NAQFC now and soon coming

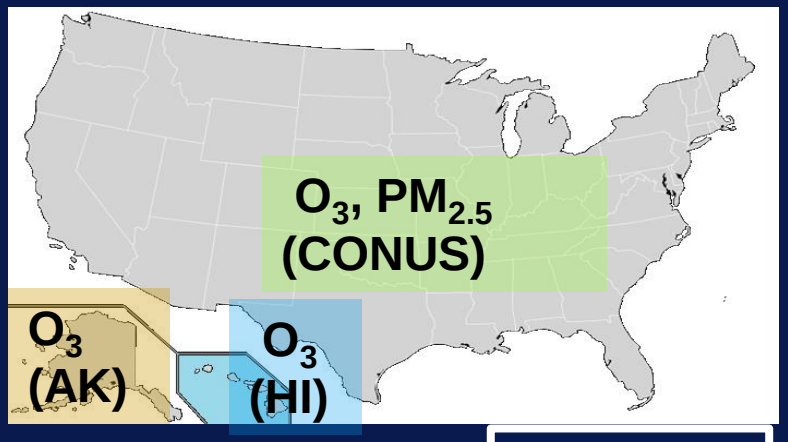
Pius Lee[1], Jeff McQueen[2], Ivanka Stajner[3],
Li Pan[1], Jianping Huang[2], Daniel Tong[1], Hyuncheol Kim[1],
Youhua Tang[1], Ho-Chun Huang[2], Sikchya Upadhayay[3],
Perry Shafran[2] and Marc Saccucci[4]

[1]Air Resources Laboratory, NOAA, College Park, MD
[2] Environmental Modeling Center, NCEP, NOAA, College Park, MD
[3]Office of Science and Technology Integration, NWS, NOAA, Silver Spring, MD
[4]Meteorological Development Laboratory, NOAA, Silver Spring, MD

Current Configuration

- CMAQ5.0.2
  - CB05 gas chemistry 157 species
  - Aero6 aerosol chemistry
- For **CONUS:**
- LBC: Static from GEOS-CHEM + Dynamic LBC for dust derived from NGAC
- 24 h analysis PM field for initialization adjustment
- Follow Prod SMOKE for assumed fire duration, speciation and strengths with Bluesky 3.5.1

2017



72 h?

Expected pseudo-operation May - Aug 2018

- NEI2014 version 1 with CMAQ5.2
- Shale oil and gas emission increase

Emissions accompany CMAQ5.0.2

- **Point source**: upgrade based on 2015 CEM and 2017 DoE Energy Outlook
  Canada 2011 Environment Canada Emission Inventory (ECEI);
  Mexico inventory (MI) 2012 version2.2

- **Area source**: agricultural, fugitive dust,
  marine, oil & gas, woodstoves;
  non-road: for U.S. used NEI2011, ECEI 2006 for Canada; MI 2012 for Mexico
- **Mobile source**: Cross State Air Pollution Rule (CSAPR) 2011 Emission Data
- **Fugitive dust emission**: modulated by snow – emission off if there is snow

- **Intermittent emissions:** windblown dust – FENGSHA Model (Tong et al., 2016)
- wild fires -- NESDIS Hazard Mapping System (HMS) & fuel from New USFS BlueSky v3.5.1

- **Natural source**: Biogenic with BEIS3 Version 3.14; Sea-salt based on 10m wind

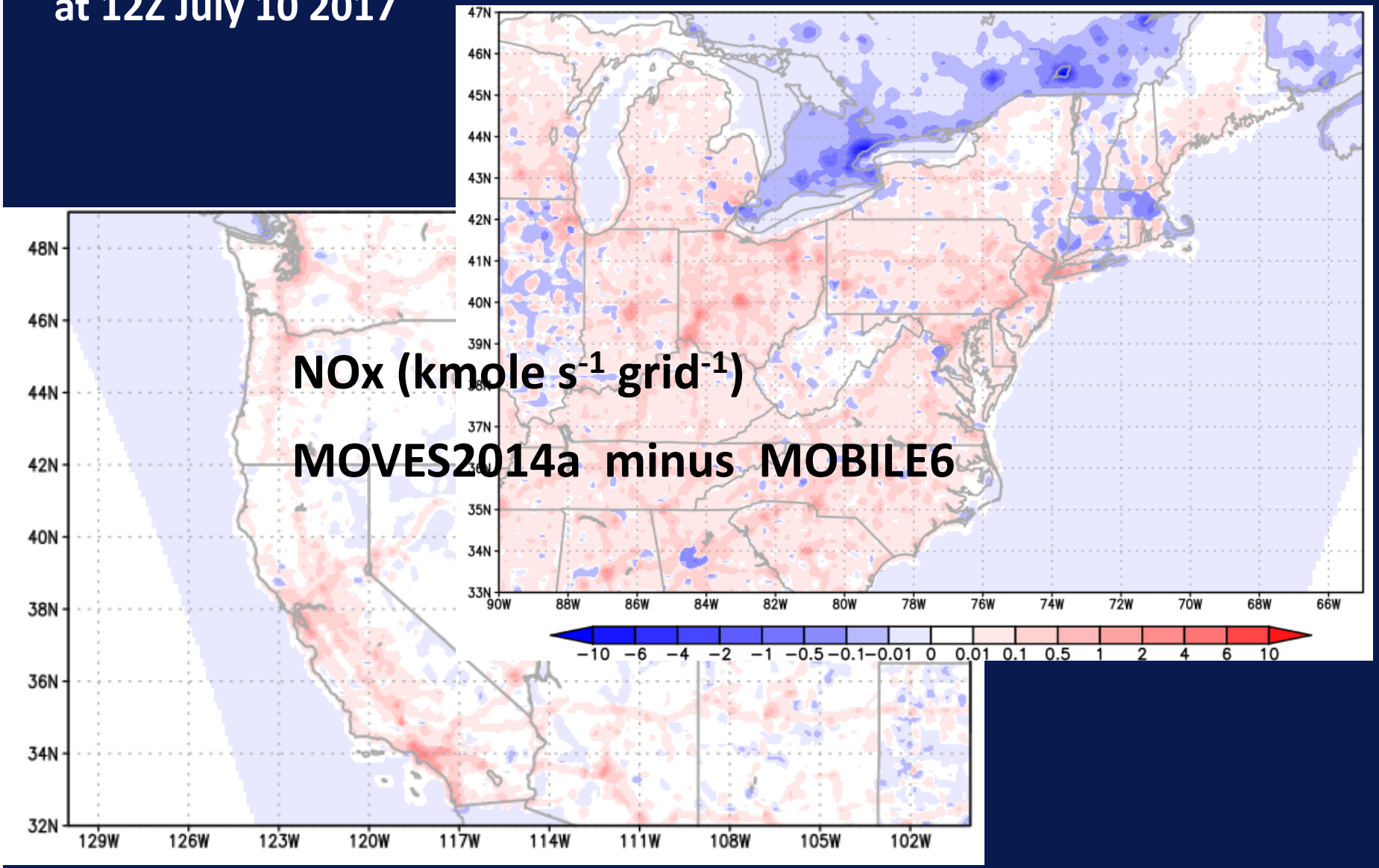
NEI 2014 vs NEI 2011-based NAQFC

- **MOVES2014a** with possible modulation from recent NOx emission observation; superior to MOBILE6: more categorizations e.g., idling, cruising and ignition
- Area source: agricultural Include **prescribed fires & point sources**; and differentiation between flaming and smoldering modes; oil & gas with **possible inclusion of increase due to fracking**
- On-road & off-road neighbors: **updated Canadian and Mexican** data
- Natural source: Biogenic with **BEIS3 Version 3.61**

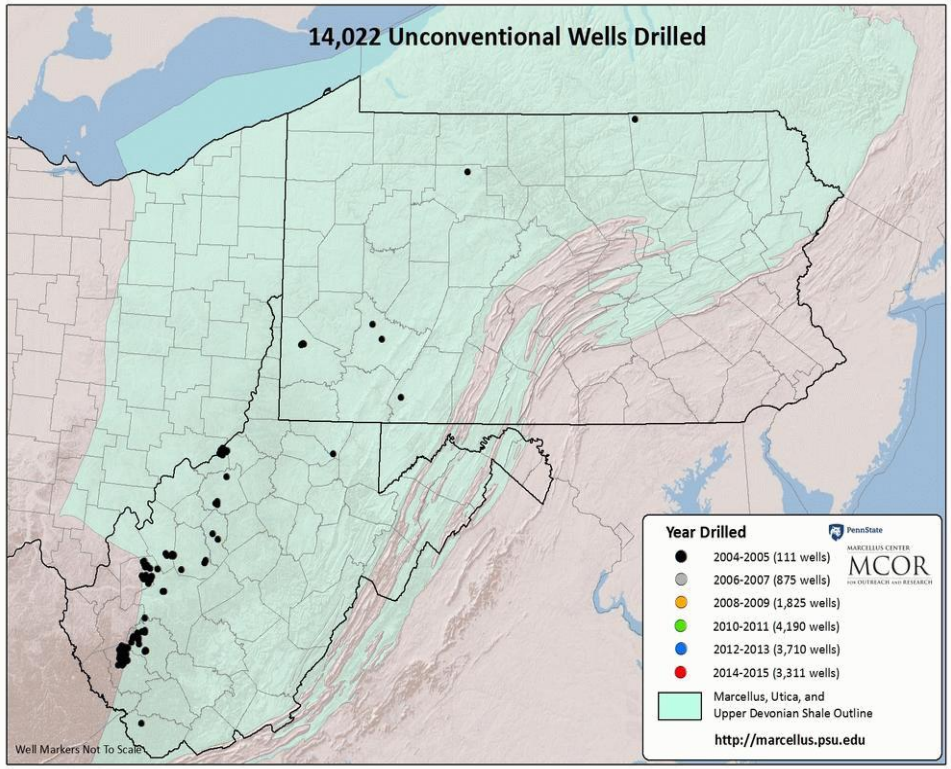
CMAQ5.2 vs CMAQ5.0.2

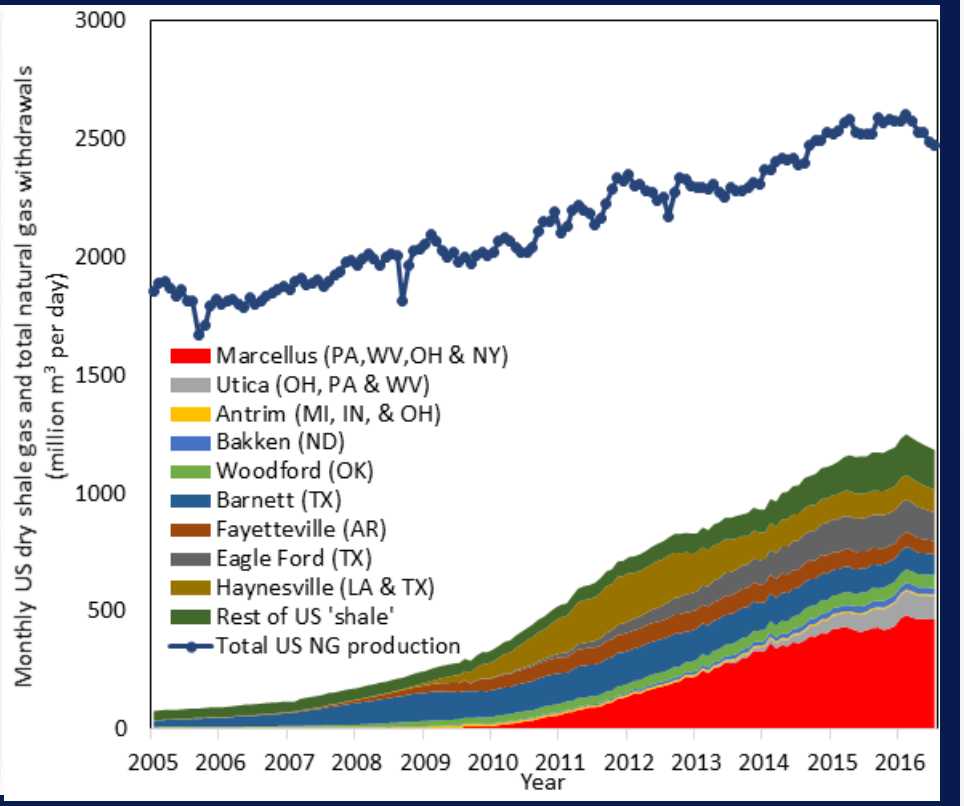
- **Gas mechanism upgraded to CB06**
- **Halogen Chemistry** that potentially reduces high O_3 bias near coast
- **Aerosol direct radiative feedback** to actinic flux thus photolytic rates
- **More efficient SOA production** that may reduce summer time PM low bias

NOx flux (kmole/s/grid) difference: MOVES2014a minus current NAQFC at 12Z July 10 2017



Shale Oil and Gas due to Marcellus Play



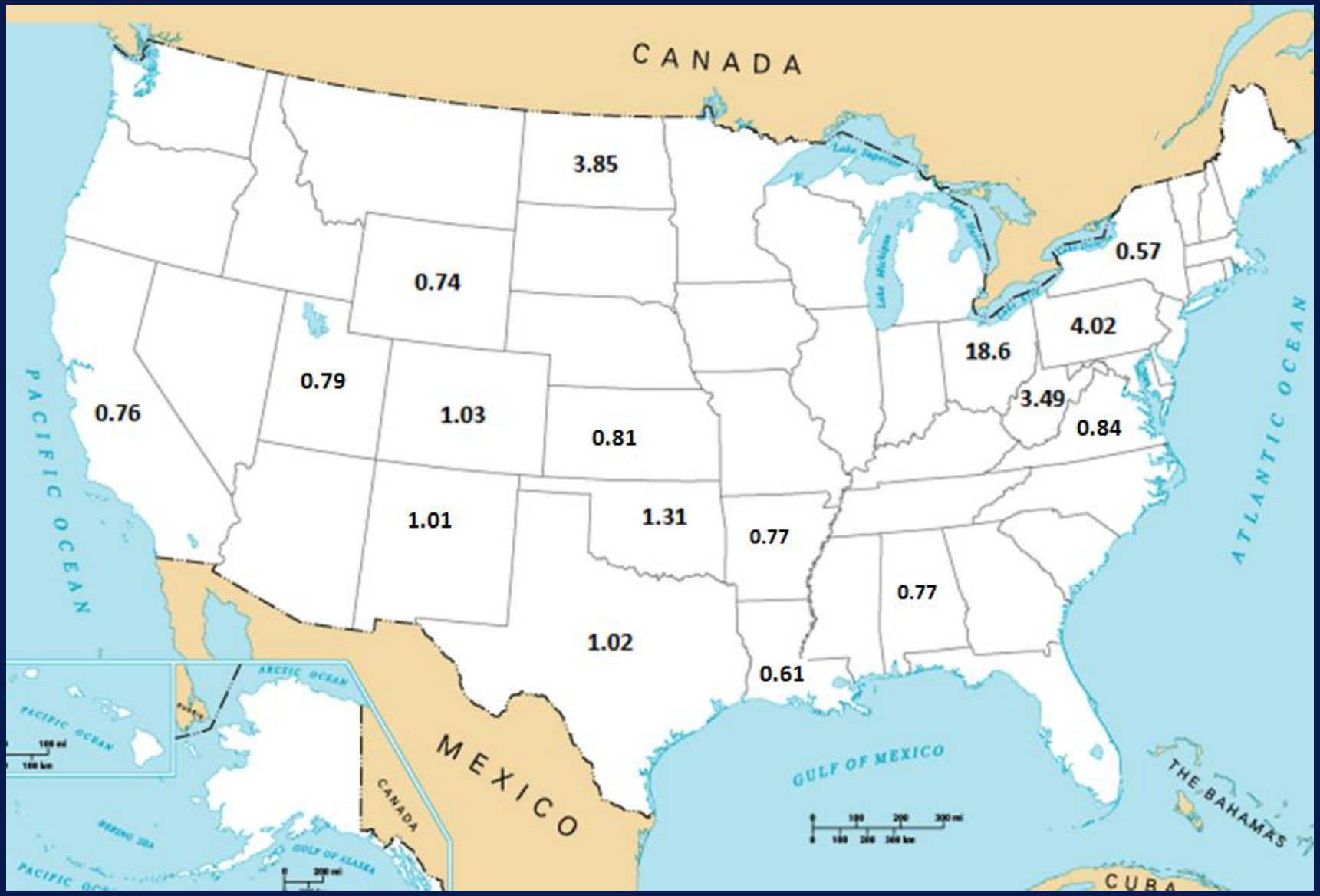


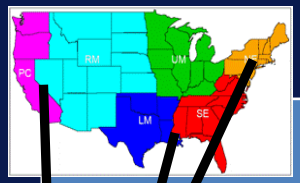
Marcellus Play is generally considered to be able to produce dry natural gas : > 95% CH_4 (Cox-Colvin 2017) www. coxcolvin.com /the-marcellus-and-utica-shale-natural-gas-play-what-are-the-issues/

Variation of state-wide top production rate and well-numbers between 2011 to 2016

	Well numbers			Million cubic feet		
Year	2011	2016	2016/2011	2011	2016	2016/2011
Texas	95,014	142,368	1.50	7,112,863	6,985,576	1.02
Pennsylvania	44,500	68,536	1.54	1,310,592	5,263,973	4.02
Louisiana	19,137	18,382	0.96	3,029,206	1,861,187	0.61
Colorado	28,813	46,322	1.61	1,637,576	1,703,277	1.03
West Virginia	52,498	47,938	0.91	394,125	1,375,108	3.49
Ohio	34,931	26,599	0.76	78,858	1,466,854	18.60
North Dakota	188	462	2.46	97,102	504,672	3.85
Utah	6,075	8,739	1.44	457,525	367,251	0.79
California	1,580	4,209	2.66	250,177	211,451	0.76
Σ	282,736	363,555	1.29	14370035	19741365	1.38

Adjustment factor applied to NEI2011 oil and gas area source sector



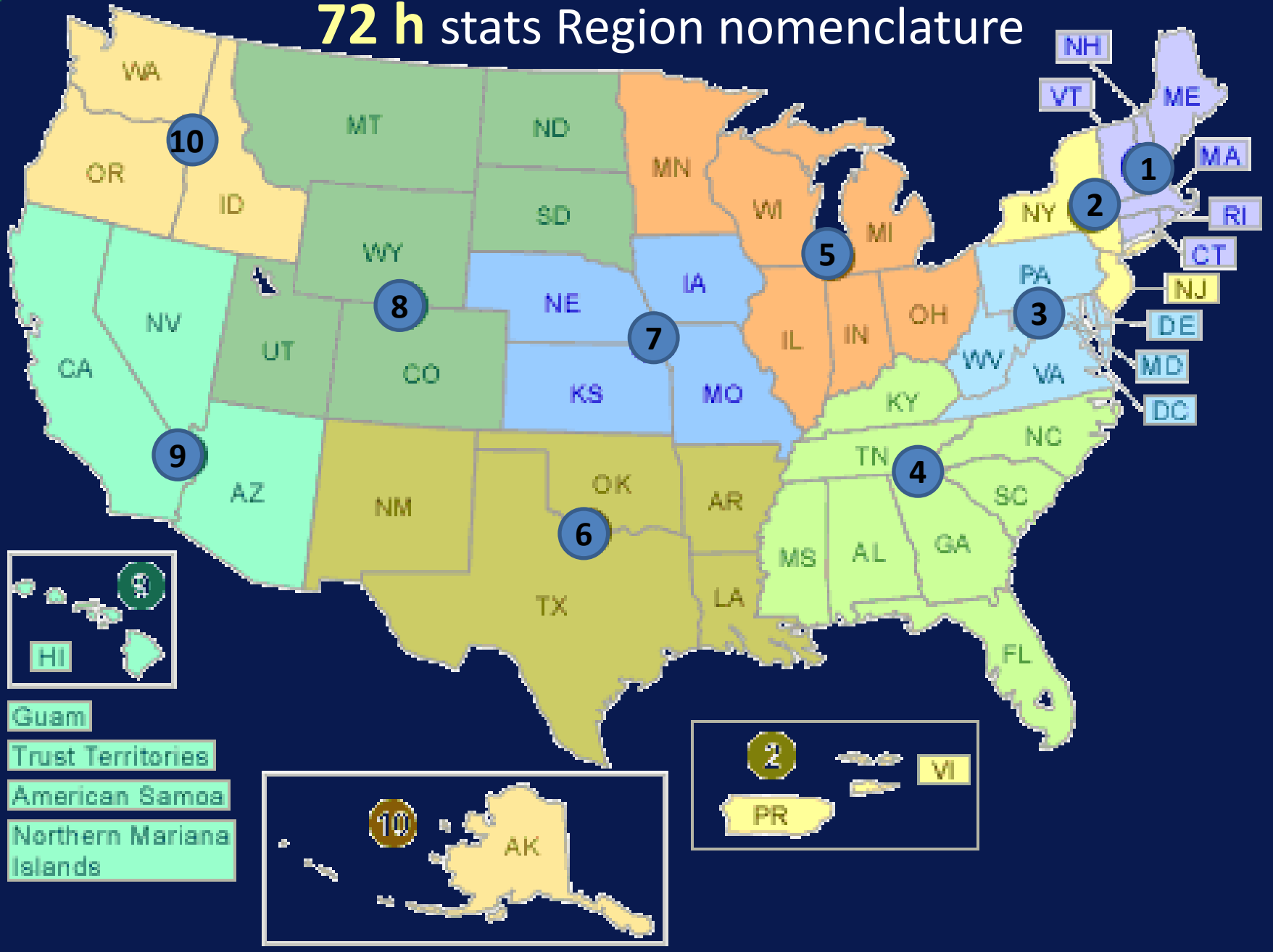


Score: PROD vs. O_n_Gas_refreshed for July 10-22 2017

		N	obs	mean	Bias	RMSE	Coeff corr
Daily Maximum 8 h average O3							
NE	PROD	17200	43.9	46.3	2.4	9.12	0.76
	O_n_Gas			47.7	3.5	9.51	0.77
LM	PROD	10200	37.6	43.3	5.7	10.92	0.68
	O_n_Gas			44.1	6.5	11.54	0.67
SC	PROD	10400	47.5	44.8	-2.7	9.80	0.84
	O_n_Gas			45.3	-2.2	9.95	0.83
Daily average PM2.5							
NE	PROD	12100	8.5	9.4	0.9	4.13	0.61
	O_n_Gas			9.7	1.2	4.40	0.60
LM	PROD	5100	7.9	7.5	-0.4	4.09	0.38
	O_n_Gas			7.9	0	3.77	0.45
SC	PROD	10300	8.7	6.7	-2.0	6.15	0.31
	O_n_Gas			8.2	-0.5	5.92	0.32

Oil_n_Gas refreshed emission helped reduced O3 and PM2.5 under-prediction

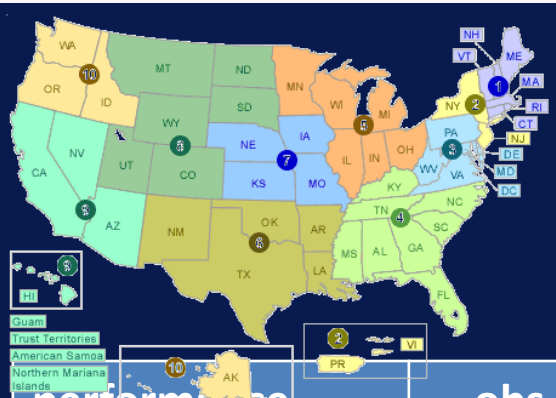
72 h stats Region nomenclature



MD8A O_3 Day1,2,3 Performance averaged over 8/2-9/19 2017

performance	obs	Bias	N-Mean B%	RMSE	corr, r	I Agreement
CON (N=58070) D1	**39.0**	**2.21**	**5.67**	**9.62**	**0.76**	**0.85**
D2		**1.86**	**4.77**	**9.93**	**0.73**	**0.83**
D3		**1.48**	**3.79**	**10.34**	**0.70**	**0.82**
R1 (N=2745) D1	**35.2**	**3.53**	**10.04**	**7.92**	**0.74**	**0.83**
D2		**3.74**	**10.62**	**8.48**	**0.69**	**0.79**
D3		**3.00**	**8.53**	**8.44**	**0.66**	**0.79**
R2(N=1925) D1	**35.1**	**4.38**	**12.46**	**8.71**	**0.76**	**0.83**
D2		**4.33**	**12.33**	**8.99**	**0.73**	**0.81**
D3		**3.65**	**10.40**	**9.98**	**0.61**	**0.75**
R3(N=6970) D1	**36.6**	**3.93**	**10.75**	**8.44**	**0.77**	**0.83**
D2		**3.66**	**10.00**	**8.64**	**0.74**	**0.82**
D3		**3.31**	**9.05**	**9.53**	**0.65**	**0.77**

missed days: August 4th, 9th, 21st and September 2nd and 5th



MD8A O_3 performance averaged over 8/2-9/19 2017 Continued

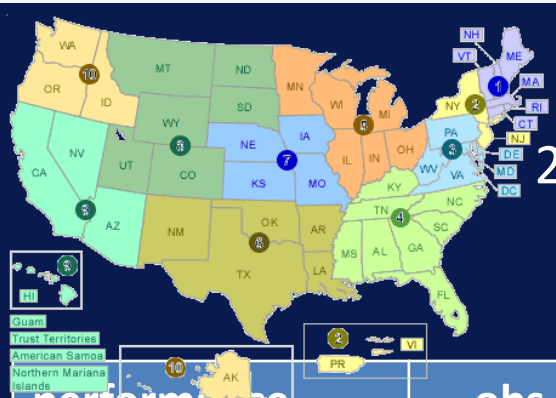
performance		obs	Bias	N-Mean B%	RMSE	corr, r	I Agreement
R4 (N=8920)	D1	**33.4**	**7.17**	**21.47**	**10.72**	**0.76**	**0.77**
	D2		**6.84**	**20.47**	**10.76**	**0.73**	**0.76**
	D3		**7.01**	**20.99**	**11.18**	**0.70**	**0.74**
R5 (N=9060)	D1	**37.6**	**0.93**	**2.46**	**7.22**	**0.79**	**0.87**
	D2		**0.62**	**1.64**	**7.67**	**0.76**	**0.85**
	D3		**0.18**	**0.48**	**8.03**	**0.73**	**0.84**
R6 (N=6245)	D1	**39.3**	**4.81**	**12.23**	**11.15**	**0.69**	**0.76**
	D2		**4.43**	**11.26**	**11.54**	**0.64**	**0.74**
	D3		**3.86**	**9.81**	**11.78**	**0.60**	**0.71**

MD8A O_3 performance averaged over 8/2-9/19 2017 Continued

performance	obs	Bias	N-Mean B%	RMSE	corr, r	I Agreement
R7 (N=2250) D1	**39.6**	**1.30**	**3.28**	**7.09**	**0.77**	**0.86**
D2		**0.92**	**2.34**	**7.54**	**0.73**	**0.83**
D3		**-0.06**	**-0.15**	**7.63**	**0.71**	**0.82**
R8 (N=3870) D1	**47.1**	**-2.52**	**-5.36**	**9.46**	**0.69**	**0.80**
D2		**-2.80**	**-5.93**	**9.68**	**0.68**	**0.79**
D3		**-3.34**	**-7.08**	**10.01**	**0.67**	**0.78**
R9 (N= 9900) D1	**49.1**	**-2.05**	**-4.17**	**11.21**	**0.77**	**0.87**
D2		**-3.02**	**-6.15**	**11.71**	**0.76**	**0.86**
D3		**-3.51**	**-7.16**	**12.17**	**0.74**	**0.84**
R10 (N=1240) D1	**40.8**	**-2.86**	**-7.00**	**12.78**	**0.69**	**0.81**
D2		**-2.79**	**-6.83**	**12.63**	**0.70**	**0.81**
D3		**-2.89**	**-7.07**	**13.26**	**0.67**	**0.80**

24h $PM_{2.5}$ Day1,2,3 Performance averaged over 8/2-9/19 2017

performance	obs	Bias	N-Mean B%	RMSE	corr, r	I Agreement
CON (N=39620) D1	**12.4**	**0.97**	**7.85**	**14.32**	**0.67**	**0.80**
D2		**0.34**	**2.77**	**14.00**	**0.67**	**0.76**
D3		**-0.06**	**-0.47**	**14.86**	**0.61**	**0.72**
R1 (N=1980) D1	**6.9**	**-0.37**	**-5.26**	**4.27**	**0.45**	**0.66**
D2		**-0.50**	**-7.19**	**4.32**	**0.45**	**0.66**
D3		**-0.38**	**-5.44**	**4.21**	**0.46**	**0.67**
R2(N=1455) D1	**7.4**	**1.52**	**20.62**	**5.09**	**0.42**	**0.63**
D2		**1.50**	**20.29**	**5.15**	**0.43**	**0.64**
D3		**1.67**	**23.00**	**5.43**	**0.40**	**0.62**
R3(N=2395) D1	**9.4**	**-0.08**	**-0.83**	**4.28**	**0.44**	**0.63**
D2		**-0.24**	**-0.25**	**4.47**	**0.45**	**0.66**
D3		**-0.15**	**-1.57**	**4.45**	**0.45**	**0.63**

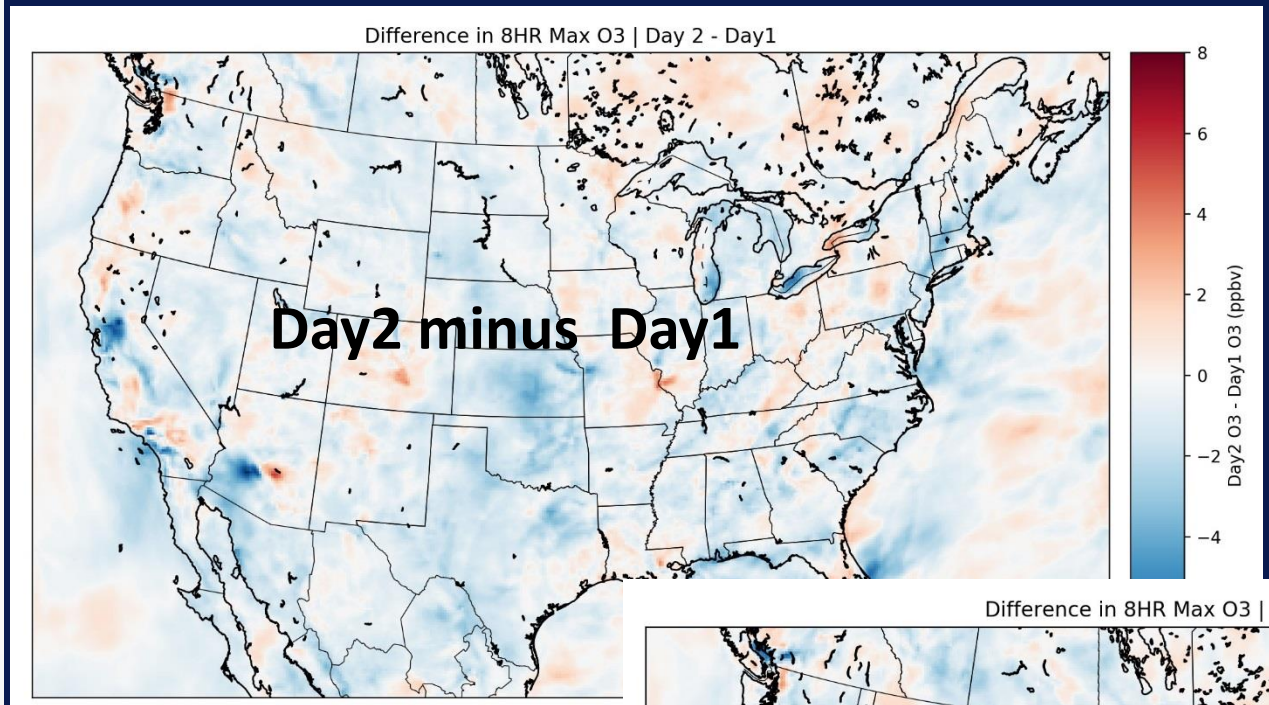


24 h $PM_{2.5}$ performance averaged over 8/2-9/19 2017 Continued

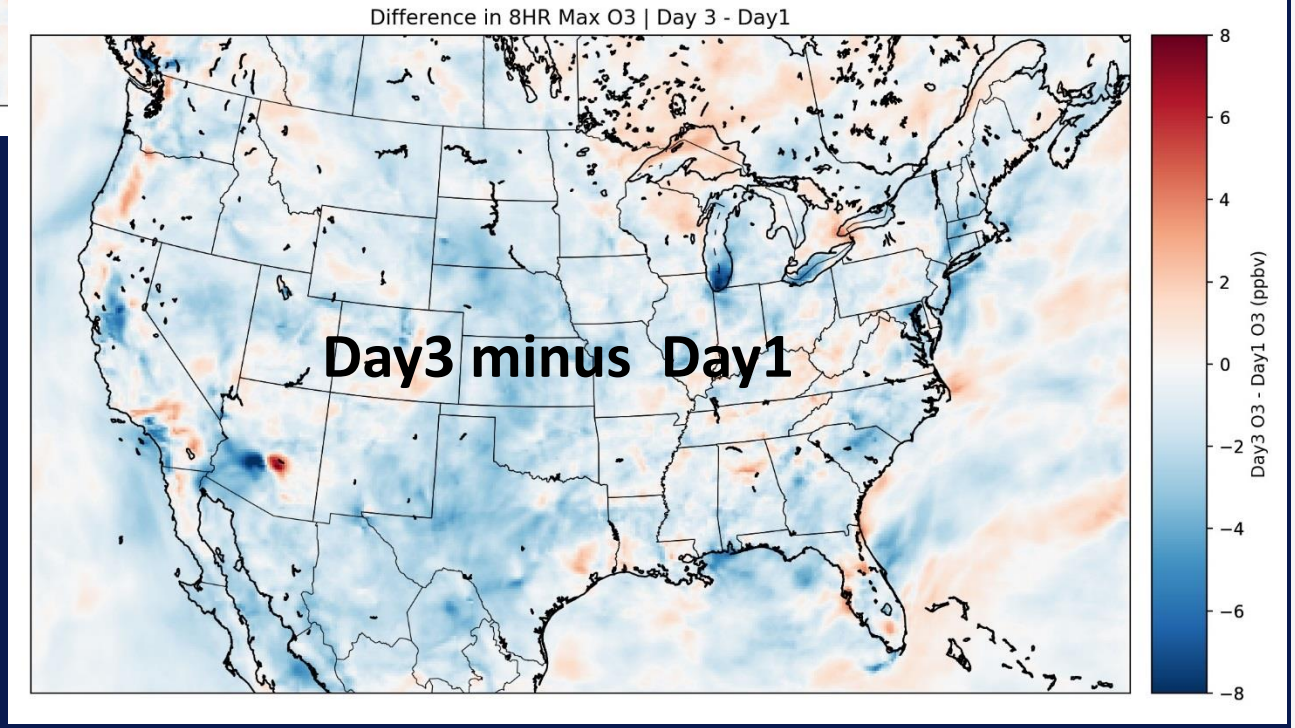
performance		obs	Bias	N-Mean B%	RMSE	corr, r	I Agreement
R4 (N=5210)	D1	8.8	1.41	16.08	4.87	0.55	0.70
	D2		1.53	17.39	5.17	0.52	0.67
	D3		1.79	20.36	5.37	0.47	0.64
R5 (N=5135)	D1	8.3	2.77	33.46	5.49	0.56	0.67
	D2		2.68	32.38	5.60	0.53	0.65
	D3		2.66	32.14	5.66	0.50	0.64
R6 (N=3210)	D1	9.0	1.91	21.13	6.14	0.38	0.59
			1.82	20.16	6.32	0.37	0.57
			1.29	14.26	6.15	0.33	0.56

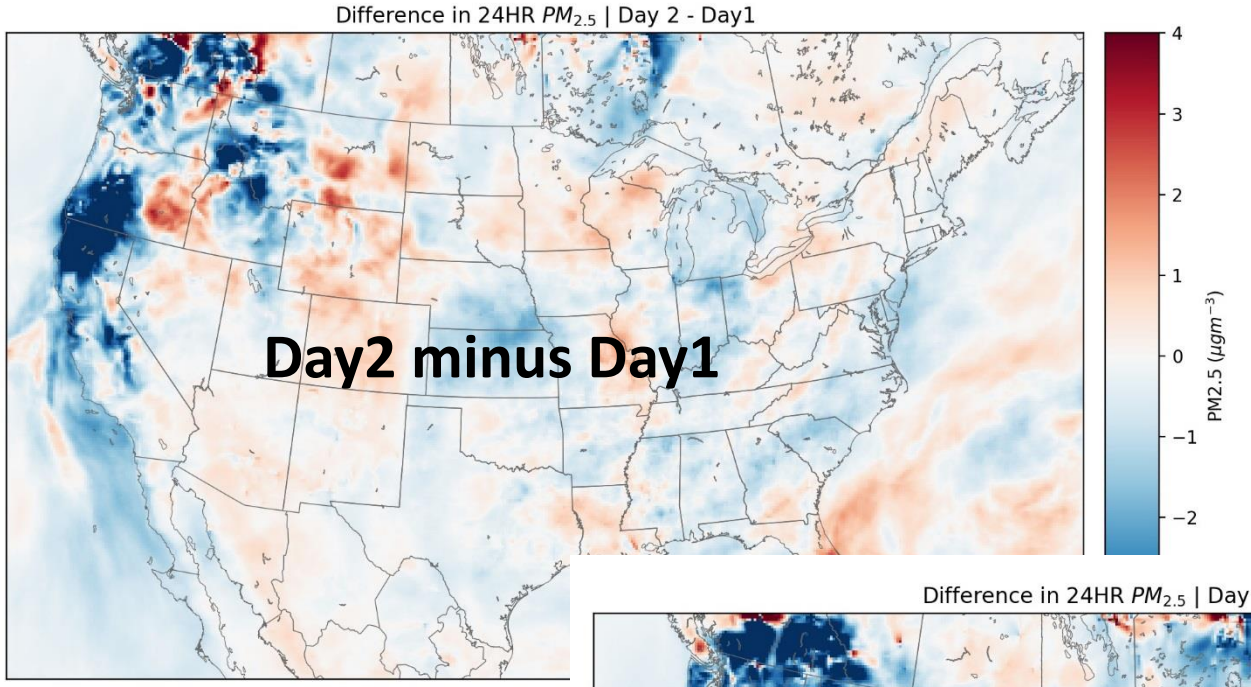
24 h $PM_{2.5}$ performance statistics averaged over 8/2-9/19 2017 Continued

performance	obs	Bias	N-Mean B%	RMSE	corr, r	I Agreement
R7 (N=1460) D1	9.1	3.70	40.60	6.61	0.43	0.59
D2		3.50	38.34	6.60	0.42	0.58
D3		3.46	37.89	6.63	0.42	0.59
R8 (N=3490) D1	17.3	-0.20	-1.18	22.78	0.63	0.75
D2		-1.78	-10.33	22.33	0.65	0.73
D3		-3.20	-18.55	23.75	0.61	0.65
R9 (N= 6140) D1	12.0	0.85	7.09	10.35	0.45	0.64
D2		0.05	0.42	9.59	0.48	0.67
D3		-0.54	-4.45	9.64	0.38	0.60
R10 (N=6125) D1	24.8	-1.38	-5.58	27.72	0.68	0.81
D2		-3.27	-13.22	27.18	0.68	0.79
D3		-4.61	-18.60	29.24	0.63	0.72

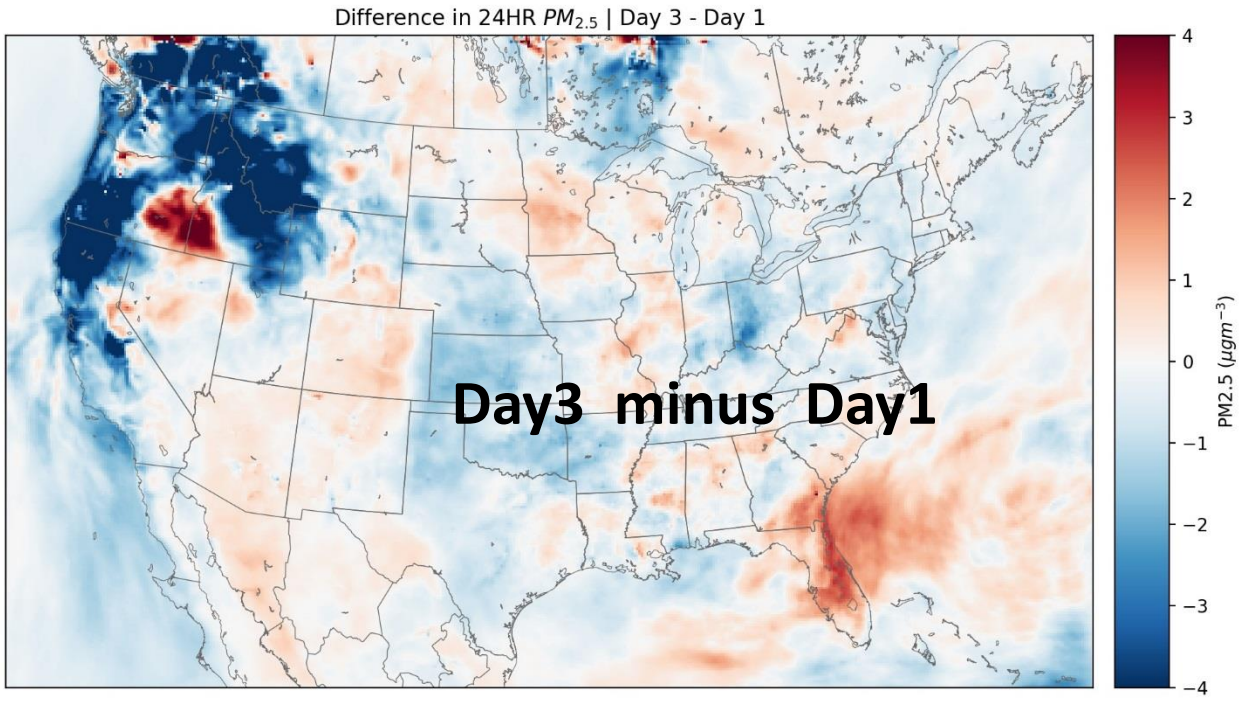


Monthly averaged MDA8 O3 for 8/2-9/19 2017

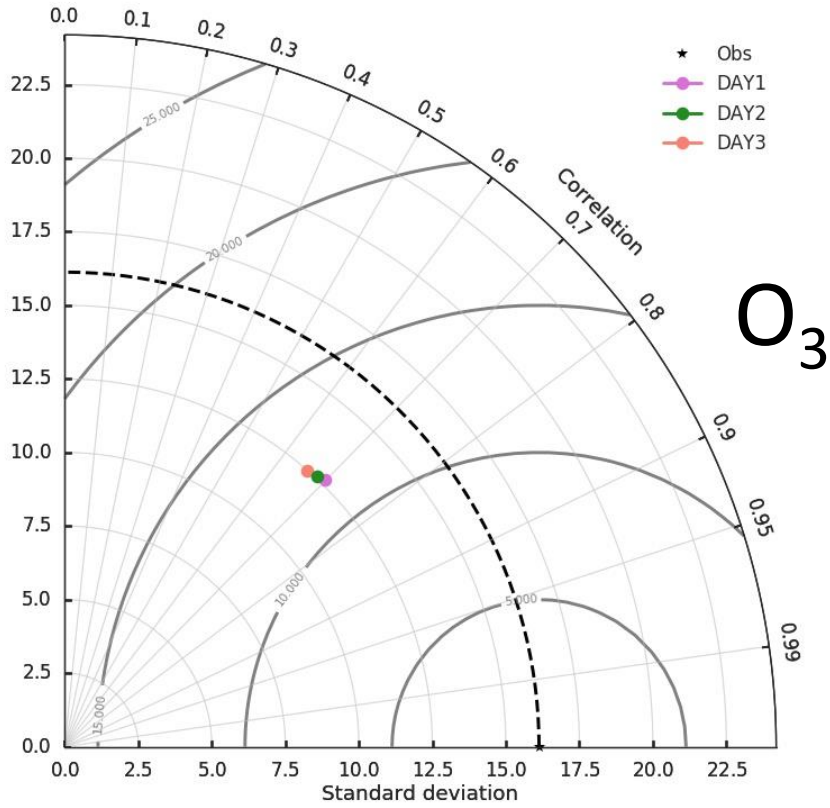




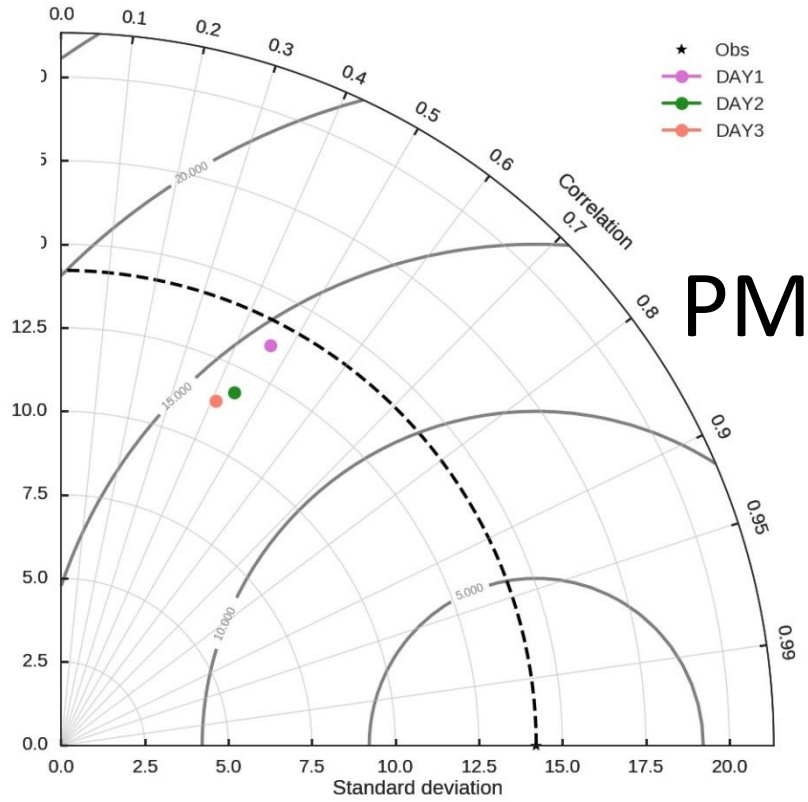
Monthly averaged 24 h $PM_{2.5}$ for 8/2-9/19 2017



Taylor Diagram for CONUS for 8/10-8/19 2017

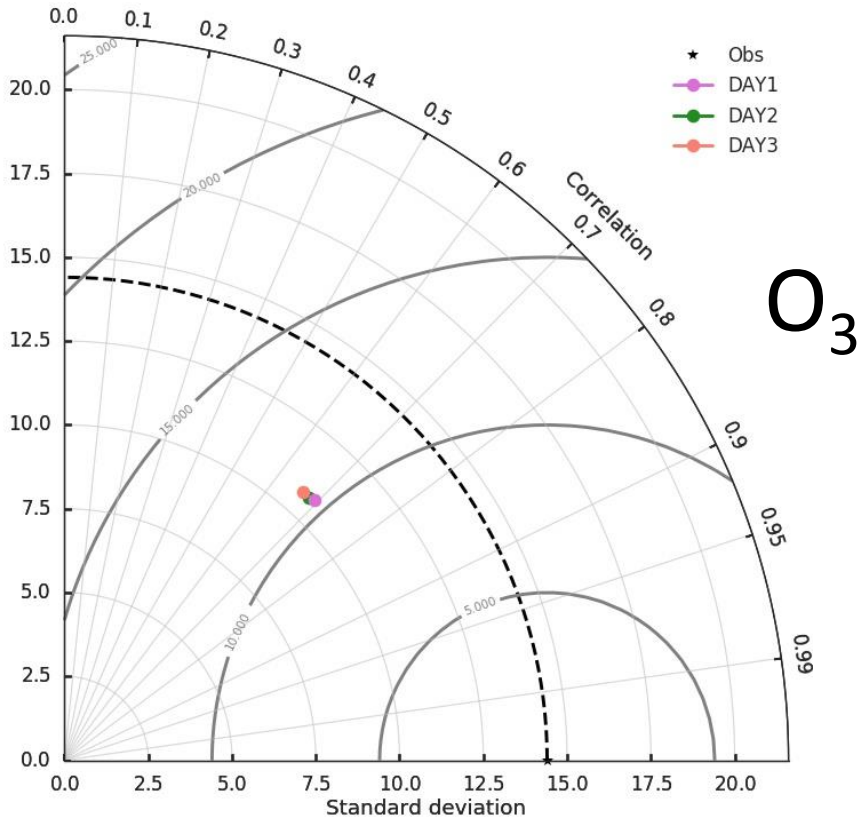


O_3

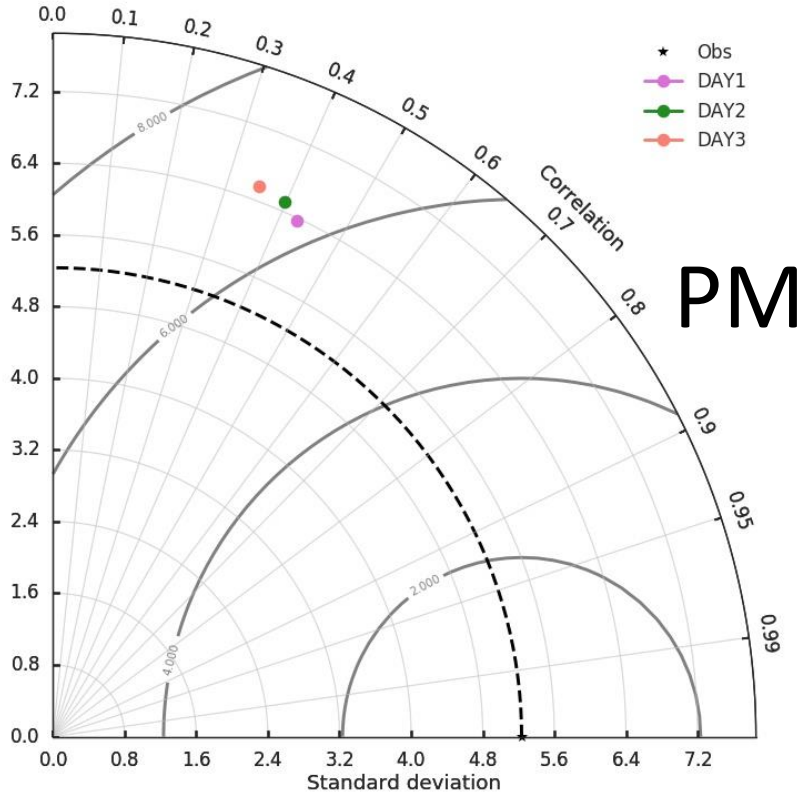


$PM_{2.5}$

Taylor Diagram for Region4 for 8/10-8/19 2017



O_3



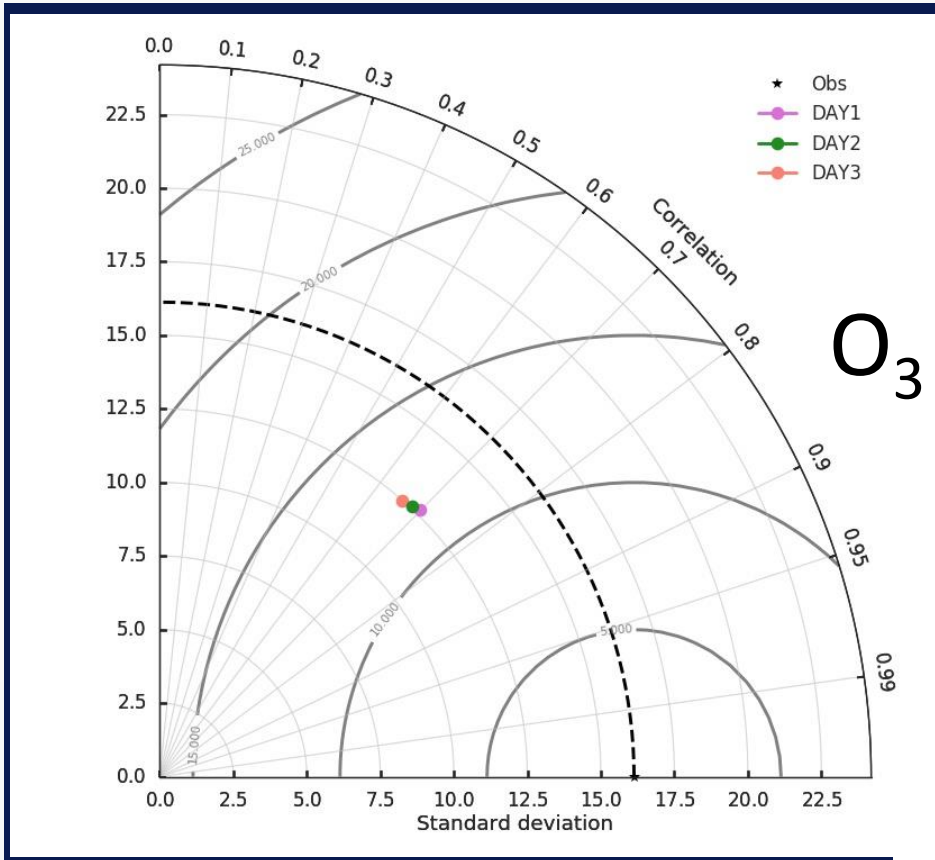
$PM_{2.5}$

NAQFC-β and pseudo ops for summer 2018

- **CMAQ5.2 with NEI2014 version 1**
  - CMAQ5.2 represents significant science advancement:
  - Gas mechanism upgrades to CB06
  - Halogen Chemistry that may reduce high O_3 bias near coast
  - Aerosol direct radiative feedback to photolytic rates
  - More efficient SOA production
- **NEI2014 fidelity in area and biogenic but may be high Mobile NO_x**
  - Area sources has updates for agricultural fires
  - Updates from neighboring countries
  - Oil and gas activity updates
  - BEIS3.61
- **72 h forecast showed promise with reasonably small degradation**
  - Biases between Day1 and Day3 maybe comparable, but the 3rd day is inferior in correlation => spatial disparity
  - Difference of monthly averaged MDA8 O_3 and 24h $PM_{2.5}$ comparable
- **For $PM_{2.5}$ a winter experiment is necessary**
  - A winter case for upper middle and NE should be interesting

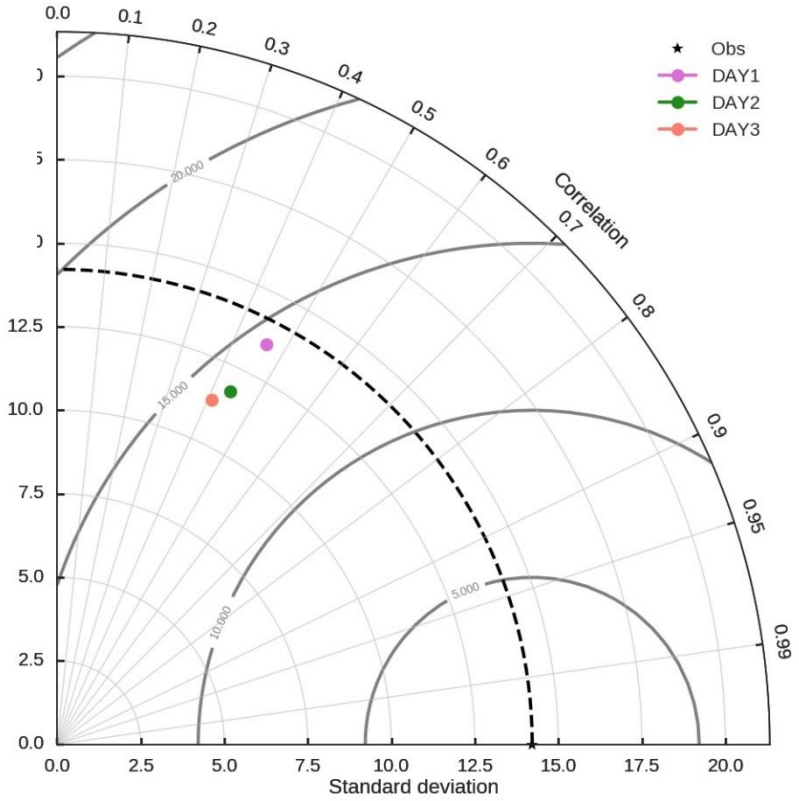
Extra Slides

Taylor Diagram for CONUS for 8/10-8/19 2017

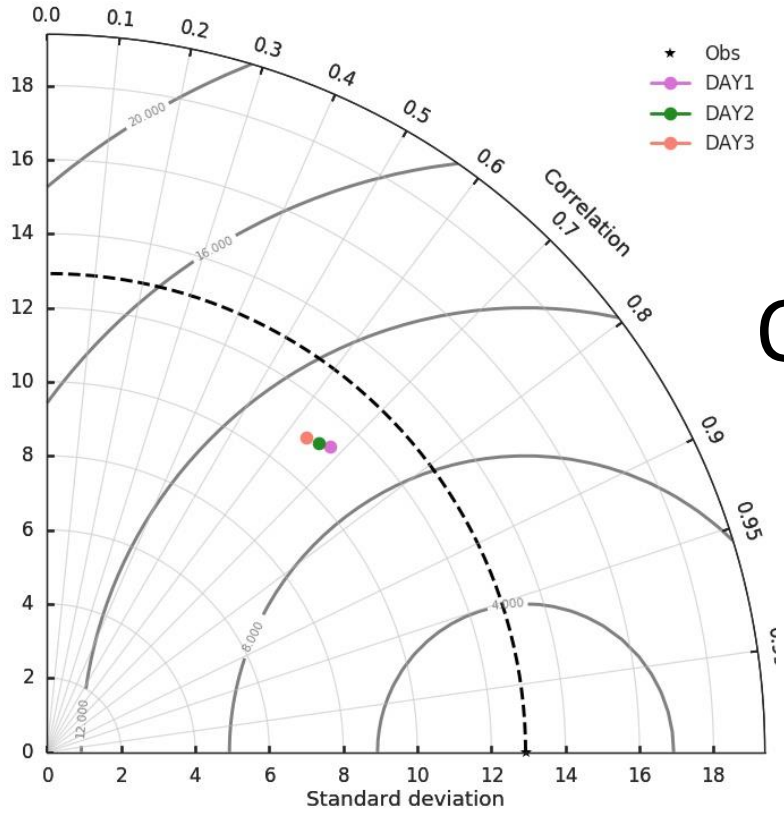


O_3

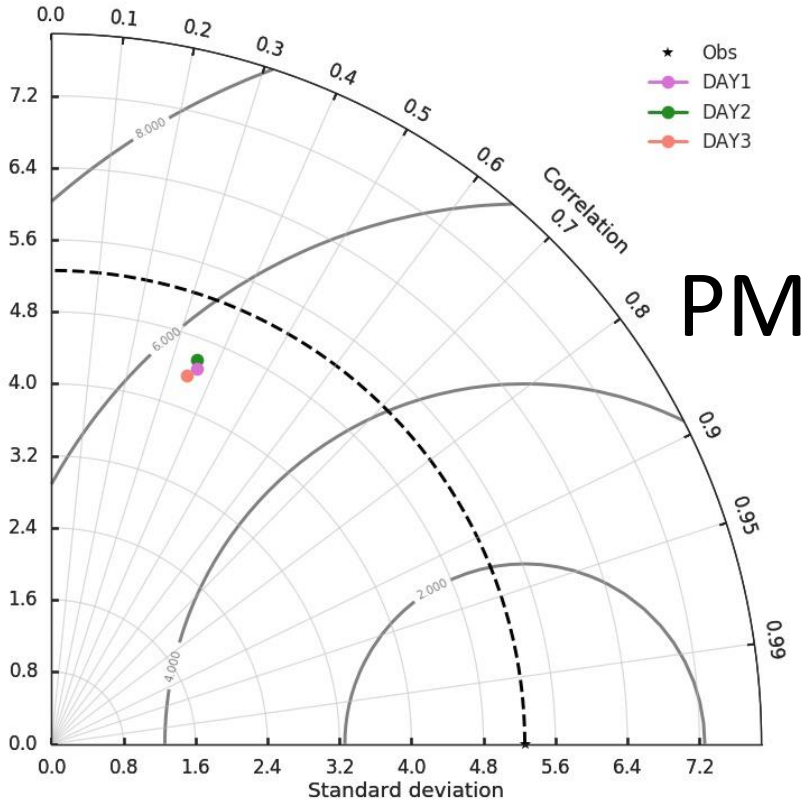
$PM_{2.5}$



Taylor Diagram for R1 for 8/10-8/19 2017

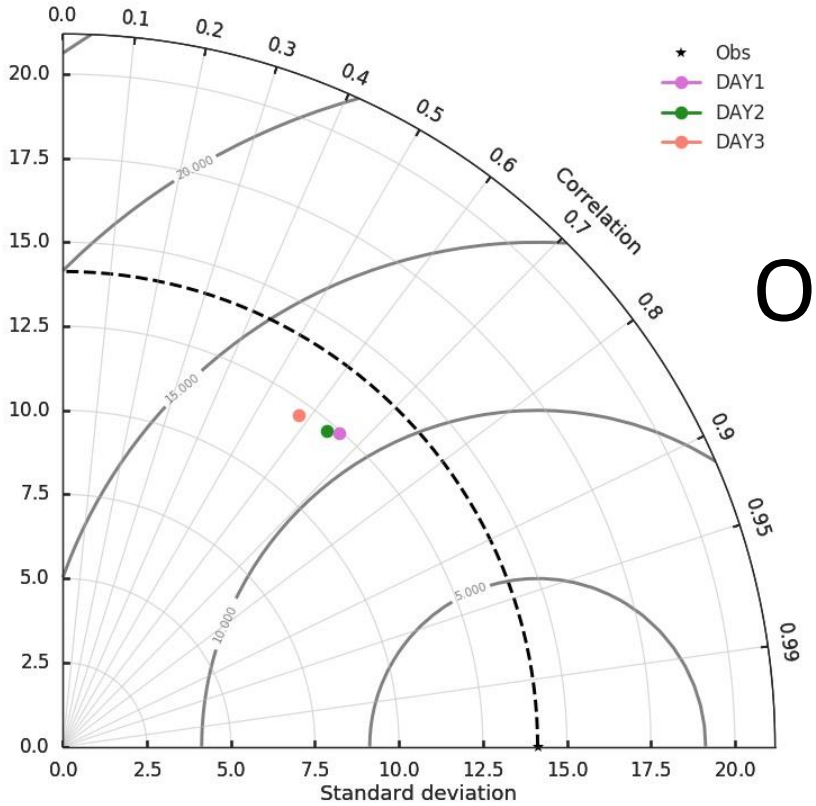


O_3

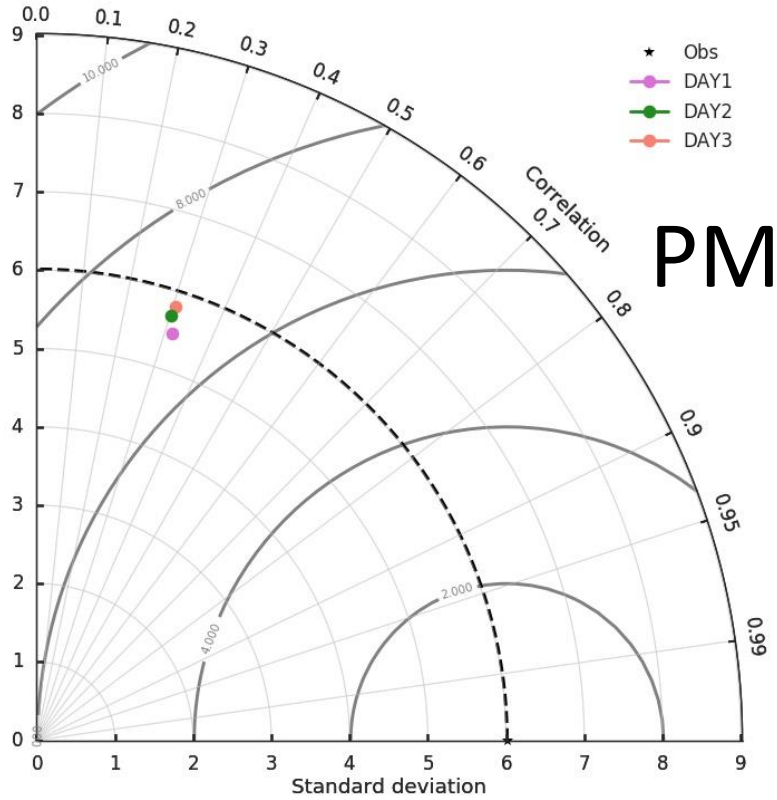


$PM_{2.5}$

Taylor Diagram for Region2 for 8/10-8/19 2017

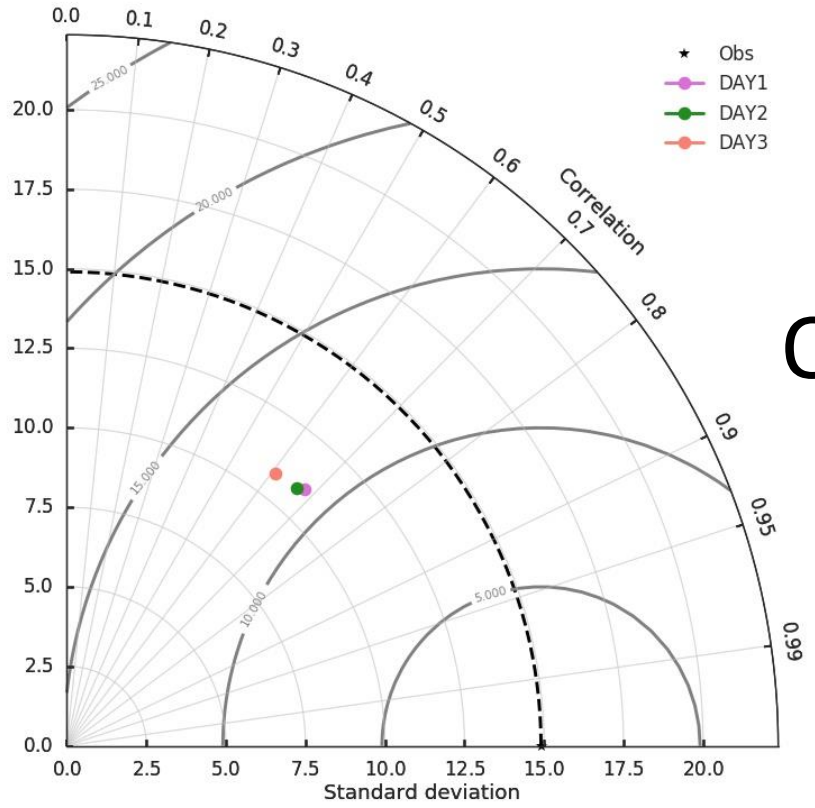


O_3

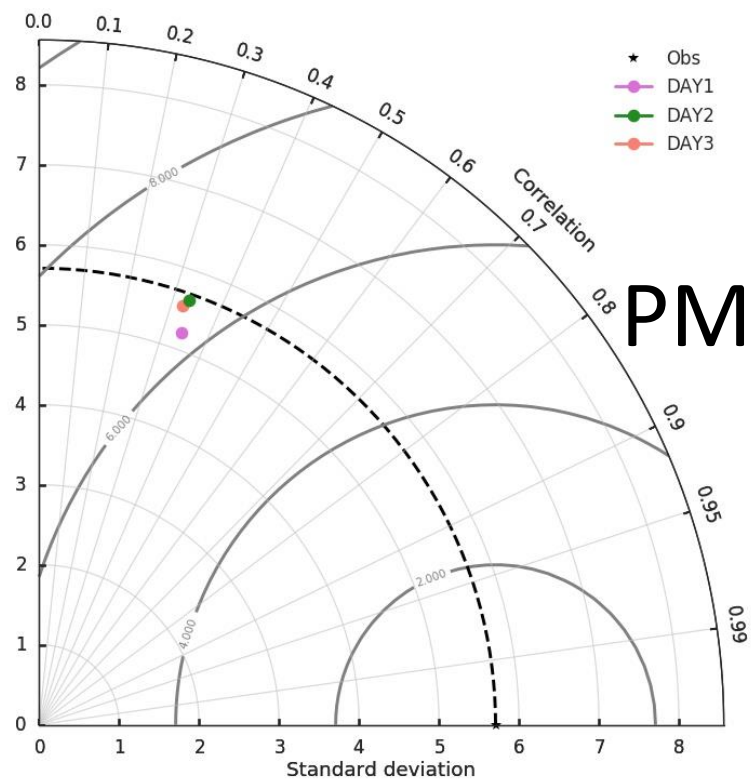


$PM_{2.5}$

Taylor Diagram for Region3 for 8/10-8/19 2017

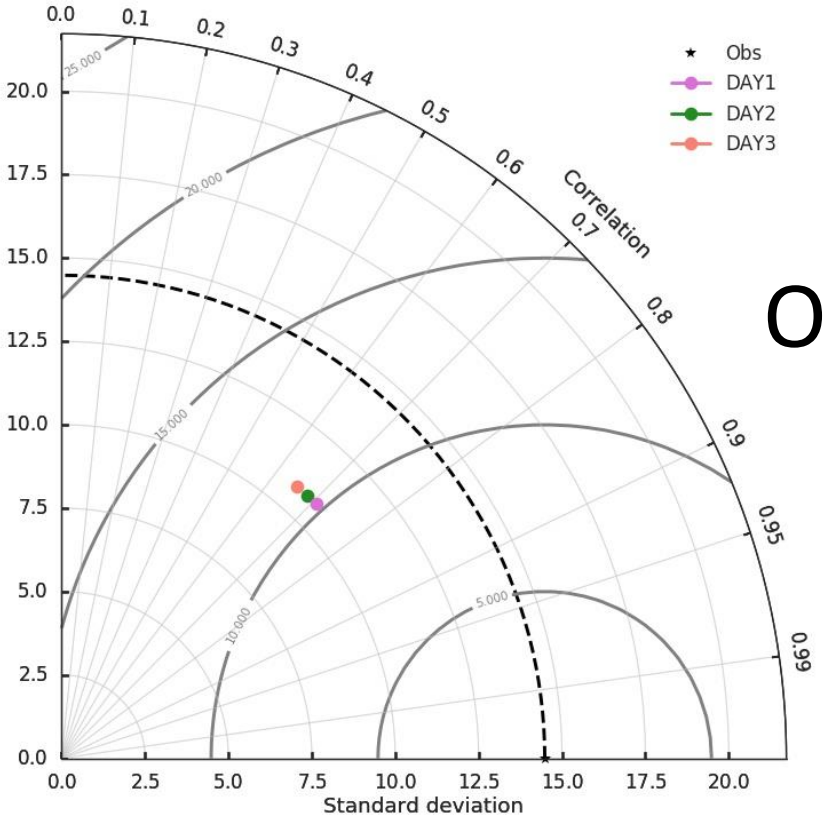


O_3

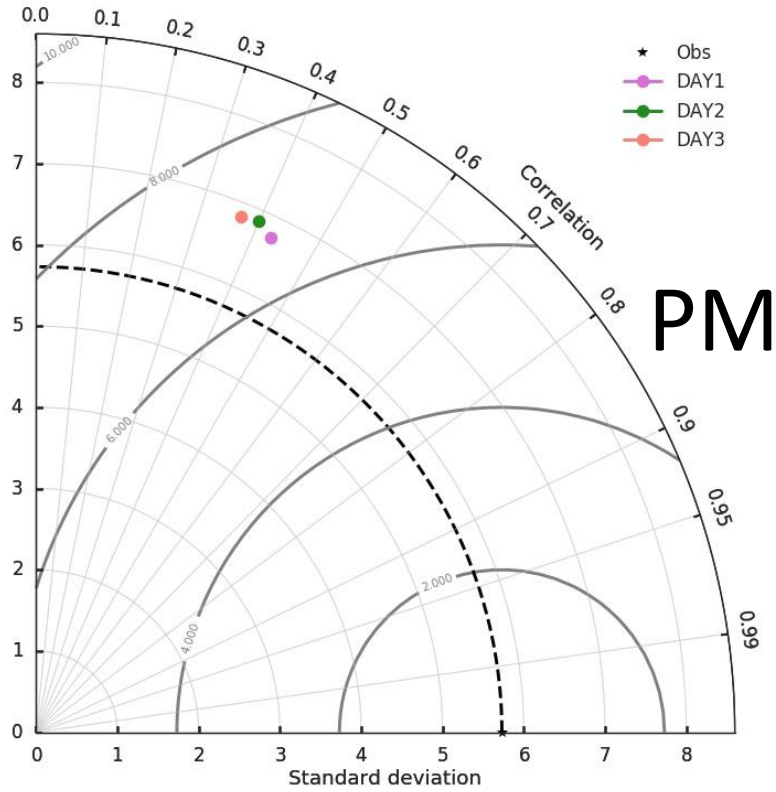


$PM_{2.5}$

Taylor Diagram for Region5 for 8/10-8/19 2017

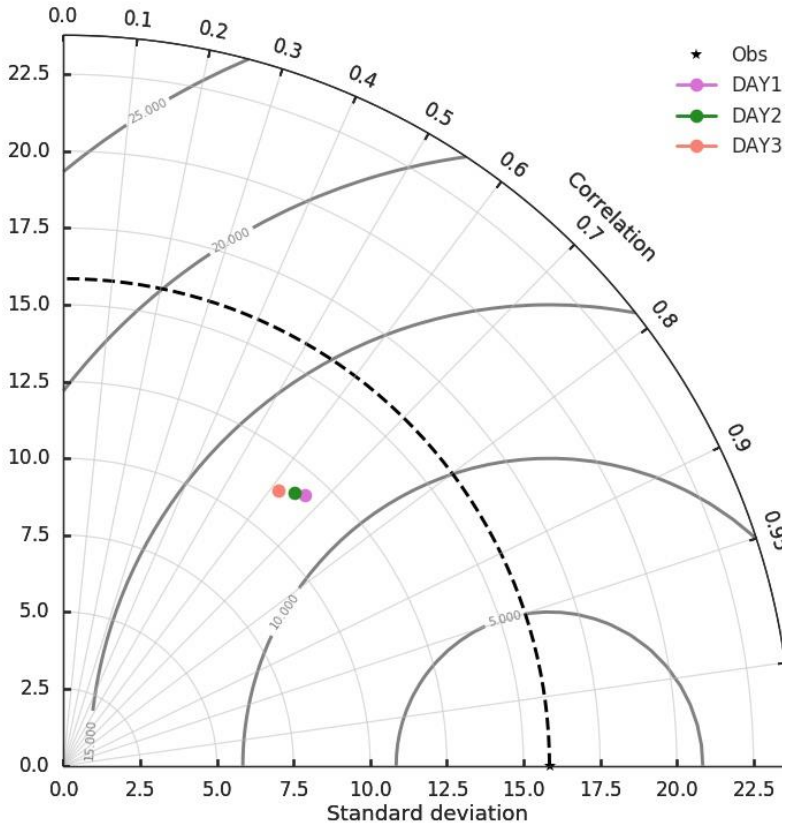


O_3

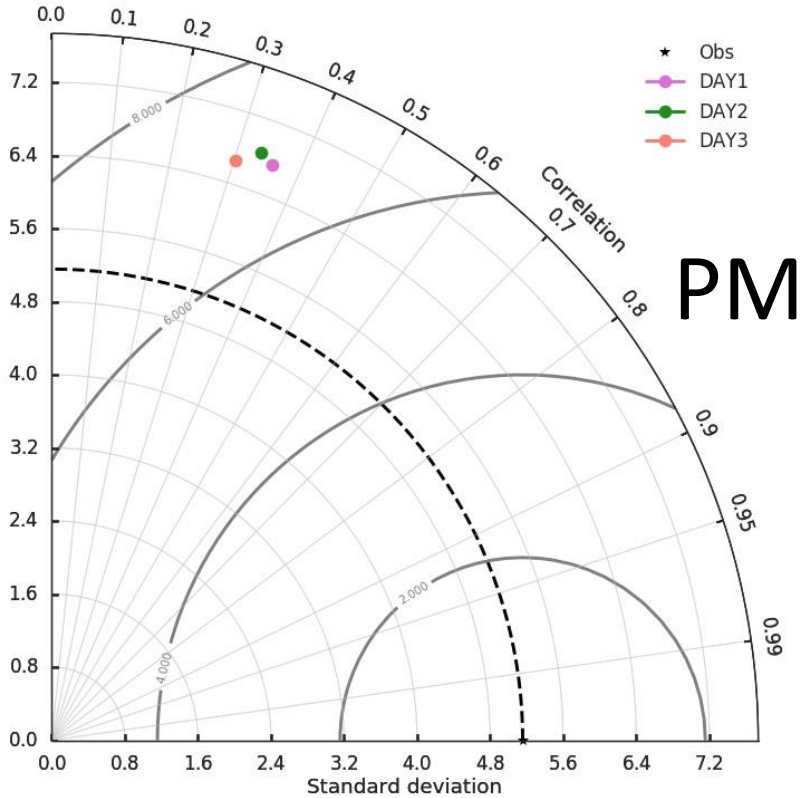


$PM_{2.5}$

Taylor Diagram for Region6 for 8/10-8/19 2017

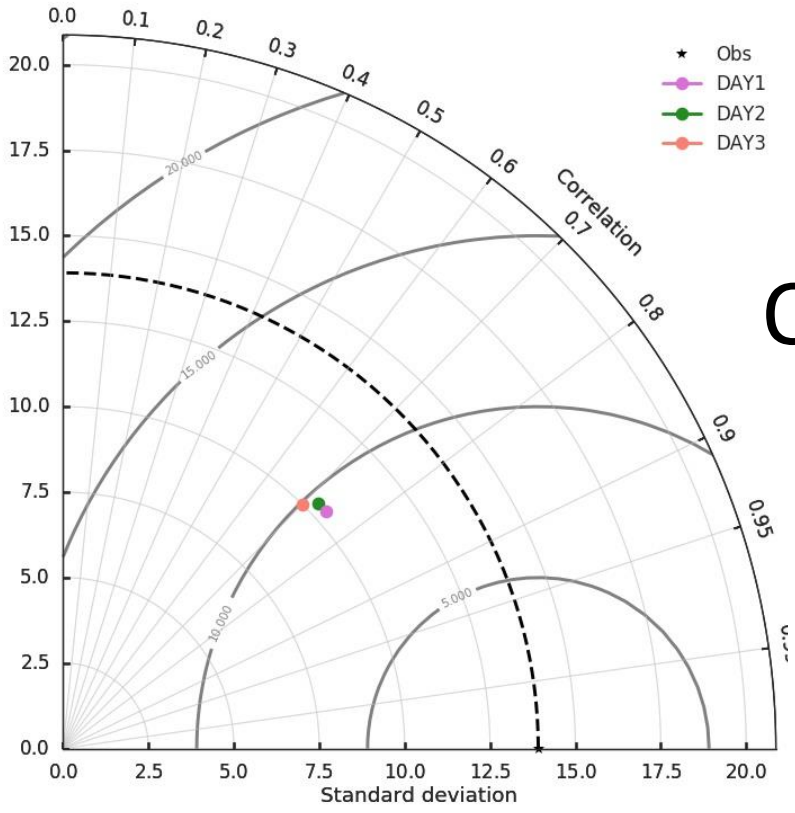


O_3

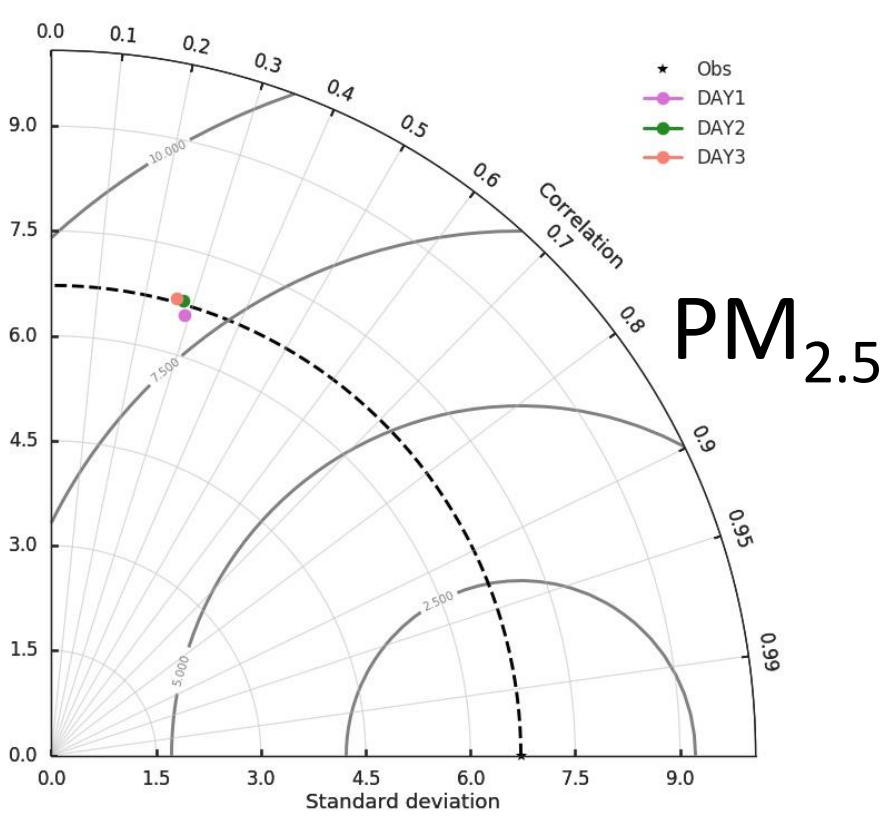


$PM_{2.5}$

Taylor Diagram for Region7 for 8/10-8/19 2017

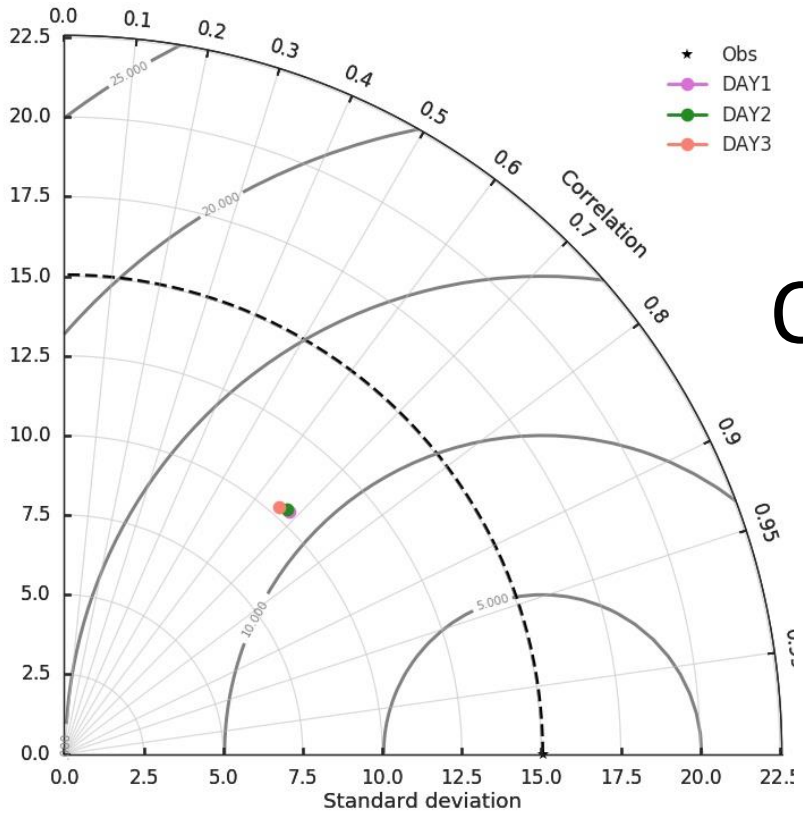


O_3

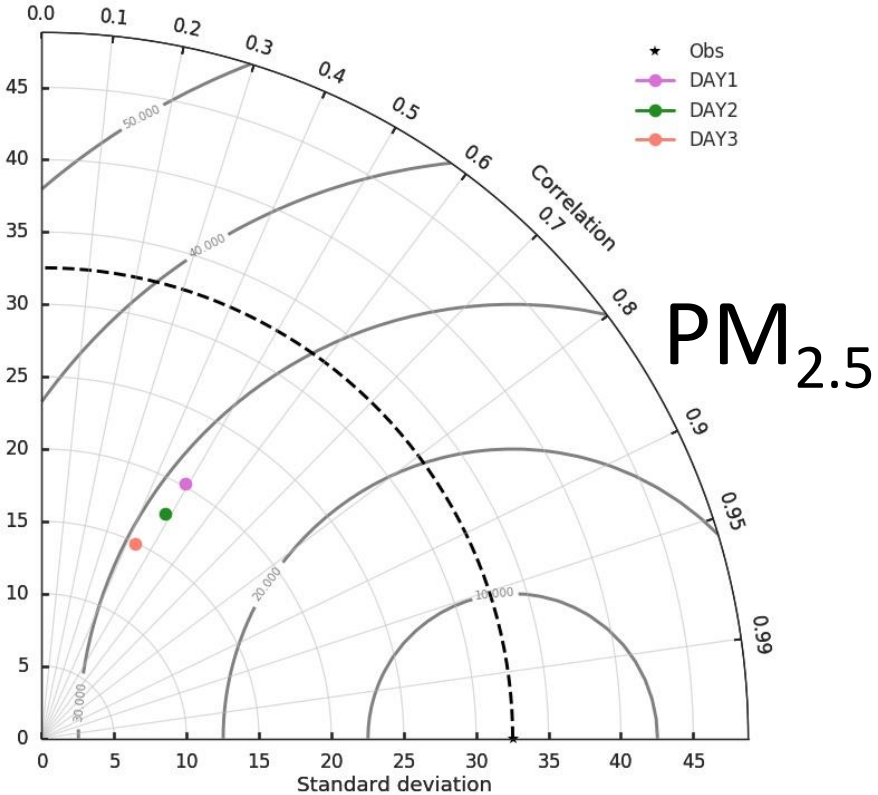


$PM_{2.5}$

Taylor Diagram for Region8 for 8/10-8/19 2017

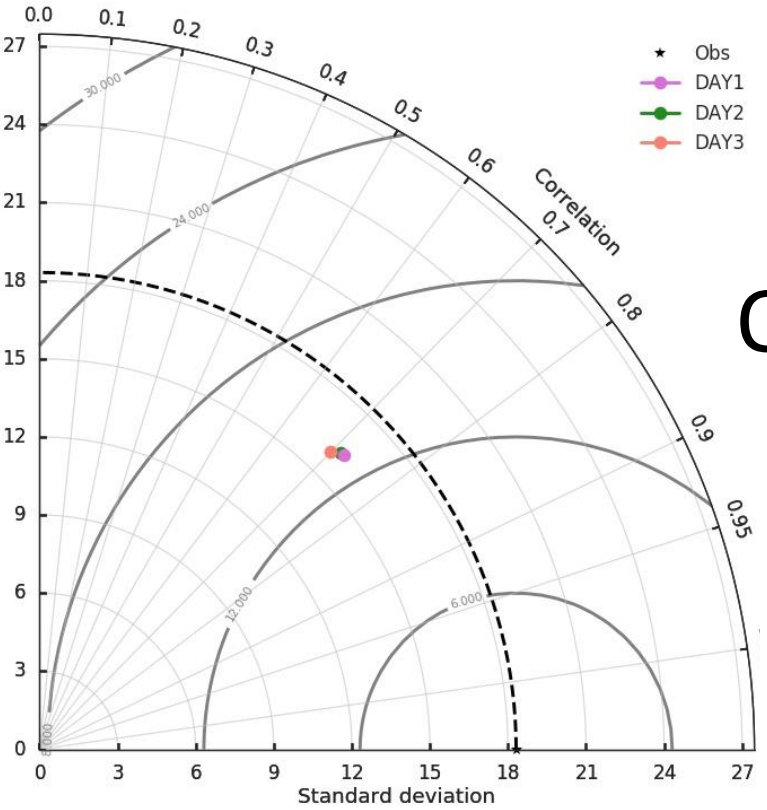


O_3

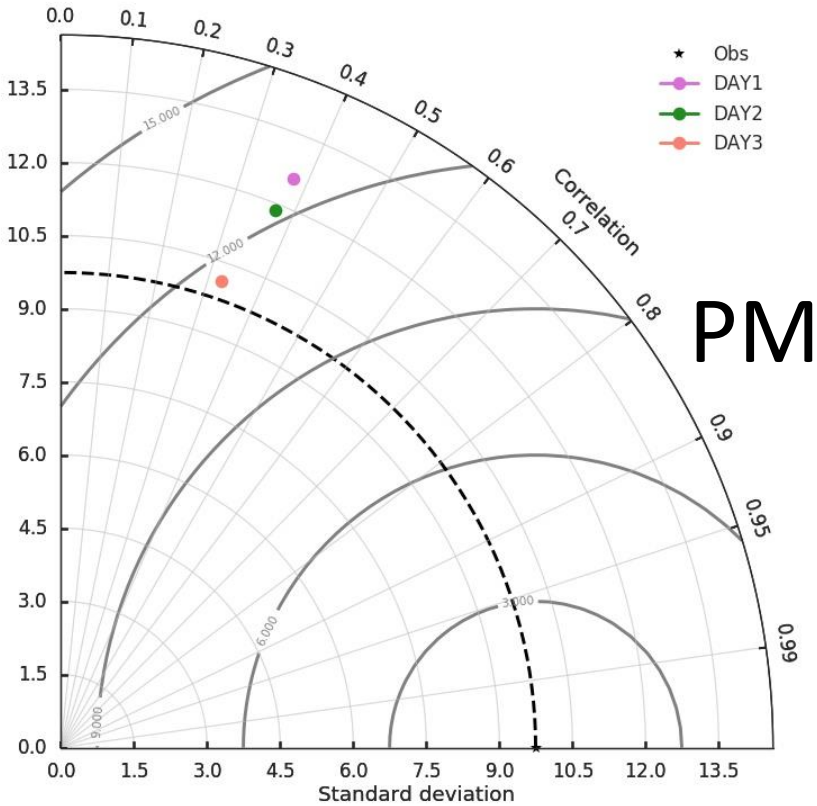


$PM_{2.5}$

Taylor Diagram for Region9 for 8/10-8/19 2017

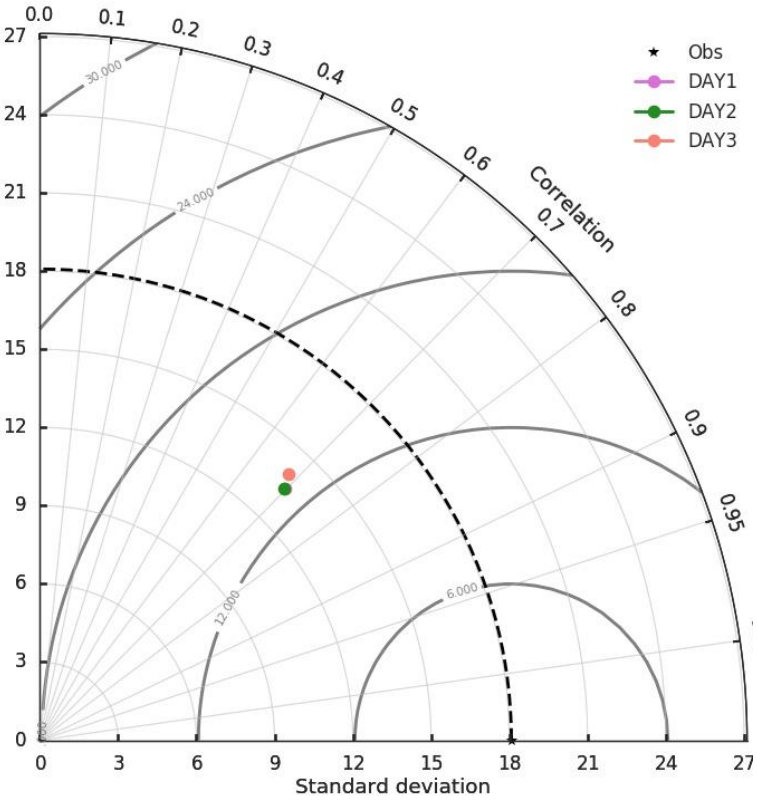


O_3

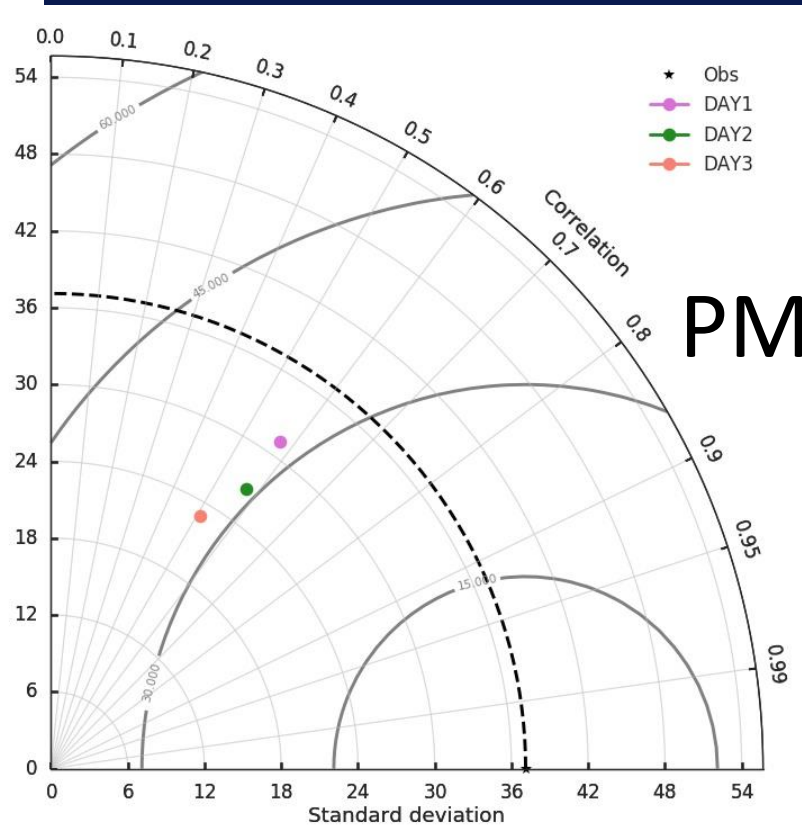


$PM_{2.5}$

Taylor Diagram for Region10 for 8/10-8/19 2017

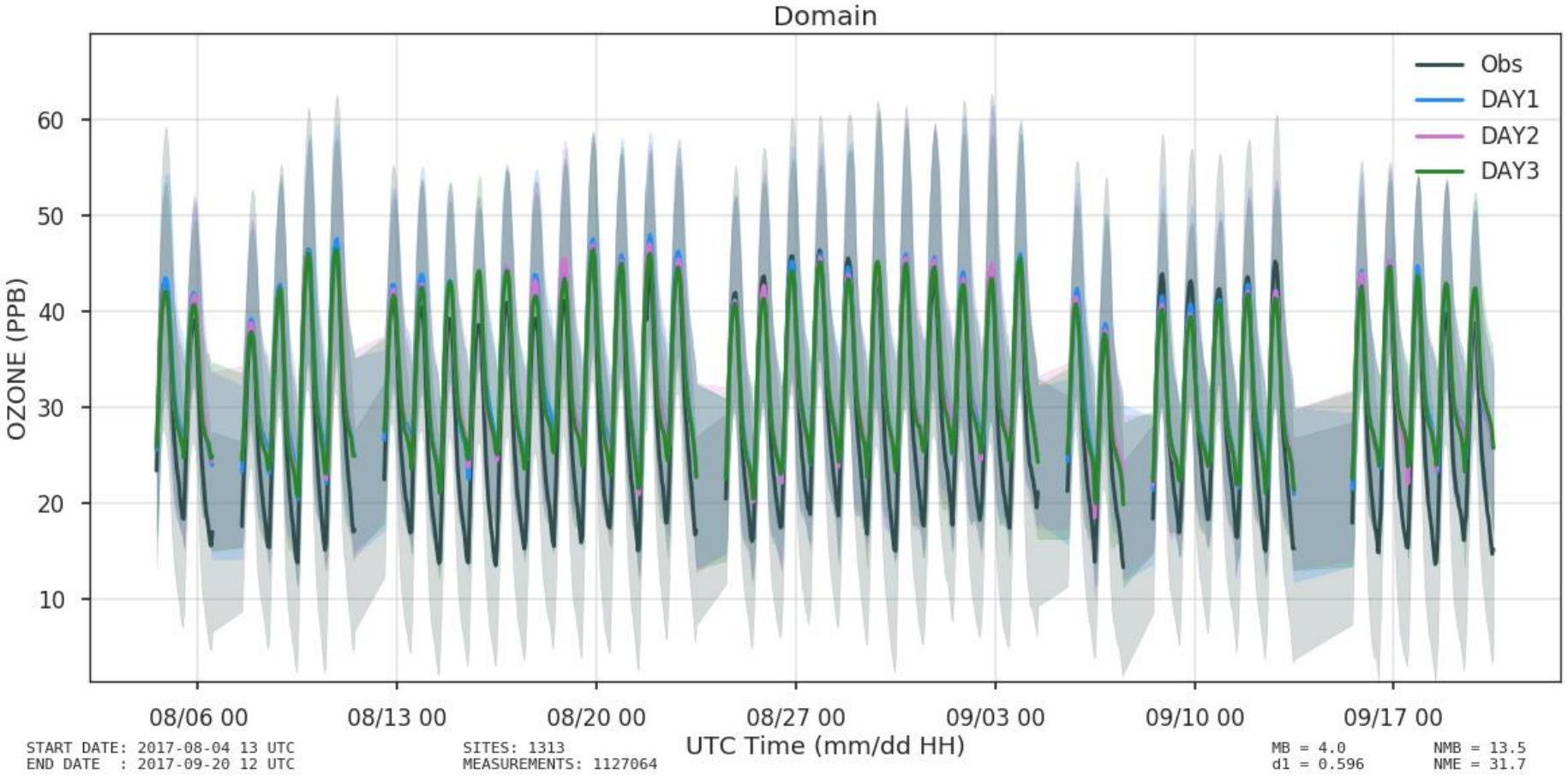


O_3



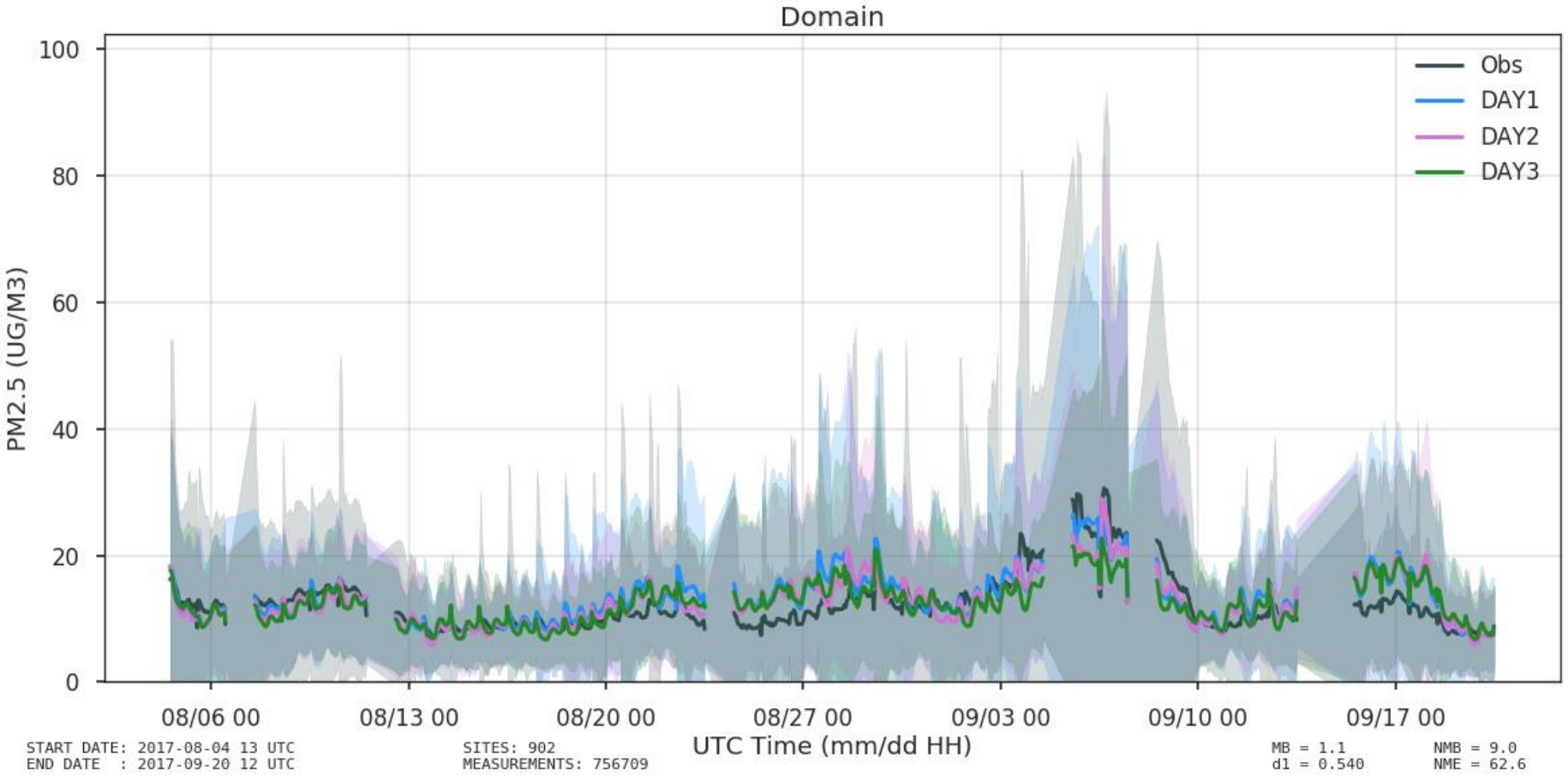
$PM_{2.5}$

Hourly O_3 forecast fidelity for Day1 Day2 & Day3 8/2-9/19 2-2017



missed days: August 4th, 9th, 21st and September 2nd and 5th

Hourly $PM_{2.5}$ forecast fidelity for Day1 Day2 & Day3 8/2-9/19 2-2017



missed days: August 4th, 9th, 21st and September 2nd and 5th