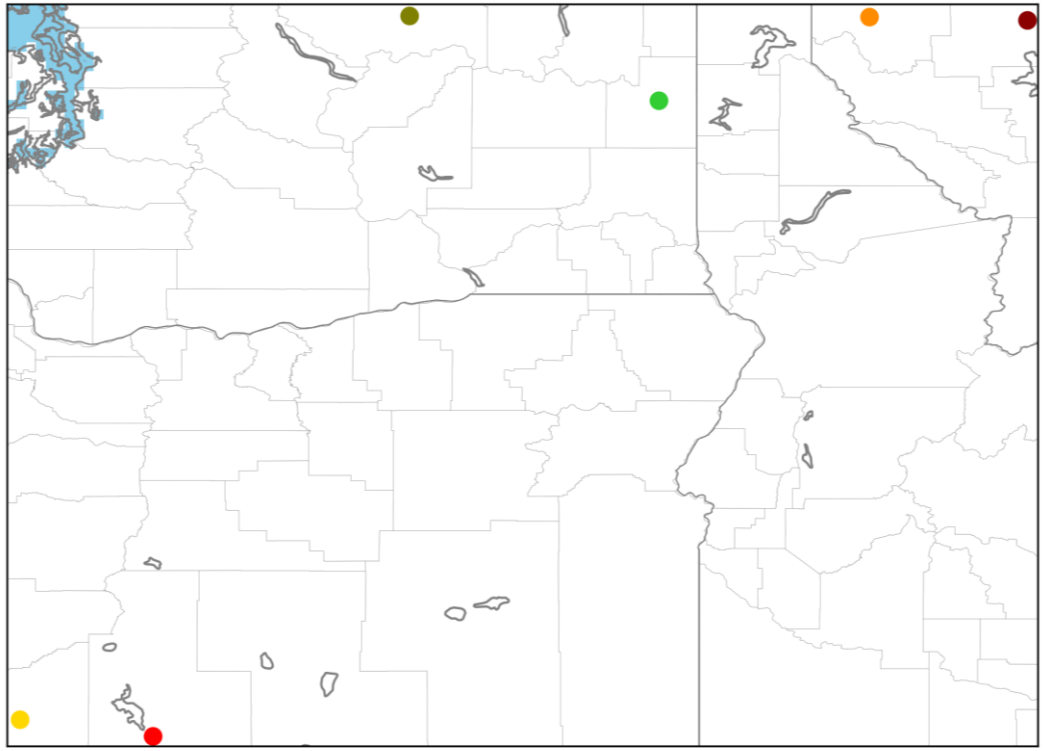
Data for Summer Fires (2018) (CA and NV)

	Yreka	Lee Vining	Cortina Indian Rancheria	Red Bluff-Walnut St. District Office	San Andreas-Gold Strike Road	Table Mountain Air Monitoring Site	Chico-East Avenue	White Mountain Research Center - Owens Valley Lab	Ranchos Aspen Park
Days above 35 (out of 37):	28	16	16	15	14	12	10	8	8
Consecutive days > 35:	8	16	16	8	8	8	7	3	4
Mean (above 35):	77.68	87.76	70.30	57.51	48.11	44.48	46.83	96.96	80.83
Consecutive days > 150:	0	1	0	0	0	0	0	1	1
Consecutive days > 55:	7	5	11	5	5	2	1	3	4
Maximum:	143.2	194.9	118.2	87.5	67.7	60.4	61.4	247.4	154.1
Median:	58.45	26.4	27.8	30.7	24.5	22.6	19.85	19	17.8

Summer Fires (2018) (OR, MT, and WA)





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Data for Summer Fires (2018) (OR, MT, and WA)

	Libby Courthouse Annex	Omak-Colville Tribe	Flathead Valley	SPOKANE - AUGUSTA AVE	Klamath Falls - Peterson School	Medford, Welch and Jackson.
Days above 35 (out of 37):	18	17	16	13	10	8
Consecutive days > 35:	13	17	9	6	1	1
Mean (above 35):	62.72	100.21	52.02	74.60	110.24	101.26
Consecutive days > 150:	0	2	0	2	1	1
Consecutive days > 55:	8	13	2	3	1	1
Maximum:	105.6	261	115.2	185	156	180
Median:	32	77.6	23.4	21	111	46.75

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Camp Fire

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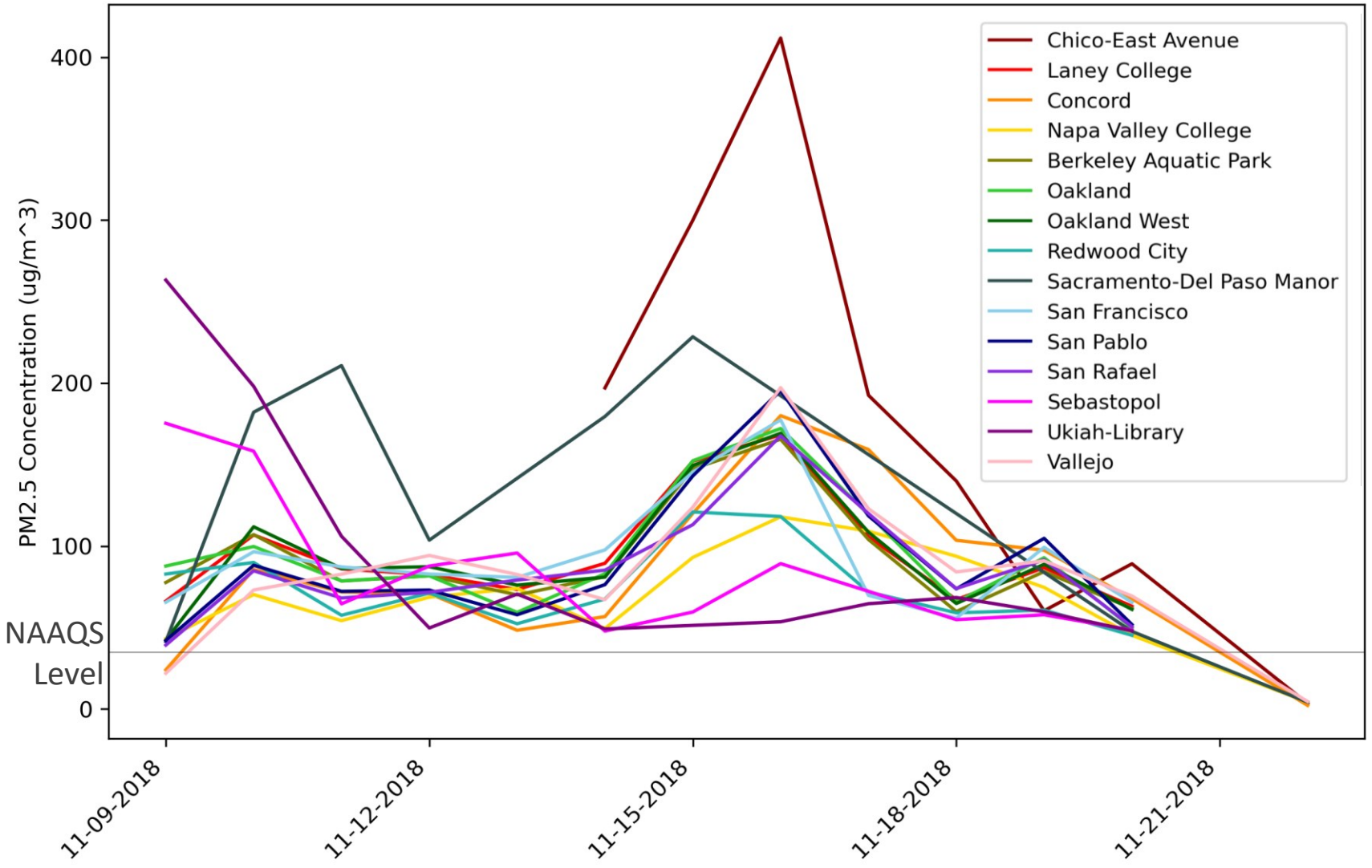
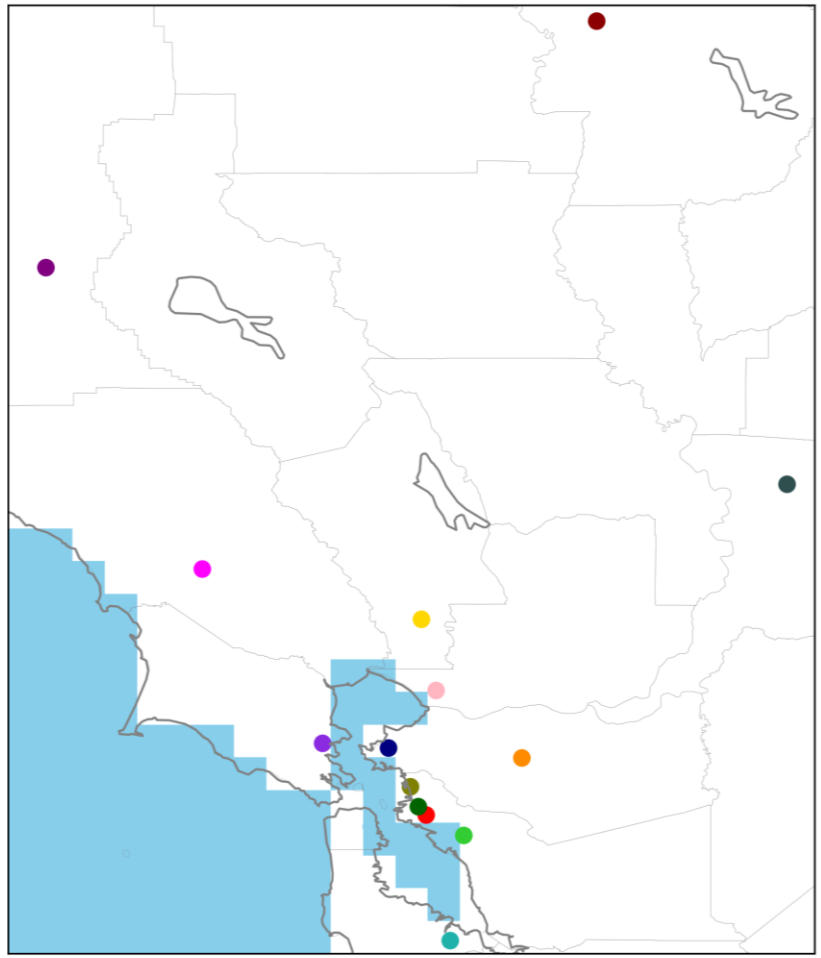
Camp Fire (2018)





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Data for Camp Fire (2018)

	Sebastopol	Ukiah-Library	Vallejo	Vallejo	San Pablo	San Francisco	Oakland	Oakland West	Laney College	San Rafael	Berkeley Aquatic Park	Redwood City	Napa Valley College	Concord	Chico-East Avenue	Sacramento-Del Paso Manor
Days above 35 (out of 13):	13	12	12	12	12	12	12	12	12	12	12	12	12	11	8	8
Consecutive days > 35:	13	12	12	12	12	12	12	12	12	12	12	12	12	11	8	7
Mean (above 35):	83.81	89.28	93.66	93.35	91.38	93.59	95.18	93.85	95.57	87.04	93.22	74.73	74.43	96.45	178.98	135.50
Consecutive days > 150:	2	2	1	1	1	1	2	1	2	1	1	0	0	2	4	2
Consecutive days > 55:	6	3	11	11	10	12	11	11	12	10	12	6	5	7	7	6
Maximum:	175.3	263.2	197.2	195.7	195.4	177.4	172.1	169.2	168.2	167.6	165.5	120.9	117.9	180	411.7	228.4
Median:	58.65	49.4	73	72.8	72.6	67.6	72.15	70.35	70.2	69.85	73.8	58.25	51.8	62.2	60.3	47.6

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Overview Conclusions

	Labor Day Fires (2020, 18 days)	Summer Fires (2018, 37 days)	Camp Fire (2018, 18 days)
1. How long did the smoke event last?			
Days above 35 ug/m^3 :	10-17 days (34 stations)	7-28 days (39 stations, 8 stations 2+ weeks)	10-13 days (31 stations)
Consecutive days > 35 ug/m^3:	10-15 days (18 stations)	7-17 days (10 stations)	10-13 days (28 stations)
2. During the smoke event, what was the average concentration?			
Mean > 35 ug/m^3:	150-315 ug/m^3 (12 stations, very unhealthy) 55-150 ug/m^3 (93 stations, unhealthy)	55-101 ug/m^3 (27 stations, unhealthy)	55-179 ug/m^3 (41 stations, unhealthy and very unhealthy)
3. How long were PM2.5 concentrations at unhealthy levels?			
Consecutive days > 55 ug/m^3 (unhealthy):	1-15 days (33 stations for one week or more)	1-13 days (4 stations for one week or more, 24 stations for 3 days or more)	1-12 days (20 stations for one week or more)
Consecutive days > 150 ug/m^3 (very unhealthy):	1-12 days (4 stations for one week or more)	1-2 days (7 stations)	1-4 days (9 stations > 1 day)
4. What was the peak concentration?			
Maximum:	824.1 ug/m^3 (36 stations > 250, hazardous)	261 ug/m^3 (7 stations > 150, very unhealthy)	411 ug/m^3 (28 stations > 150, very unhealthy, 2 stations > 250, hazardous)

Appendix

Data Source and Analysis

For this analysis, I used Python (version 3.8) to explore the EPA Air Quality System (AQS) 24-hour PM2.5 data for three fire events. I subset the data to six states: California, Oregon, Washington, Nevada, Montana, and Idaho. I included both 24-hour average FEM and 24-hour FRM measurements. For the three events, I cut down the data by date as follows:

- 9/7/2020-9/24/2020 (Labor Day fires)
- 7/24/2018-8/29/2018 (Summer 2018 fires)
- 11/8/2018-11/25/2018 (Camp fire).
- For each fire, I analyzed data from all stations in the six states mentioned and developed graphs and statistics for each fire, and summarized the statistics in the final table.

Link to data source: https://aqs.epa.gov/aqsweb/airdata/download_files.html

Date of download: 5/18/2021 at 9:12PM (daily_88101_2018.csv) and 5/18/2021 at 8:57PM (daily_88101_2020.csv)