



CMAQ Evaluation and Feedback – An Arizona Perspective

Summer Season

Jonny W. Malloy
Meteorologist

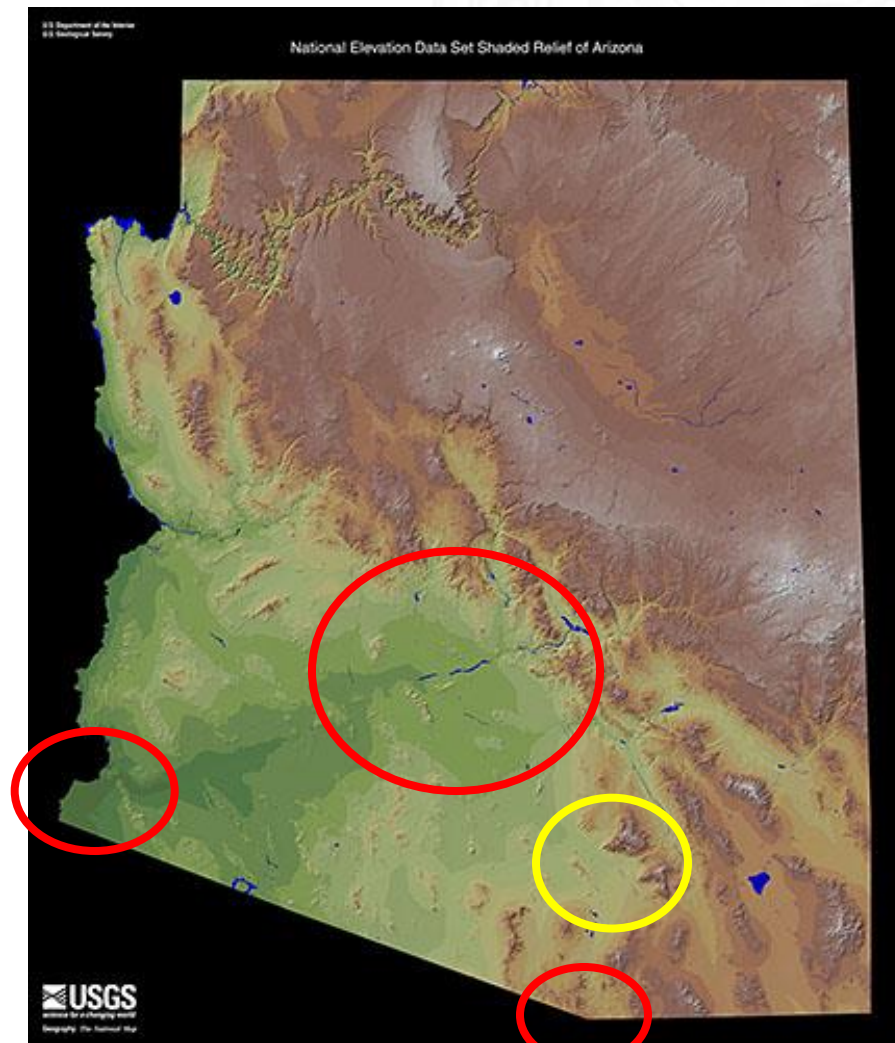
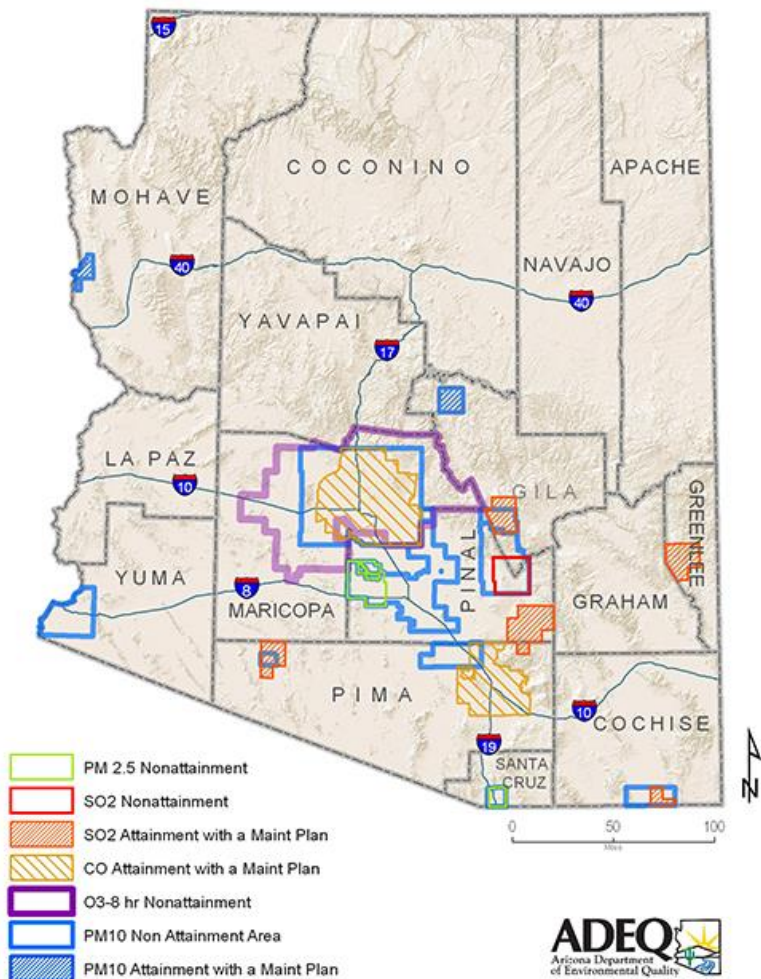
Arizona Department of Environmental Quality
September, 2017



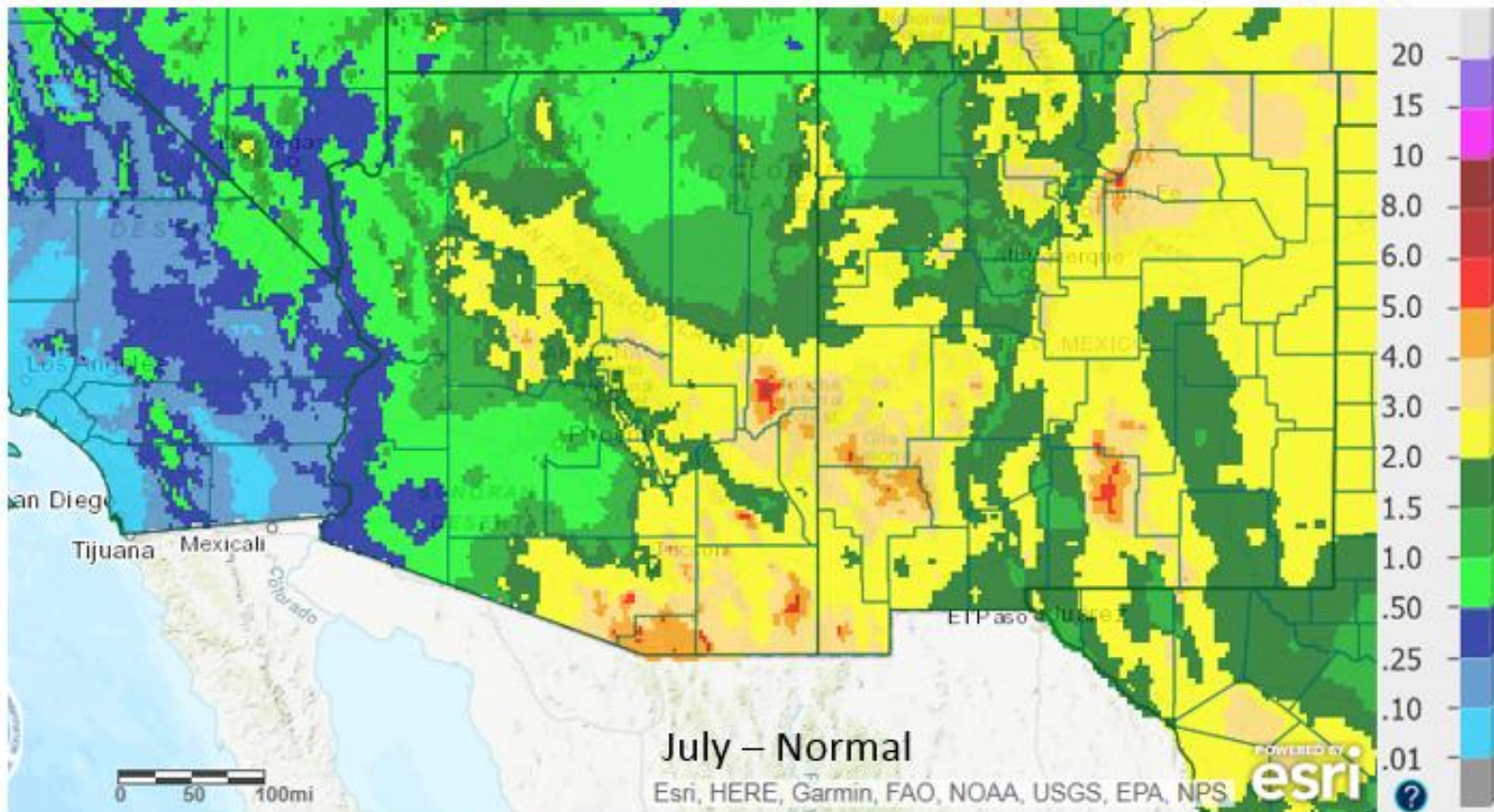
- Provide brief background to ADEQ air quality forecast program.
- Show air quality climatology of current ADEQ forecast zones.
- Summarize types of summer air quality events affecting Arizona.
- How did CMAQ perform?
- Considerations for using CMAQ in Arizona.
- Briefly highlight a new way to view CMAQ data operationally.

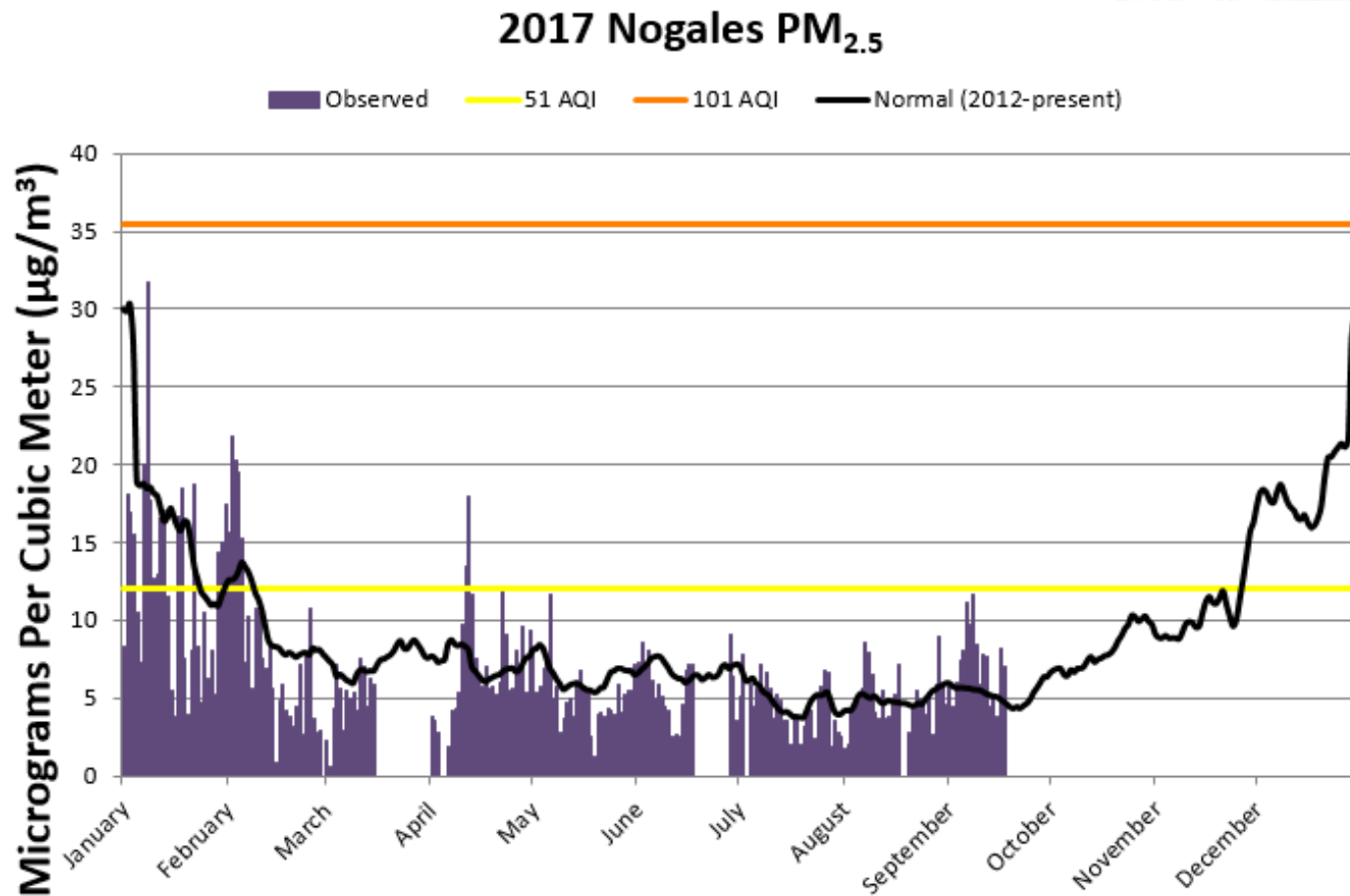
Air Quality Forecast Zones

Nonattainment and Attainment Areas



Arizona Climatology – Monsoon Setup





06/15/2017 Yuma Morning Observations

15 Jun 11:57 pm	86	33	15	SW	3	10.00	CLR	29.55	1007.6	29.77	109	73
15 Jun 10:57 pm	87	33	15	SE	3	10.00	CLR	29.75	1007.6	29.97	108	87
15 Jun 9:57 pm	87	34	15	SSE	5	10.00	CLR	29.54	1007.4	29.76		
15 Jun 8:57 pm	95	31	10	SSW	7	10.00	CLR	29.52	1006.8	29.74		
15 Jun 7:57 pm	98	38	13	SSW	10	10.00	CLR	29.51	1006.3	29.73		
15 Jun 6:57 pm	105	29	7	W	7	10.00	CLR	29.50	1006.0	29.72		
15 Jun 5:57 pm	107	26	6		3	7.00	CLR	29.49	1005.8	29.71		
15 Jun 4:57 pm	107	22	5	NW	3	7.00	CLR	29.51	1006.2	29.73	109	98
15 Jun 3:57 pm	108	23	5	N	5	7.00	CLR	29.53	1006.9	29.75		
15 Jun 2:57 pm	106	30	7	W	7	7.00	CLR	29.55	1007.5	29.77		
15 Jun 1:57 pm	106	26	6		3	7.00	Smoke, DustFEW020	29.56	1008.1	29.78		
15 Jun 12:57 pm	104	31	8	WNW	5	7.00	Smoke, DustFEW020	29.58	1008.7	29.80		
15 Jun 11:57 am	100	34	10		5	7.00	Smoke, DustFEW020	29.59	1009.2	29.81		
15 Jun 10:57 am	98	36	11	W	7	7.00	Smoke FEW020	29.60	1009.5	29.82	98	73
15 Jun 9:57 am	93	38	15	SSW	7	7.00	Smoke, DustFEW030	29.61	1009.5	29.83		
15 Jun 8:57 am	89	40	18		5	7.00	CLR	29.61	1009.5	29.83		
15 Jun 7:57 am	84	33	16	N	CALM	7.00	CLR	29.59	1009.1	29.81		
15 Jun 6:57 am	80	32	17	NNE	3	7.00	CLR	29.57	1008.5	29.79		
15 Jun 5:57 am	74	34	23	N	CALM							
15 Jun 4:57 am	74	40	29	N	CALM						88	74
15 Jun 3:57 am	76	39	26	N	CALM	10.00	CLR	29.53	1007.0	29.75		
15 Jun 2:57 am	78	38	24	SE	5	10.00	CLR	29.53	1007.0	29.75		
15 Jun 1:57 am	79	37	22	N	CALM	10.00	CLR	29.54	1007.3	29.76		
15 Jun 12:57 am	82	34	18	N	CALM	10.00	CLR	29.54	1007.4	29.76		

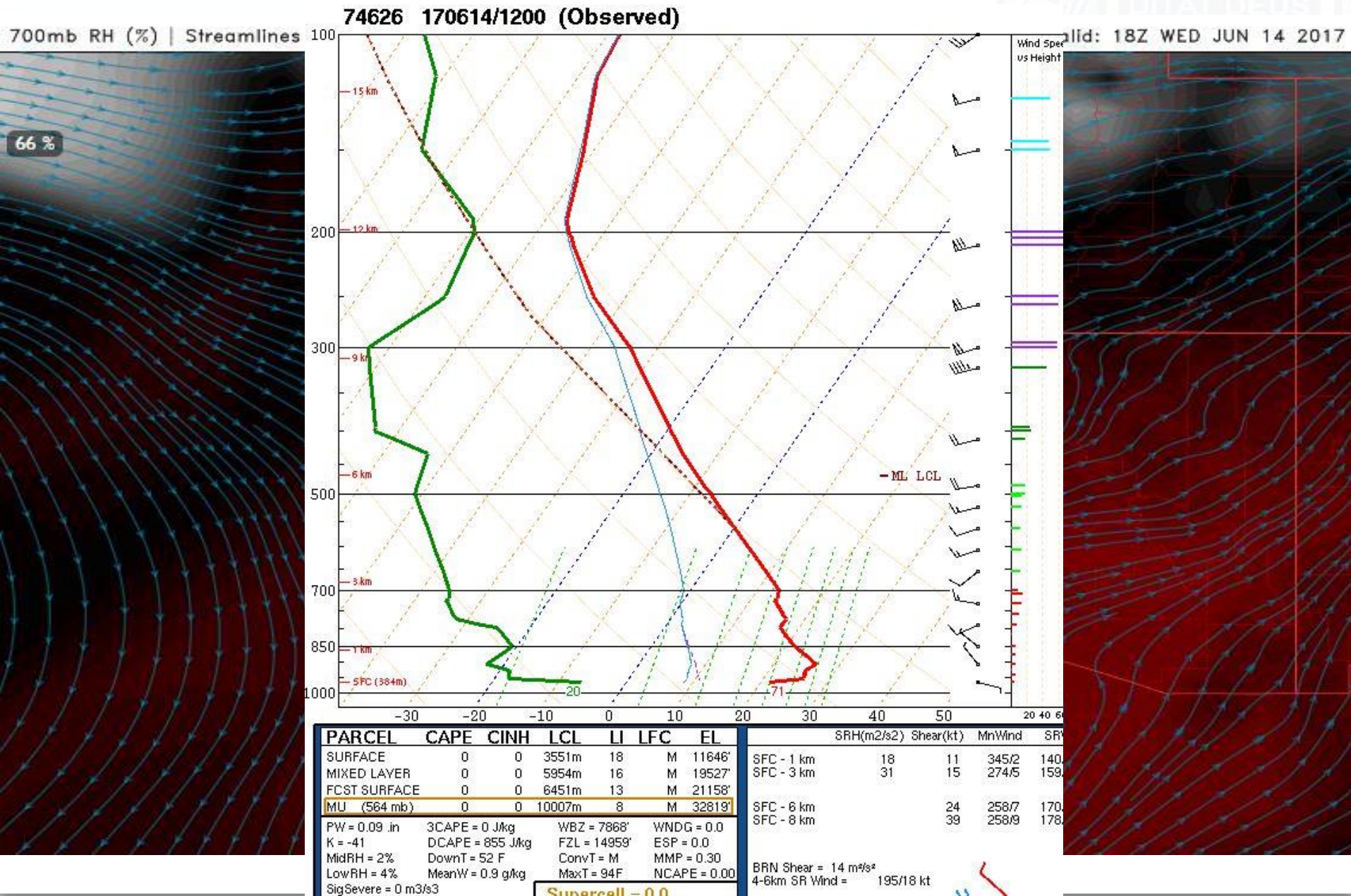
Wind shift indicating inversion breaking?

Time Control (hours)

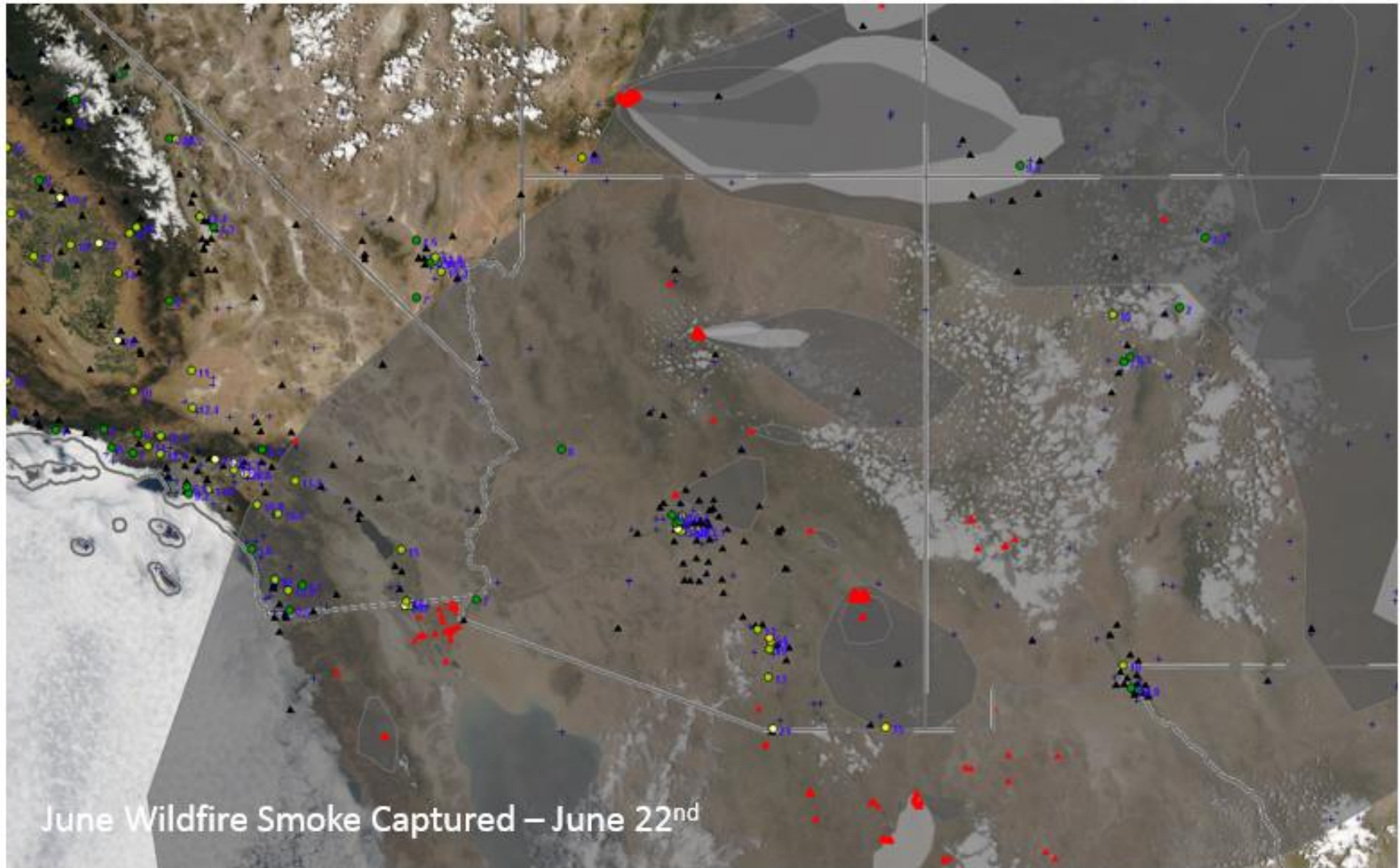
-24 -8 -1 +1 +8 +24



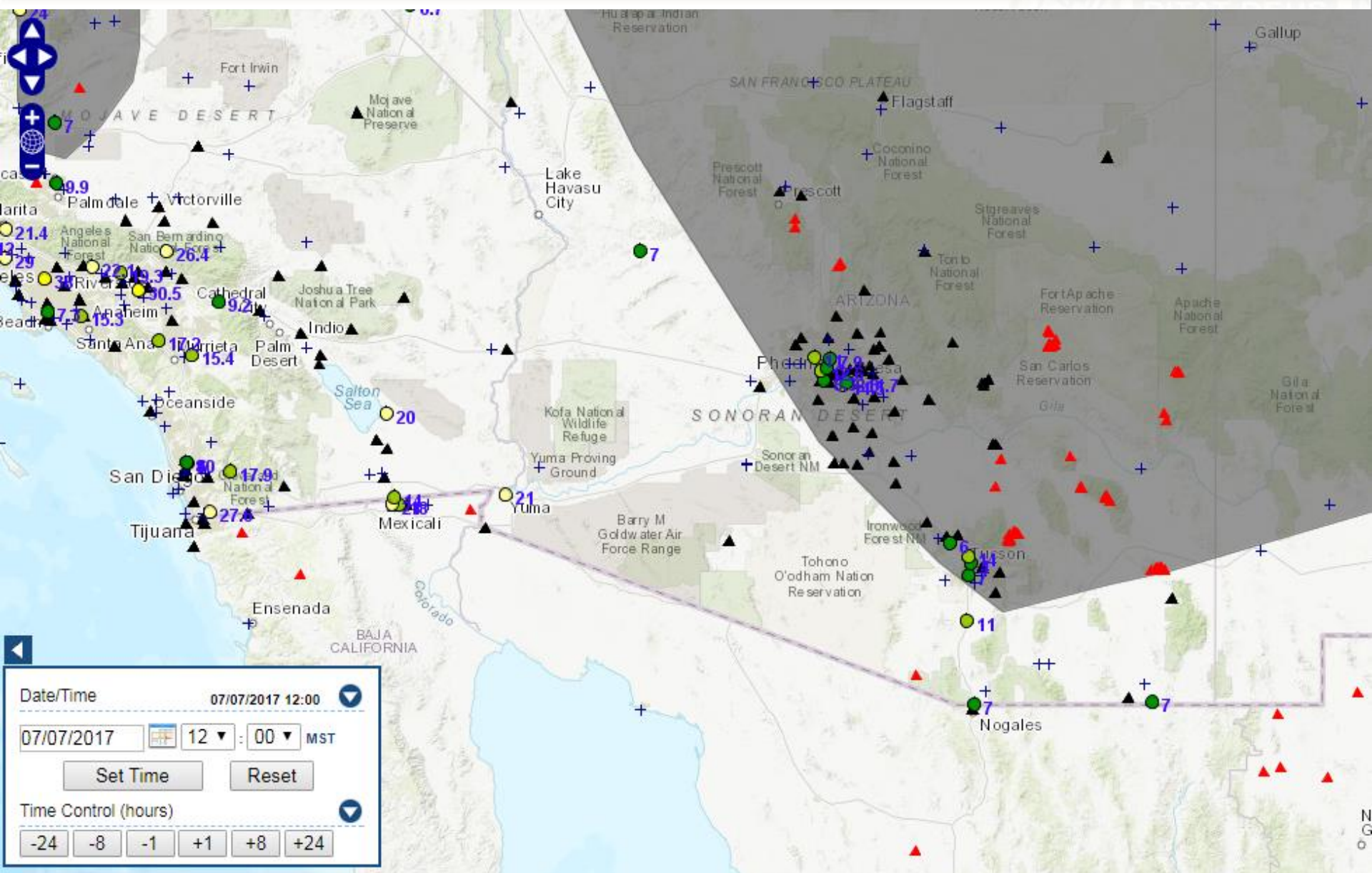
Long-range Transport and Ozone Mixing – June



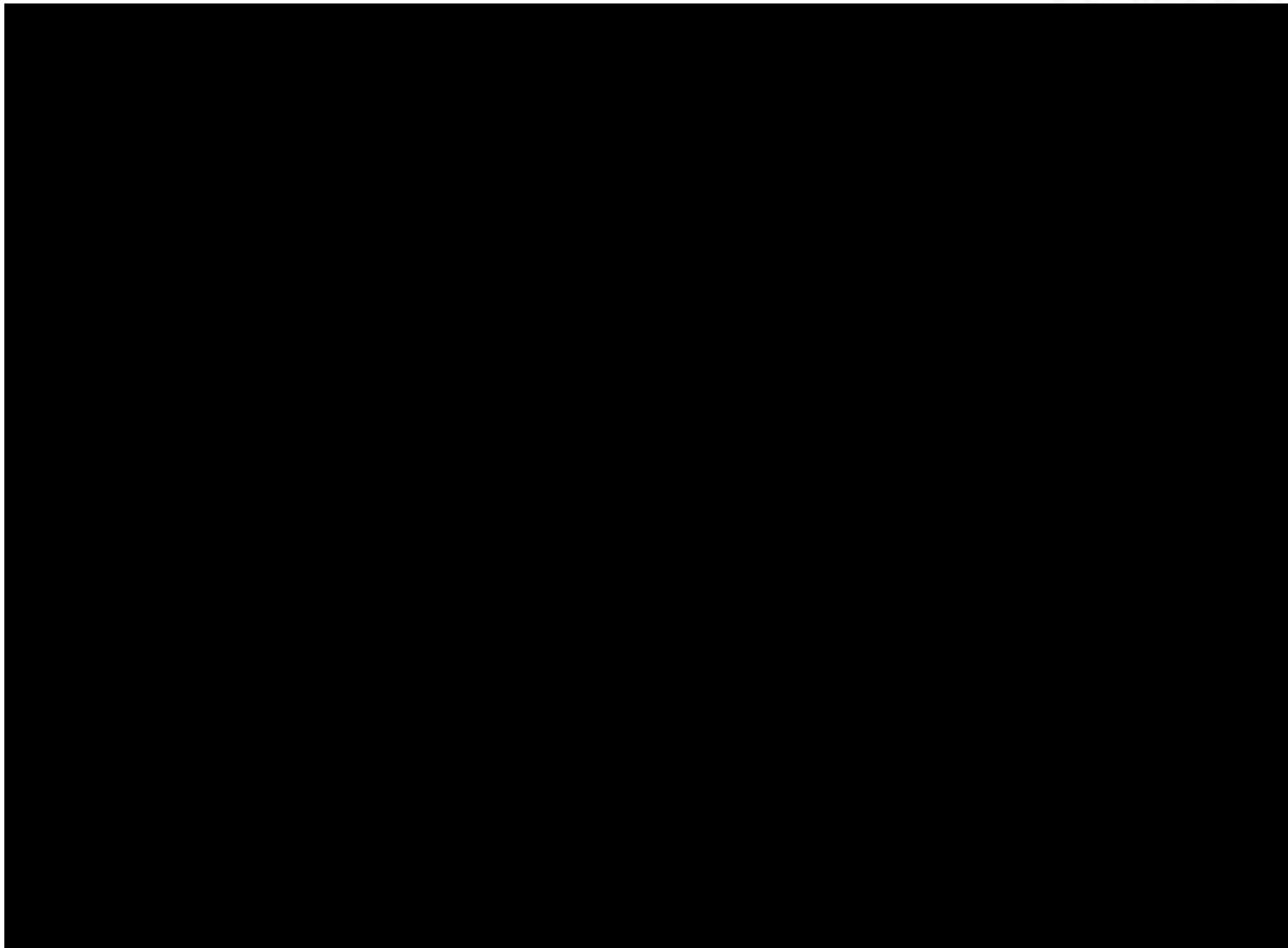
Regional Smoke (late June) – PM-2.5



Wildfire Smoke (Early July) – PM-2.5 and Ozone



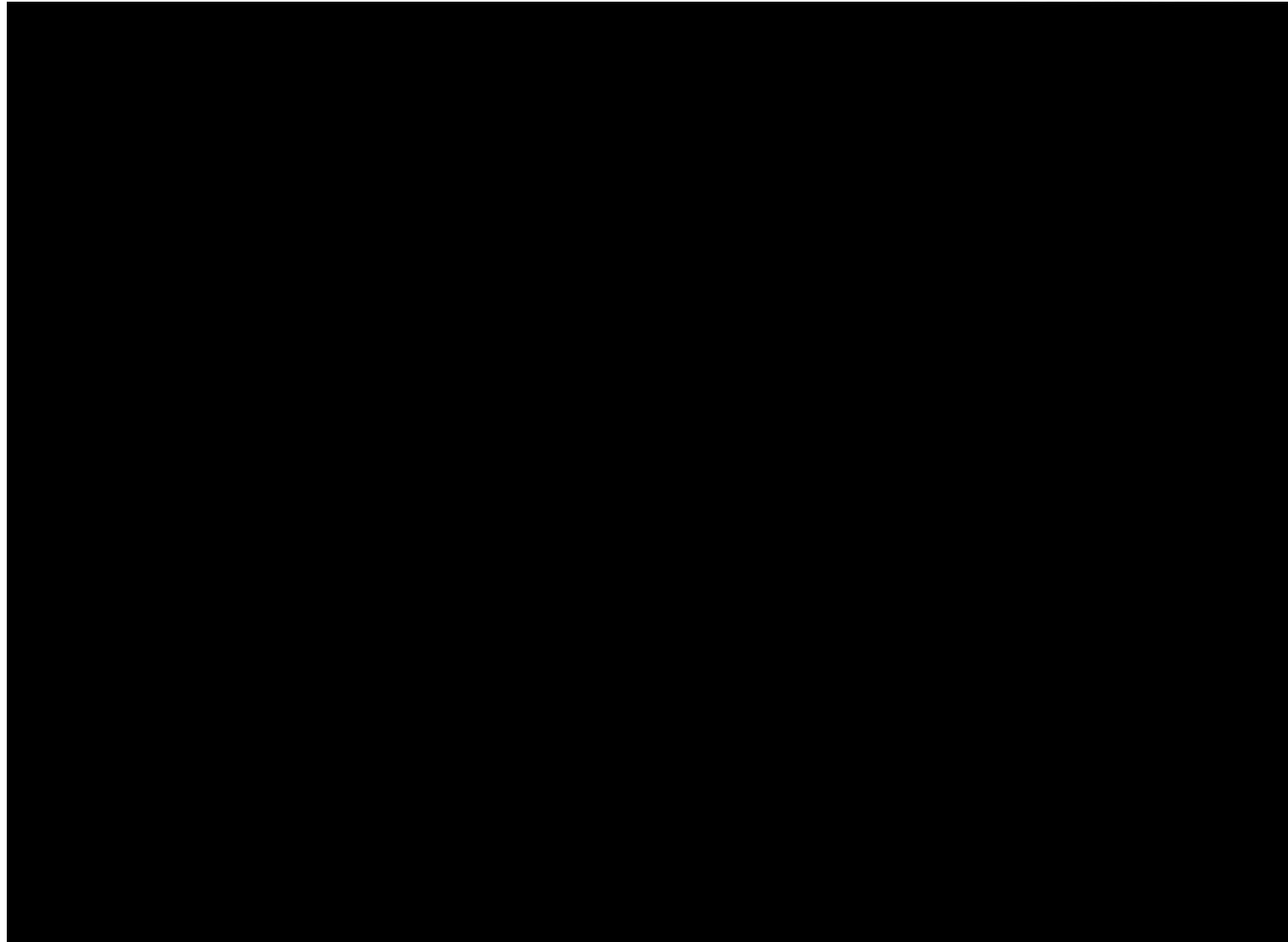
Thunderstorm Outflows vs. Ozone – Too Late - July 6th Ozone Exceedance



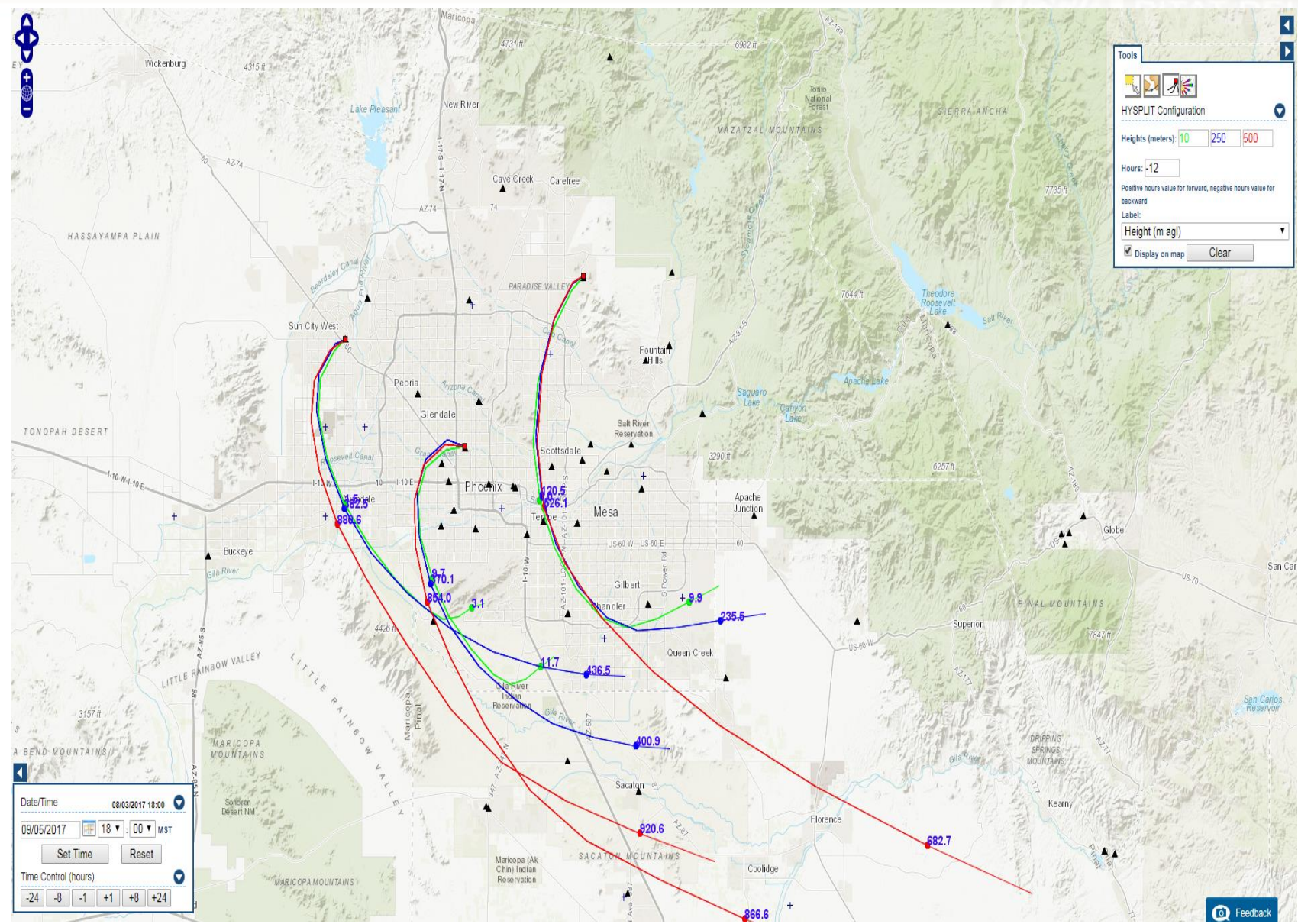
Severe Thunderstorms and Ozone Exceedance – August 3rd

Site/Site AQS/Param/POC	Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Avg	Max
AJ Maintenance /040213001/O3/1	08/03/17	24	17	13	13	14	9	7	13	34	38	45	49	52	52	53	52	51	49	48	37	43	34	37	30	33.92	53
Blue Point Sher/040139702/O3/1	08/03/17	23	22	19	16	20	14	14	19	30	42	44	47	55	57	58	54	52	48	55	47	43	39	29	20	36.13	58
Cave Creek/040134008/O3/1	08/03/17	30	33	34	31	23	21	23	39	38	42	46	51	54	58	58	3	0	0	0	0	0	0	0	169	46.88	169
Central Phoenix/040133002/O3/1	08/03/17	30	35	32	28	23	14	15	23	29	35	47	60	71	72	73	65	61	60	48	45	36	33	30	28	41.38	73
Dysart/040134010/O3/1	08/03/17	33	28	27	31	28	19	21	25	46	44	54	64	69	72	68	63	50	57	57	55	46	45	46	43	45.43	72
Falcon Field Po/040131010/O3/1	08/03/17	39	35	33	34	29	26	17	26	73	43	53	61	61	63	64	64	58	58	54	51	50	43	37	36	45	64
Fountain Hills/040139704/O3/1	08/03/17	33	32	29	23	25	26	20	23	33	39	43	44	49	55	59	56	51	43	53	48	42	40	36	27	38.71	59
Glendale Commun/040132001/O3/1	08/03/17	27	27	19	15	14	14	13	13	19	28	41	53	63	76	79	78	59	57	54	44	45	43	37	29	39.46	79
Humbolt Mountai/040139508/O3/1	08/03/17	48	49	49	48	48	49	49	47	42	40	42	46	50	53	52	53	50	51	56	56	55	57	55	59	50.17	59
Mesa - Brooks R/040131003/O3/1	08/03/17	38	36	34	32	24	23	23	27	39	47	58	64	69	69	71	72	71	63	56	52	43	44	36	40	47.13	72
North Phoenix/040131004/O3/1	08/03/17	43	45	40	36	31	25	26	65	72	41	52	62	76	90	96	95	72	65	58	59	51	46	46	45	54.55	96
Phoenix JLG Sup/040139997/O3/1	08/03/17	34	31	29	29	27	15	11	26	35	41	45	60	78	86	88	78	67	64	56	56	49	38	39		47.04	88
Pinnacle Peak C/040132005/O3/1	08/03/17	37	29	29	29	32	32	24	35	77	44	47	54	58	61	58	60	56	57	58	54	45	46	42	40	44.65	61
Rio Verde Sheri/040139706/O3/1	08/03/17	24	27	21	18	17	13	10	12	20	31	36	34	39	43	44	41	41	36	43	40	35	33	26	23	29.46	44
South Phoenix/040134003/O3/1	08/03/17	32	32	31	22	13	3	13	33	36	46	58	64	65	63	60	58	54	57	52	49	42	41	38	39	42.09	65
South Scottsdal/040133003/O3/1	08/03/17	31	30	30	28	23	18	13	20	34	42	51	58	66	66	67	69	64	54	47	40	33	30	25	26	40.21	69
Tempe/040134005/O3/1	08/03/17	33	28	27	23	21	17	16	19	28	40	50	57	59	57	57	62	61	50	46	31	26	29	20	20	36.54	62
West Chandler F/040134004/O3/1	08/03/17	37	34	27	23	19	17	17	27	35	42	52	61	64	66	63	58	60	56	54	46	43	37	33	35	41.92	66
West Phoenix/040130019/O3/1	08/03/17	30	27	31	24	12	10	18	28	36	41	48	64	84	80	78	65	62	66	57	55	42	45	37	34	44.75	84

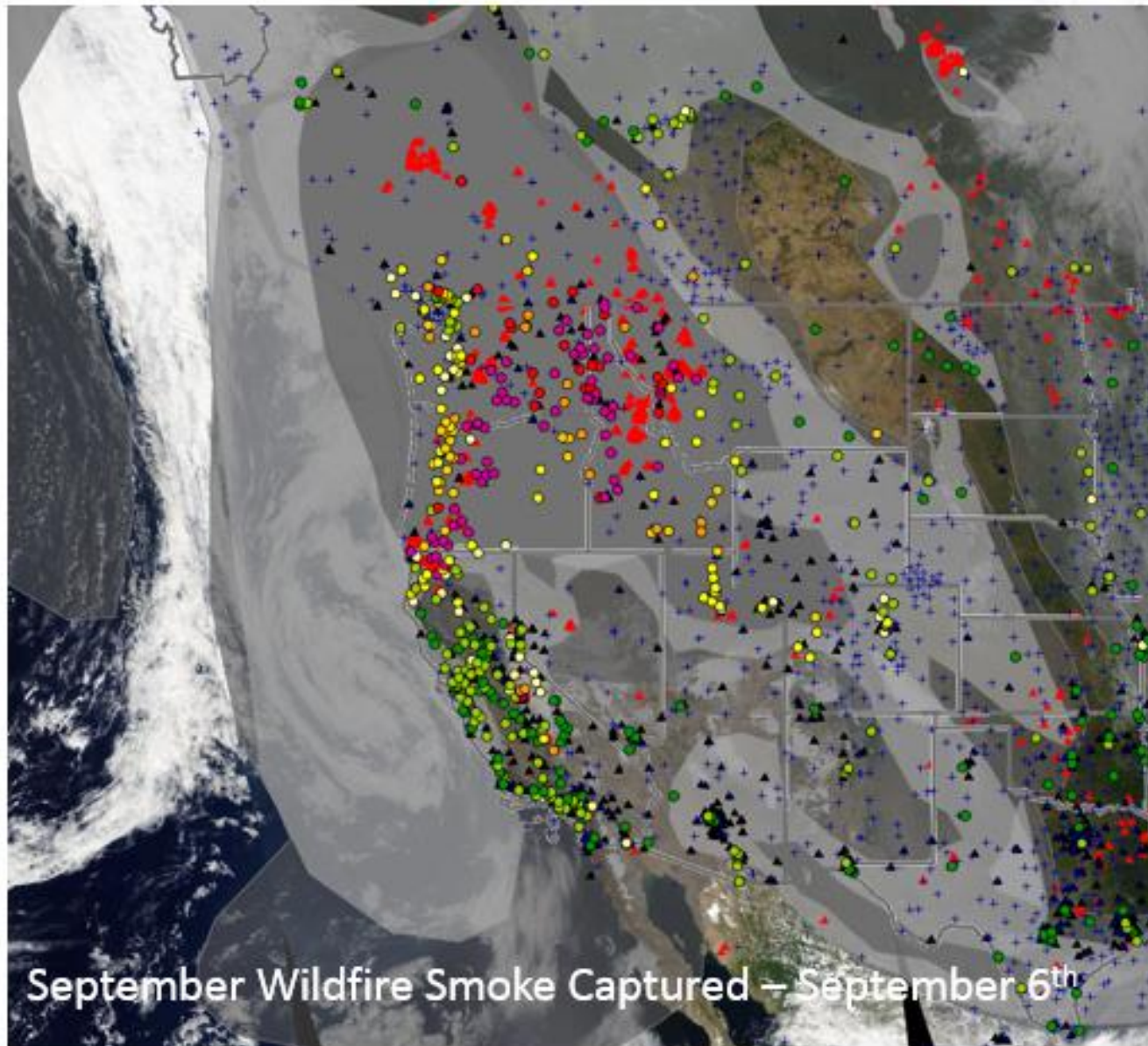
Convective Blowups Curb Ozone (GOES-16) – August 10th



Monsoon Break (late August and early September) – Ozone

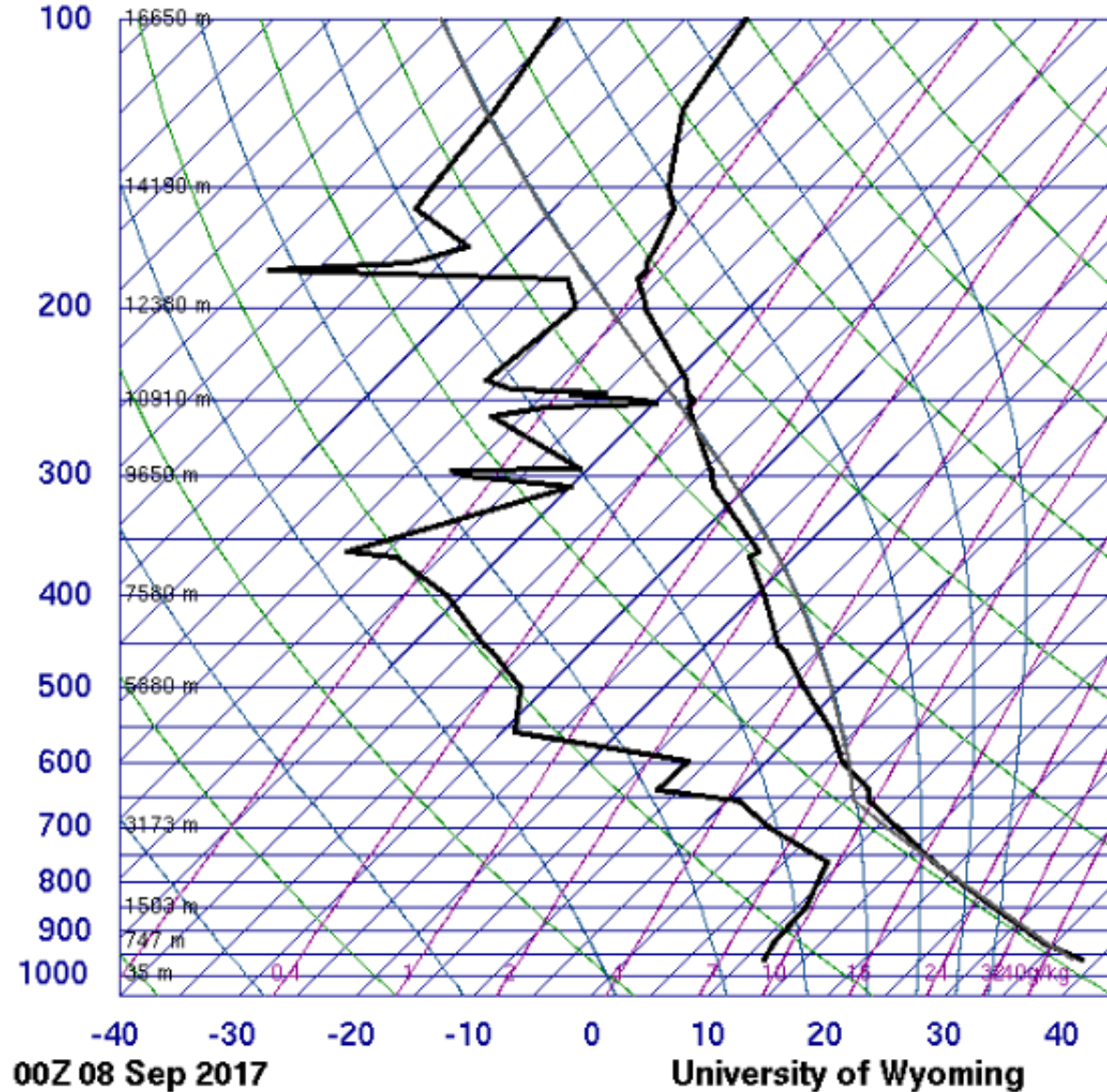


Wildfire Smoke and Stagnation – Ozone and PM-2.5



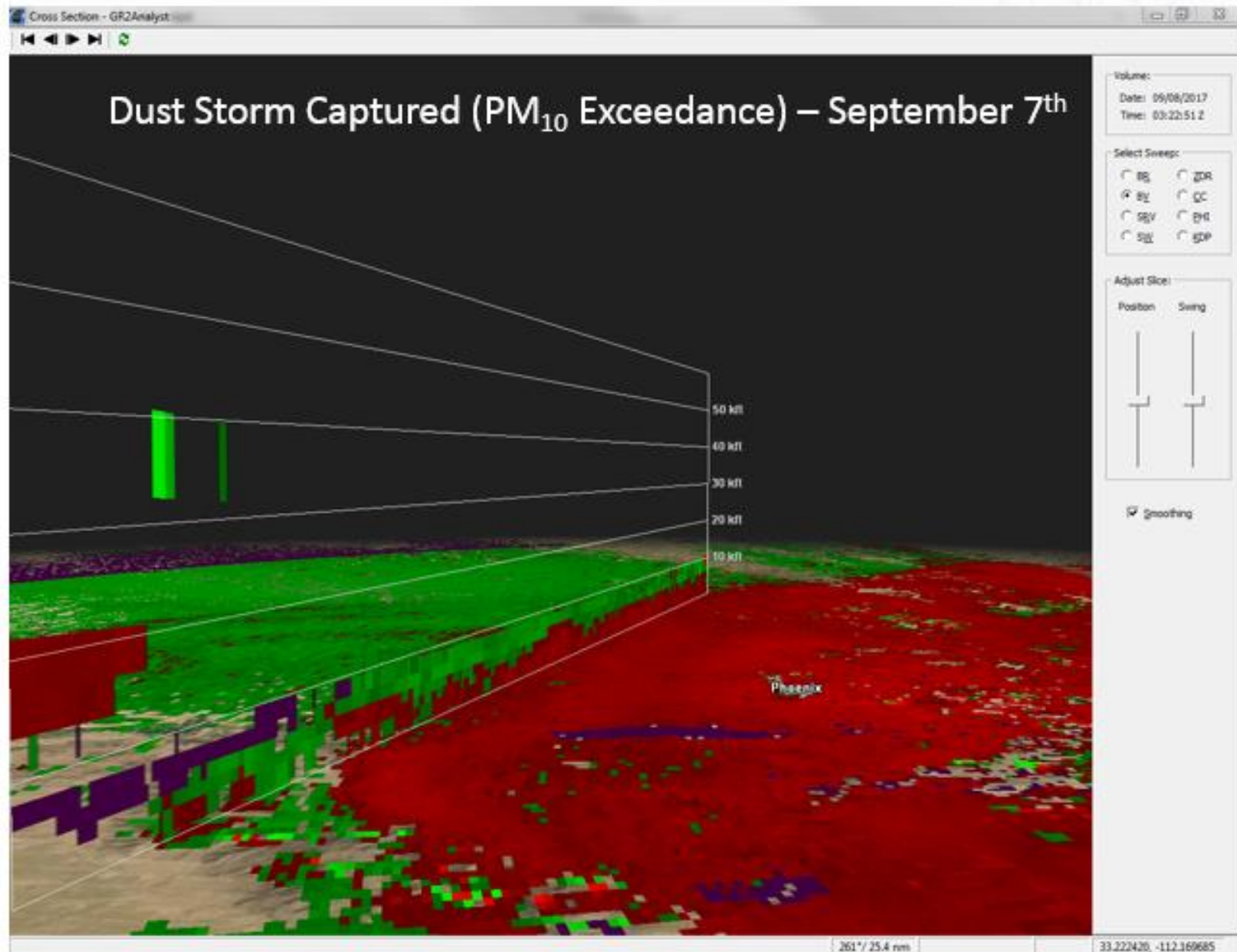
September 7th – “Perfect Storm”

74626 Wfo Phoenix



SLAT 33.45
SLON -111.95
SELV 384.0
SHOW -3.03
LIFT -2.37
LFTV -3.10
SWET 246.6
KINX 34.70
CTOT 18.90
VTOT 34.90
TOTL 53.80
CAPE 444.6
CAPV 550.6
CINS -48.9
CINV -15.6
EQLV 267.1
EQTV 266.0
LFCT 611.3
LFCV 633.3
BRCH 93.29
BRCV 115.5
LCLT 279.1
LCLP 659.0
MLTH 314.4
MLMR 9.00
THCK 5845.
PWAT 29.29

September 7th – “Perfect Storm”



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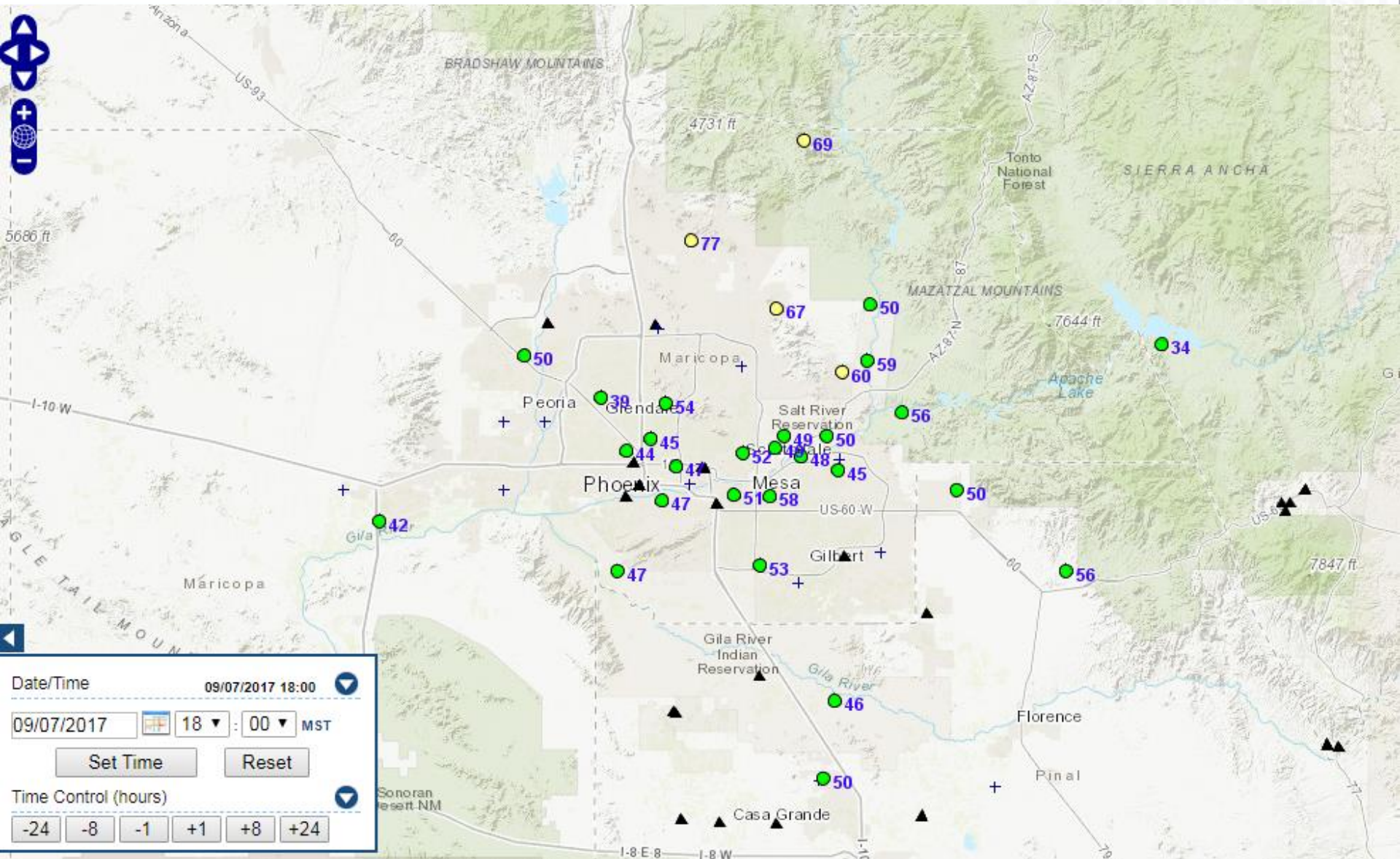
U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Current Location: Elev: 1107 ft. Lat: 33.4277° N Lon: -112.0038° W
Station: PHOENIX AIRPORT, AZ US 23183

Local Climatological Data Hourly Observations September 2017 Generated on 09/26/2017

National Centers for Environmental Information
151 Patton Avenue
Asheville, North Carolina 28801

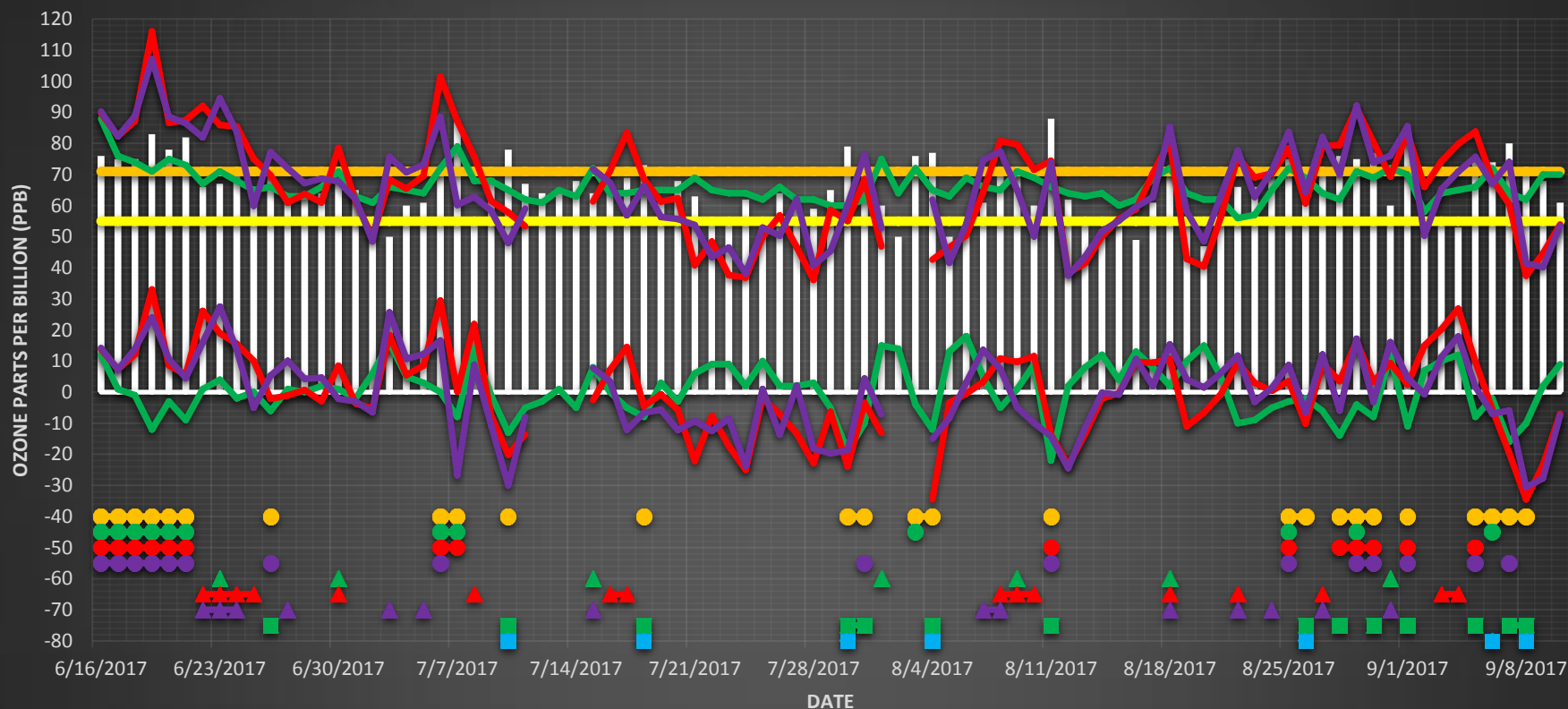
Date	Time (LST)	Station Type	Sky Conditions	Visi- bility	Weather Type (see documentation)	Dry Bulb Temp		Wet Bulb Temp		Dew Point Temp		Rel Hum %	Wind Speed (MPH)	Wind Dir (Deg)	Wind Gusts (MPH)	Station Press (inHg)	Press. Tend	Net 3-Hr Change (inHg)	Sea Level Press. (inHg)	Report Type	Precip Total (in)	Alti-meter Setting (inHg)
					AU AW MW	(F)	(C)	(F)	(C)	(F)	(C)											
1	2	3	4	5	6	(F)	(C)	(F)	(C)	(F)	(C)	13	14	15	16	17	18	19	20	21	22	23
07	0051	7	FEW:02 250	10.00		91	32.8	65	18.4	47	8.3	22	3	230		28.66			29.76	FM-15	0.00	29.83
07	0151	4		10.00		90	32.2			50	10.0	25	5	080					29.75	FM-15		29.82
07	0251	7	FEW:02 250	10.00		90	32.2	66	19.0	50	10.0	25	8	090		28.66			29.76	FM-15	0.00	29.83
07	0351	7	FEW:02 250	10.00		88	31.1	66	18.8	51	10.6	28	7	070		28.66			29.77	FM-15	0.00	29.84
07	0451	4		10.00		87	30.6			56	13.3	35	8	090					29.78	FM-15		29.84
07	0500	4		9.94		87	30.6	68	19.9	56	13.3	35	8	090		28.67	1	-0.02	29.78	FM-12		
07	0551	4		10.00		86	30.0			58	14.4	39	8	080					29.79	FM-15		29.86
07	0651	7	FEW:02 60 FEW:02 120 SCT:04 250	10.00		85	29.4	69	20.7	60	15.6	43	8	110		28.70			29.82	FM-15	0.00	29.88
07	0751	7	FEW:02 120 FEW:02 250	10.00		87	30.6	72	22.0	63	17.2	45	9	110		28.72	1	-0.05	29.83	FM-15	0.00	29.90
07	0851	7	FEW:02 120 FEW:02 250	10.00		88	31.1	72	22.4	64	17.8	45	6	120		28.73			29.85	FM-15	0.00	29.91
07	0951	7	FEW:02 120 FEW:02 250	10.00		91	32.8	73	22.6	63	17.2	39	3	070		28.74			29.85	FM-15	0.00	29.92
07	1051	7	CLR:00	10.00		95	35.0	74	23.2	63	17.2	35	3	VRB		28.73	0	-0.01	29.85	FM-15	0.00	29.91
07	1100	4		9.94		95	35.0	74	23.2	63	17.2	35	3			28.74	9	0.01	29.85	FM-12		
07	1151	7	CLR:00	10.00		96	35.6	74	23.4	63	17.2	34	6	330		28.71			29.82	FM-15	0.00	29.89
07	1251	7	CLR:00	10.00		99	37.2	74	23.5	62	16.7	30	3	VRB		28.69			29.79	FM-15	0.00	29.86
07	1351	7	FEW:02 85	10.00		101	38.3	75	24.1	62	16.7	28	6	160		28.66	8	+0.08	29.76	FM-15	0.00	29.83
07	1451	7	FEW:02 85 SCT:04 100 SCT:04 250	10.00		103	39.4	75	23.8	60	15.6	24	5	300		28.61			29.72	FM-15	0.00	29.78
07	1551	7	FEW:02 85 SCT:04 100 SCT:04 250	10.00		102	38.9	74	23.1	58	14.4	23	3	VRB		28.58			29.68	FM-15	0.00	29.75
07	1651	7	FEW:02 85 SCT:04 100 SCT:04 200	10.00		102	38.9	72	22.4	55	12.8	21	7	270		28.56	6	+0.09	29.66	FM-15	0.00	29.73
07	1700	4		9.94		102	38.9	72	22.4	55	12.8	21	7	270		28.56	6	+0.09	29.66	FM-12		
07	1751	7	FEW:02 85 SCT:04 100 SCT:04 200	10.00		99	37.2	73	22.7	59	15.0	27	14	240		28.56			29.67	FM-15	0.00	29.73
07	1851	7	FEW:02 100 SCT:04 150 SCT:04 210	10.00		97	36.1	72	22.4	59	15.0	28	10	240		28.59			29.69	FM-15	0.00	29.76
07	1938	7	BKN:07 22 BKN:07 110 OVC:08 150	4.00	DU DU	95	35.0	70	21.0	55	12.8	26	14	200	22	28.61				FM-16		29.78
07	1951	7	BKN:07 22 OVC:08 110	4.00	DU s DU s	94	34.4	70	20.9	55	12.8	27	10s	170	22	28.64	3	-0.08	29.75	FM-15	0.00	29.81
07	2028	7	BKN:07 13 OVC:08 140	3.00	DU DU	91	32.8	69	20.6	56	13.3	31	29	150	48	28.66				FM-16		29.83
07	2049	6	SCT:04 9 OVC:08 150	10.00		91	33.0	67	19.6	52	11.0	26	18	170		28.65				FM-16		29.82
07	2051	7	SCT:04 9 OVC:08 150	10.00		92	33.3	67	19.3	50	10.0	24	18	170	29	28.65			29.76	FM-15	T	29.82
07	2110	7	FEW:02 60 SCT:04 95 BKN:07 110	7.00	[RA]	97	36.1	67	19.3	46	7.8	17	15	190	54	28.66				FM-16	T	29.83

September 7th – “Perfect Storm”



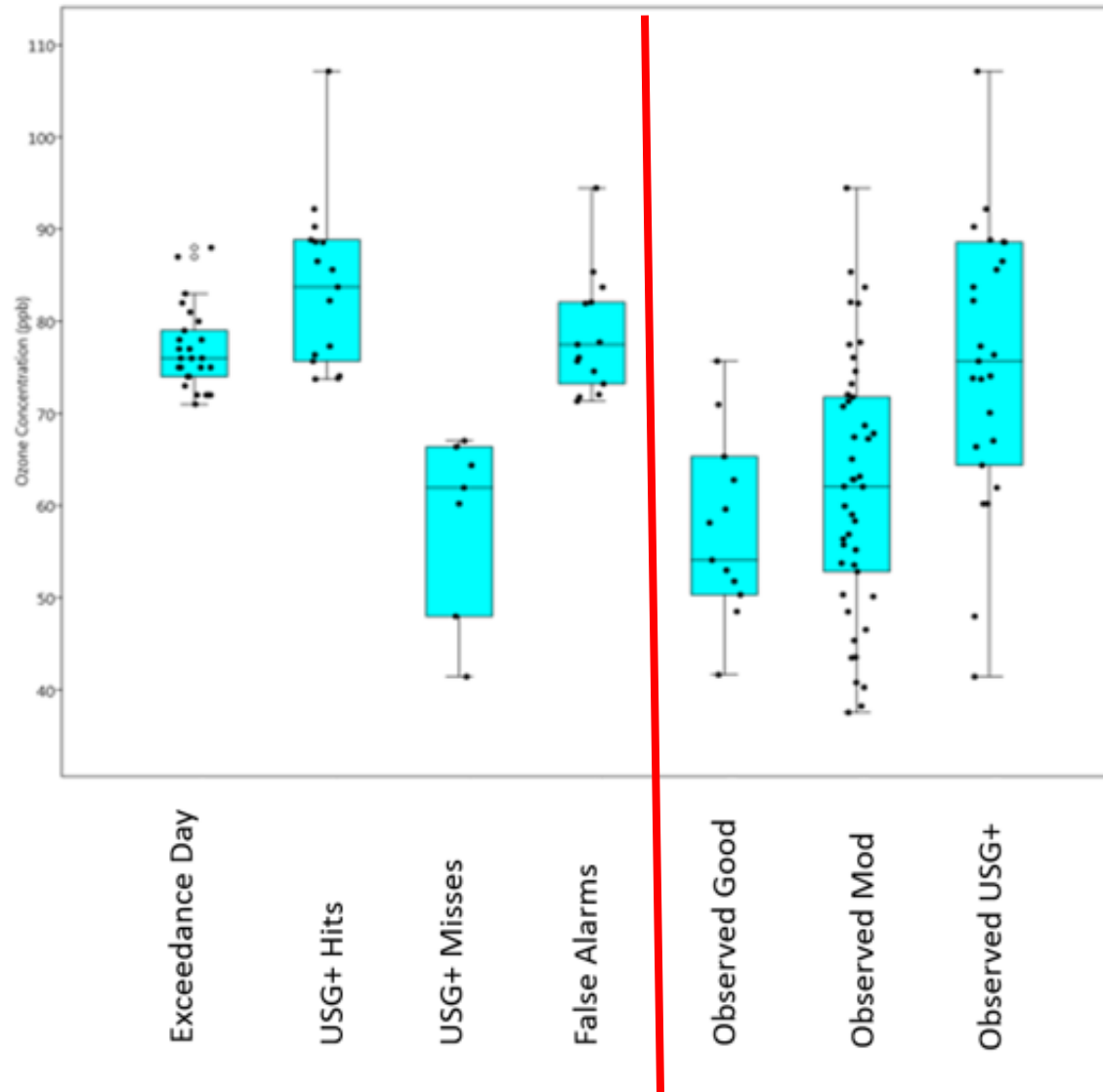
- June 16 – September 8, 2017 (North American Monsoon Season)
- CMAQ Data Unavailable (7/12 – 7/14; 8/2 – 8/3)
- Ozone (Phoenix and Yuma) and PM-2.5 (Phoenix and Nogales)
- Focus on Day 2 Predictions in Current Forecast Zones
 - Air Quality Episodes (≥ 100 AQI)
 - Correct AQI Category
 - 6Z and 12Z Run Comparisons for Ozone
 - **Ozone Predictions Limited to 0700-2300 Only**
- Hits, Misses, False Alarms, AQI Day Transitions

CMAQ Evaluation Phoenix Nonattainment Ozone



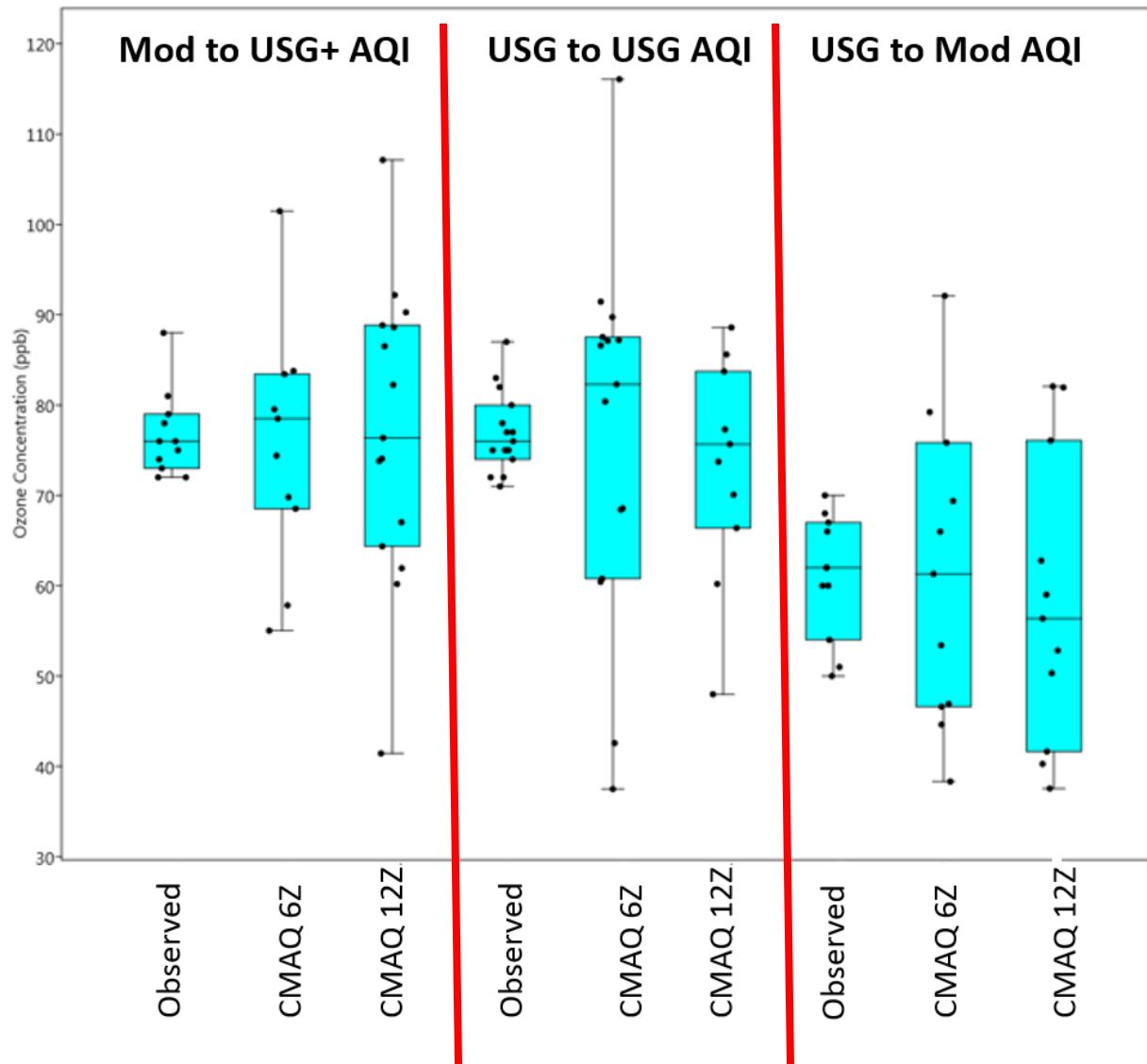
Phoenix – Ozone: AQI Categorical Days

Phoenix – CMAQ 12Z Ozone Prediction

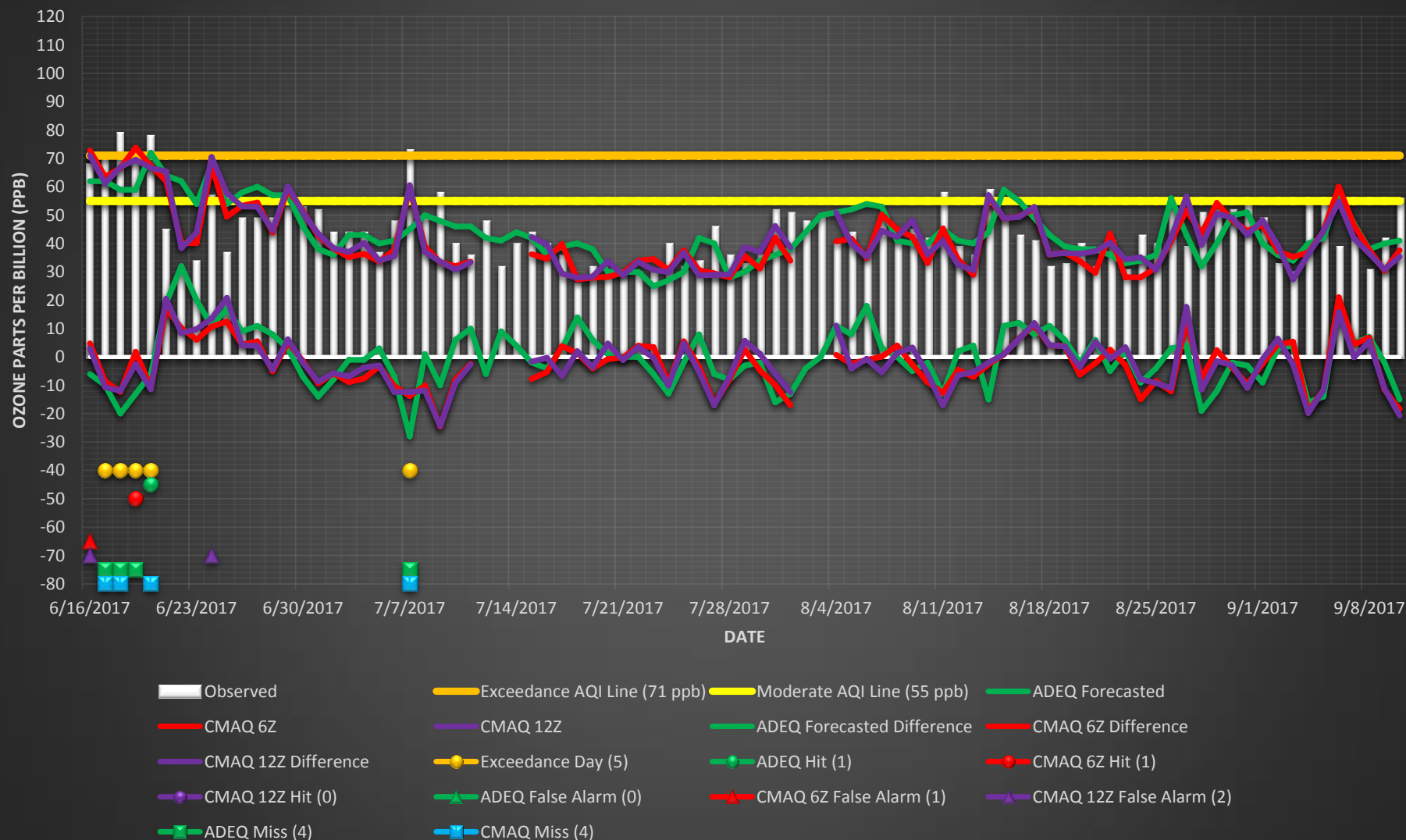


Phoenix – Ozone: AQI Transition Days

Phoenix Ozone Transition Days

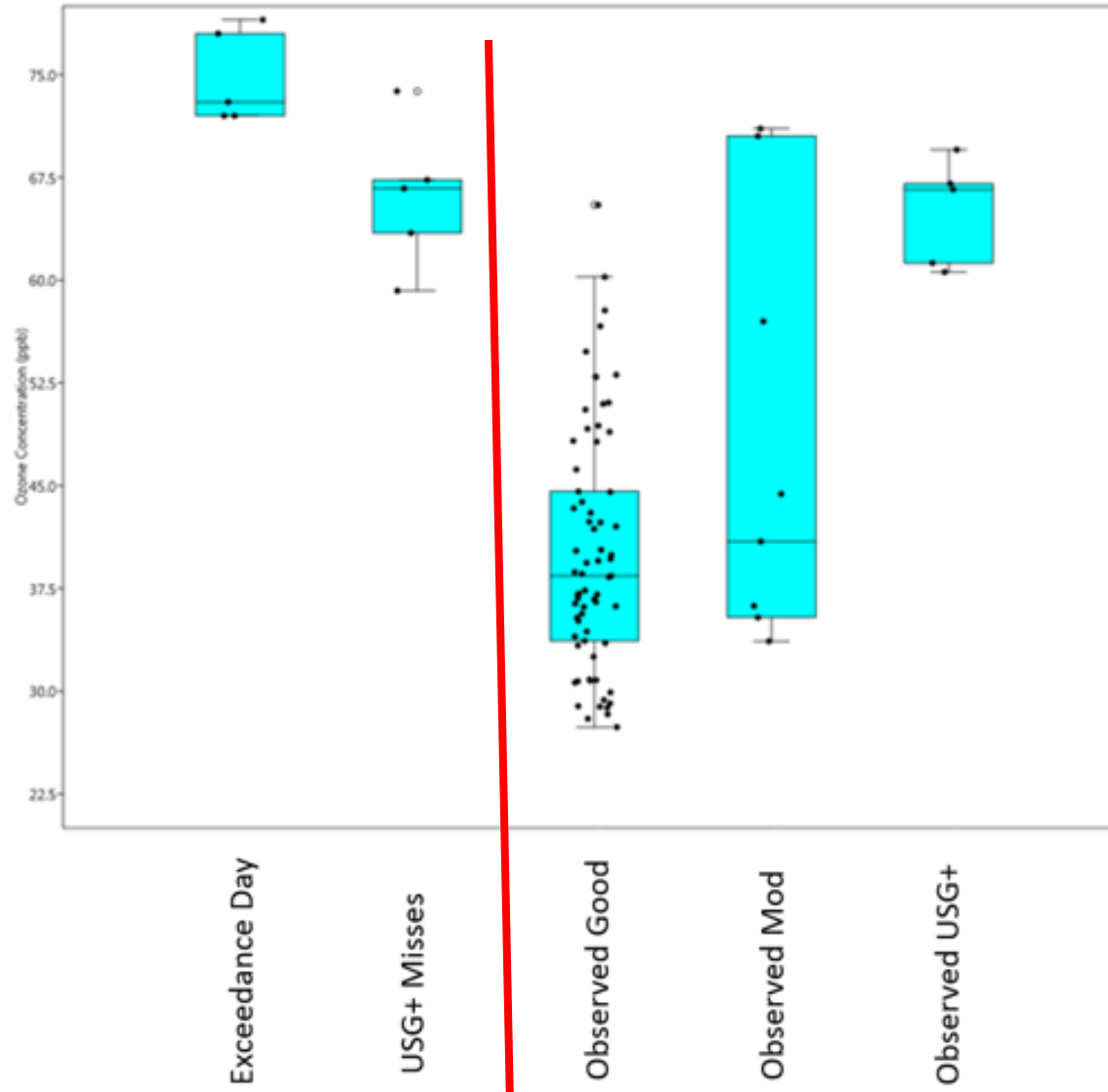


CMAQ Evaluation Yuma Ozone



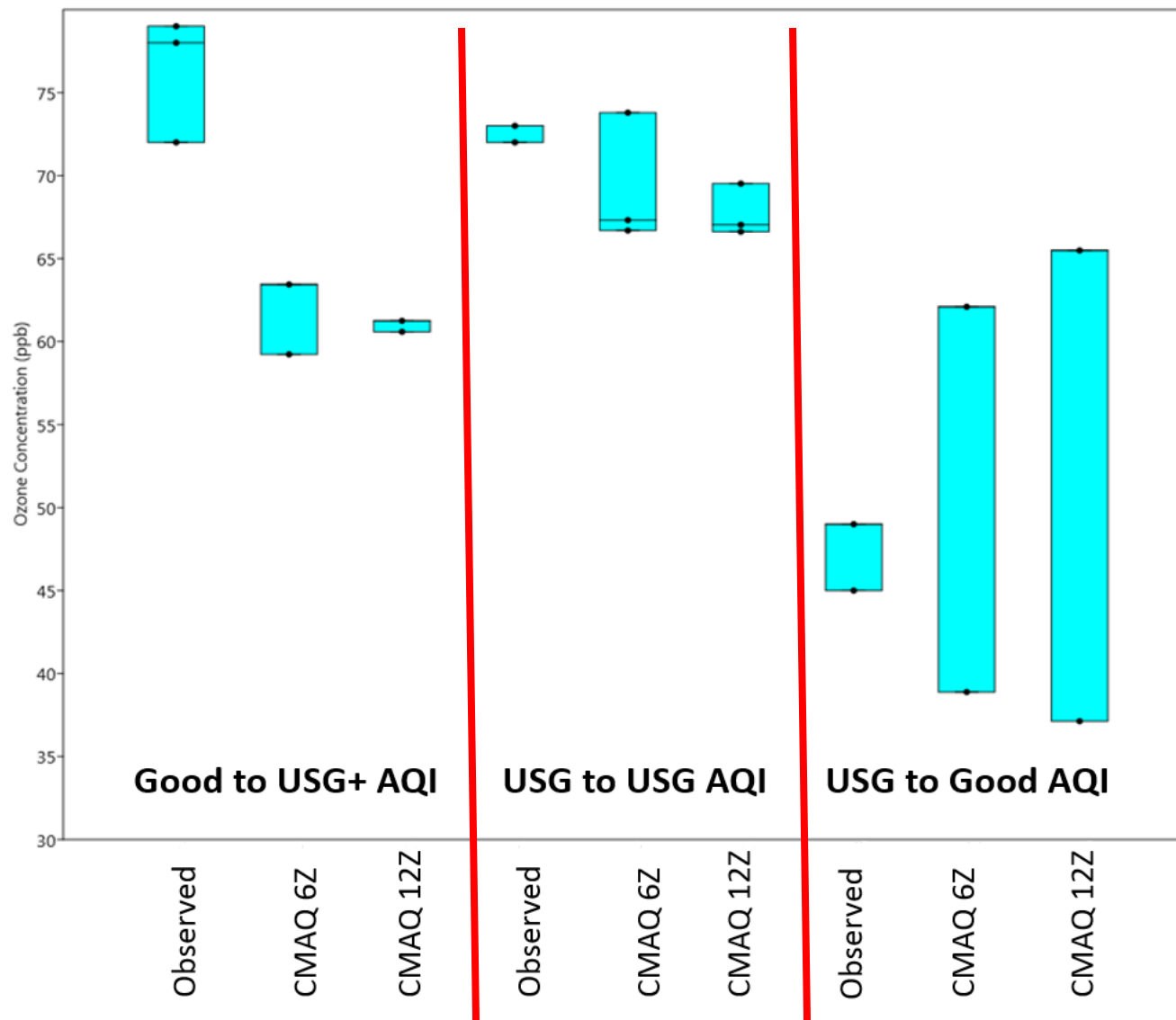
Yuma – Ozone: AQI Categorical Days

Yuma – CMAQ 12Z Ozone Prediction

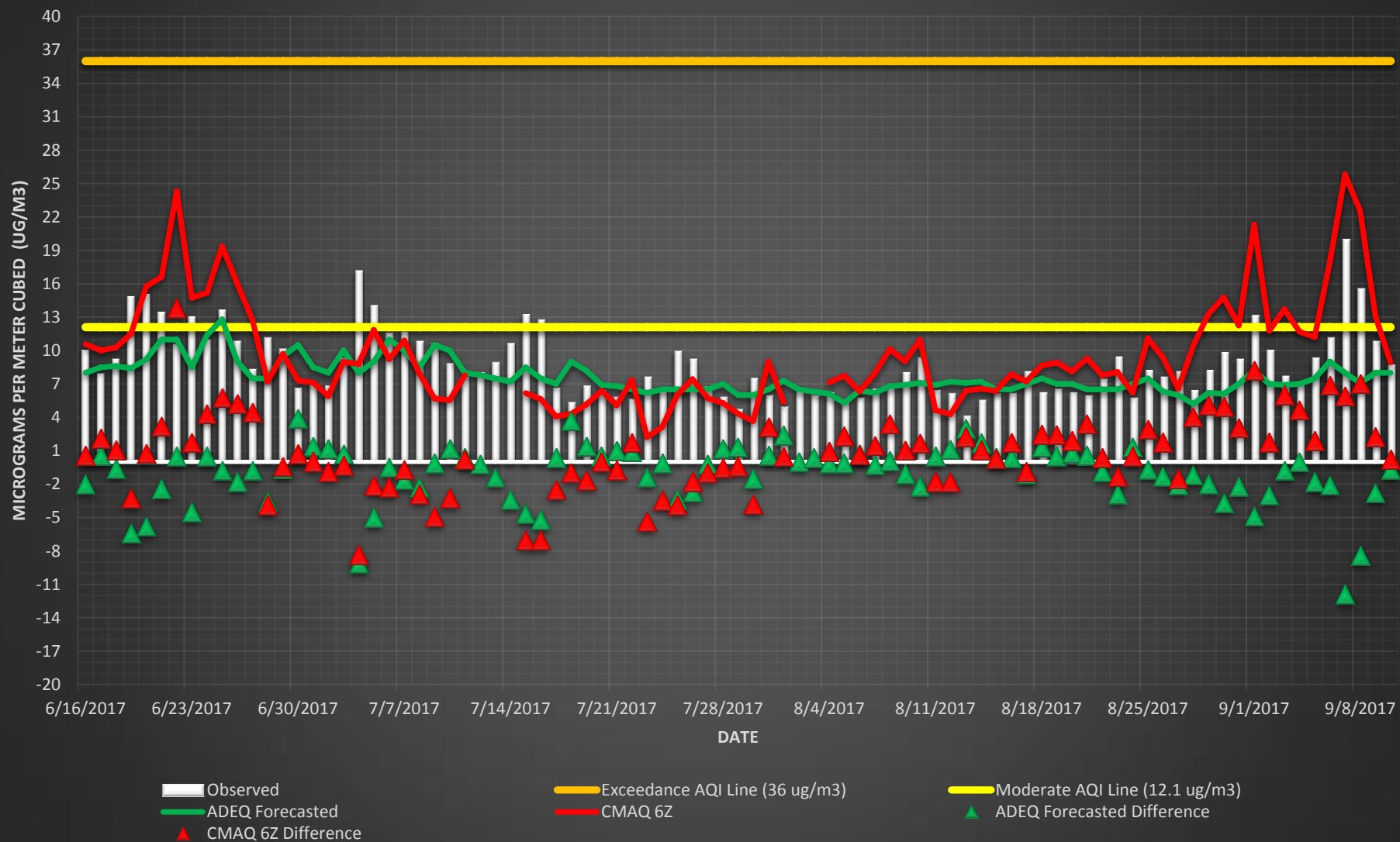


Yuma – Ozone: AQI Transition Days

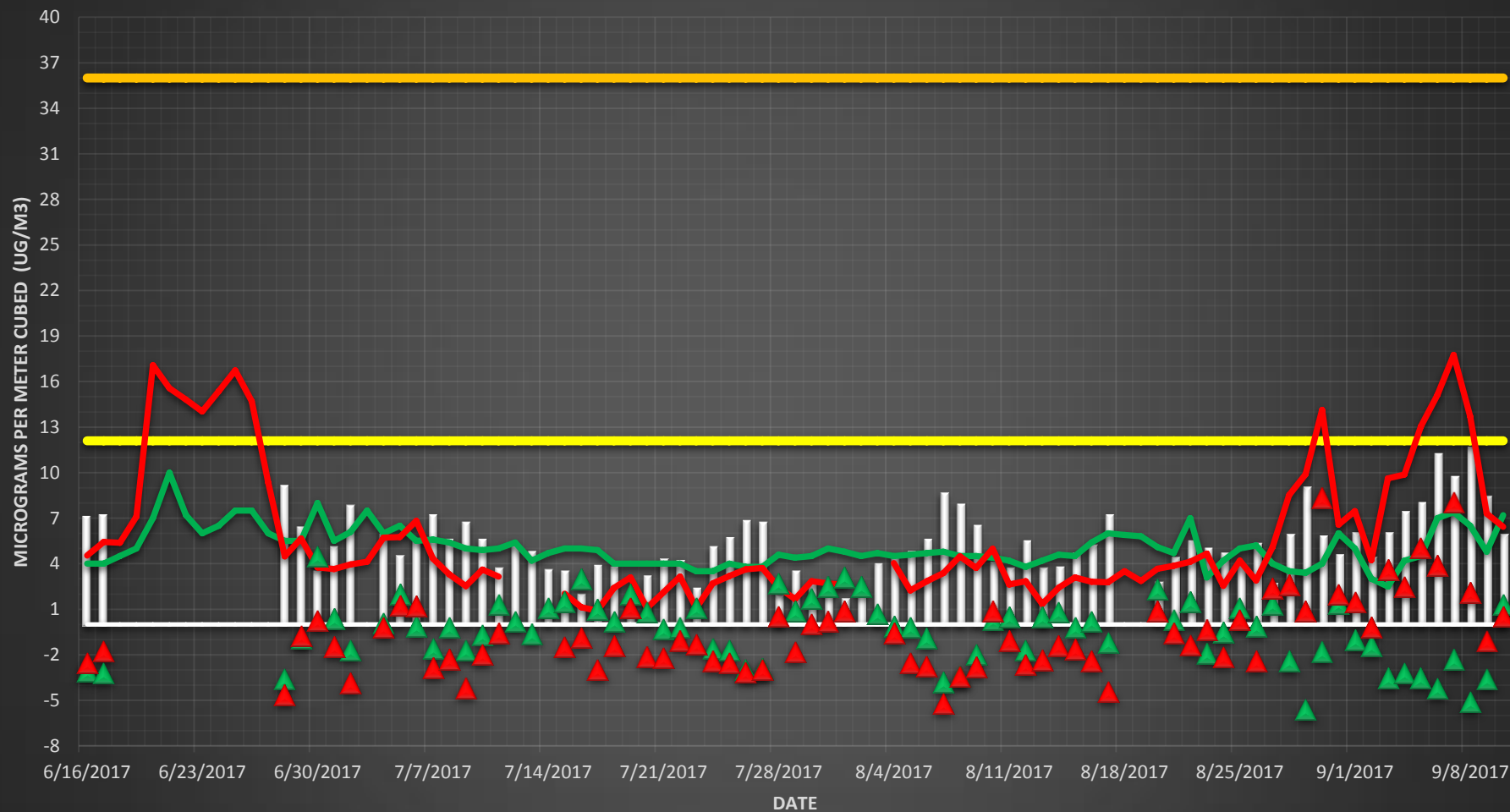
Yuma Ozone Transition Days



CMAQ Evaluation Phoenix Nonattainment PM_{2.5}



CMAQ Evaluation Nogales PM_{2.5}



Observed

Exceedance AQI Line (36 ug/m3)

Moderate AQI Line (12.1 ug/m3)

ADEQ Forecasted

CMAQ 6Z

ADEQ Forecasted Difference

CMAQ 6Z Difference

- CMAQ remains a viable guidance tool for preparing air quality forecasts in Arizona
- **Caution when certain meteorological conditions present themselves**
 - **Transport Ozone Mixing Events (especially rural locations?)**
 - **Timing and Strength of Diurnal Winds**
 - **Rapid Weather Pattern Changes**
 - Common in Monsoon
 - Outflows boundaries (ozone and particulates)
 - A couple hours can be significant in an exceedance day versus non-exceedance day!
- Bias towards ozone over prediction on exceeding days
- A high bias may explain prevalence of CMAQ False Alarms?
- Large spread of predicted ozone versus all AQI categories
 - Transitions appear to be difficult to capture
- No strong preference for 6Z versus 12Z model runs
- PM_{2.5} magnitude high for smoke events, but presence is indicated (urban and rural sites)
- More weight needed on blowing dust for PM_{2.5}?
- Soil Moisture Considerations? Suppression of PM₁₀ leading to lower PM_{2.5}

ADEQ's Air Quality Workstation

