Western Regional Modeling and Analysis Platform

2014 Sensitivity Modeling Results

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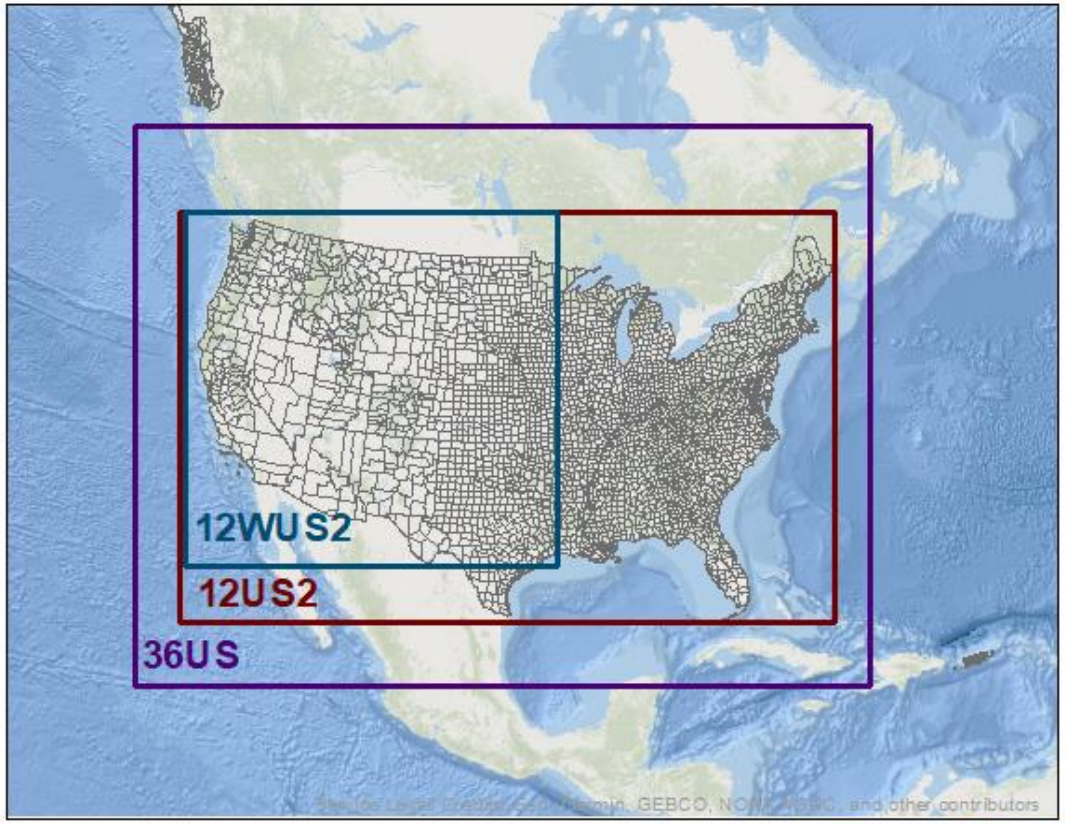
Summary Overview Model Sensitivity Results

- CAMx Model configuration
- Boundary Conditions Sensitivity Results
- Meteorological Sensitivity Results
- Biogenic Sensitivity Results
- Final configuration for CAMx and CMAQ 2014 shakeout Annual Simulations

Overview of Horizontal Modeling Domain

- 2014 January and July sensitivities with 12-km domain
  - One WAQS 36-km CONUS (36US1) to set lateral boundary concentrations in 12-km domains
  - Two 12-km domains:
    - EPA 12US2 (396 x 246 cells)
    - WAQS 12WUS2 (225 x 213 cells)



Overview of Vertical Modeling Domain

- 36US1 and 12WUS2 use same WAQS WRF meteorology and have same vertical structure
- 12US2 driven by EPA WRF meteorology has a different vertical structure:
  - Boundary conditions from 36US1 are vertically interpolated to match EPA WRF vertical structure
- Both 12-km domains use a layer collapsing strategy that takes the WRF 36/37 vertical layers to 25 layers for CAMx
  - Results in ~30% speed-up in run times

WAQS 2014 WRF				
PGM Layers	WRF Layer	WRF eta	WRF Pressure (mb)	Height (m)
	0	1	1000	0
	1	0.9985	998.575	12
1	2	0.997	997.15	24
	3	0.995	995.25	40
2	4	0.993	993.35	56
	5	0.991	991.45	72
3	6	0.988	988.6	97
	7	0.985	985.75	121
4	8	0.98	981	162
5	9	0.97	971.5	243
6	10	0.96	962	326
7	11	0.95	952.5	409
	12	0.94	943	492
8	13	0.93	933.5	577
9	14	0.91	914.5	747
10	15	0.89	895.5	921
11	16	0.87	876.5	1098
12	17	0.84	848	1369
13	18	0.8	810	1742
14	19	0.76	772	2130
15	20	0.72	734	2533
16	21	0.68	696	2954
17	22	0.64	658	3393
18	23	0.6	620	3854
19	24	0.55	572.5	4463
	25	0.5	525	5115
20	26	0.45	477.5	5816
	27	0.4	430	6576
21	28	0.35	382.5	7408
	29	0.3	335	8328
22	30	0.25	287.5	9360
	31	0.2	240	10541
23	32	0.15	192.5	11930
	33	0.1	145	13630
24	34	0.06	107	15355
	35	0.027	75.65	17205
25	36	0	50	19260

EPA 2014 WRF				
PGM Layers	WRF Layer	WRF eta	WRF Pressure (mb)	Height (m)
	0	1	1000	0
1	1	0.9975	997.625	20
2	2	0.995	995.25	40
3	3	0.99	990.5	80
	4	0.985	985.75	121
4	5	0.98	981	162
5	6	0.97	971.5	243
6	7	0.96	962	326
	8	0.95	952.5	409
7	9	0.94	943	492
	10	0.93	933.5	577
8	11	0.92	924	662
	12	0.91	914.5	747
9	13	0.9	905	834
10	14	0.88	886	1009
11	15	0.86	867	1188
12	16	0.84	848	1369
13	17	0.82	829	1554
14	18	0.8	810	1742
15	19	0.77	781.5	2031
16	20	0.74	753	2329
17	21	0.7	715	2741
18	22	0.65	667.5	3282
19	23	0.6	620	3854
	24	0.55	572.5	4463
20	25	0.5	525	5115
	26	0.45	477.5	5816
21	27	0.4	430	6576
	28	0.35	382.5	7408
22	29	0.3	335	8328
	30	0.25	287.5	9360
23	31	0.2	240	10541
	32	0.15	192.5	11930
24	33	0.1	145	13630
	34	0.05	97.5	15863
25	35	0	50	19260

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Overview of Emissions

- Anthro Emissions: 2014NEIv2 with Updates from Western States
- Biogenic Emissions: MEGAN and BEIS biogenic emissions
- Fire Emissions: 2014 NEI (Bluesky) with Fire and Smoke WG Updates
- Natural Emissions: LNOx; WBD; Oceanic (SSA/DMS) CAMx processors
- EPA has developed CMAQ-ready emissions based on the 2014 NEI version 2 inventories
- Start with the EPA 2014 CMAQ-ready 12-km 12US2 domain emissions and conduct SMOKE processing as needed to update any emission inputs that are different than the 2014 NEIv2
  - Example: Point and Non-Point source sectors updated by the western states

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Boundary Conditions Sensitivity

Based on EPA's 2014 GEOS-Chem simulation used to define BCs for EPA's 2014 Modeling Platform (NATA)

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Boundary Conditions Sensitivity: Background

- Lateral concentrations at the boundary of 36-km domain (36US) in the 2014 modeling platform are downscaled from 2014 GEOS-Chem global model
- EPA's 2014 GEOS-chem simulation attributes (out-of-the-box):
  - Model version: v11-01
  - Spatial Resolution: horizontal – 4x5 degree (~440-km), vertical – 47 layers
  - Temporal Resolution: 3-hourly, Spatial Coverage: (-147.5, 8) to (-52.5, 64)
  - Chemistry/Aerosol Options: SOA
  - Barron Henderson (EPA/OAQPS) indicated 2014 GEOS-Chem run included volcano eruptions not representative of 2014 that leads to excessive SO2 and sulfate in June and July and has overstated tropospheric ozone year-round
- CAMx boundaries obtained with geos2camx tool
- CMAQ boundaries obtained with Air Quality Model Boundary Conditions (AQMBC) python-based tool

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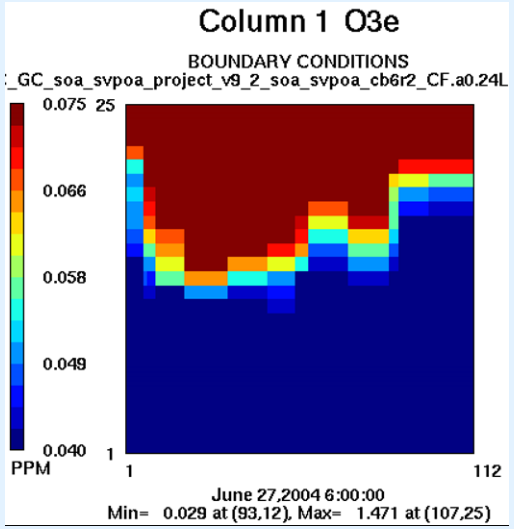
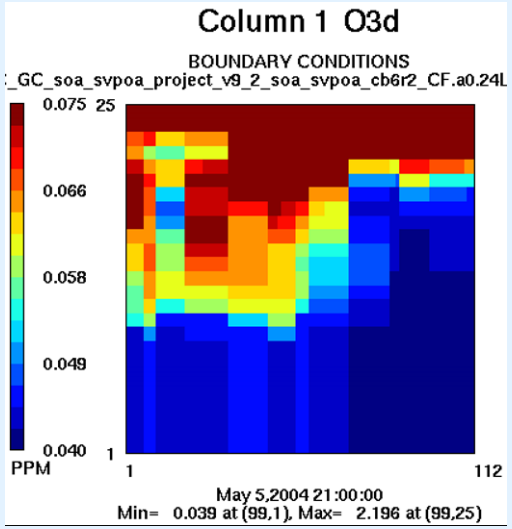
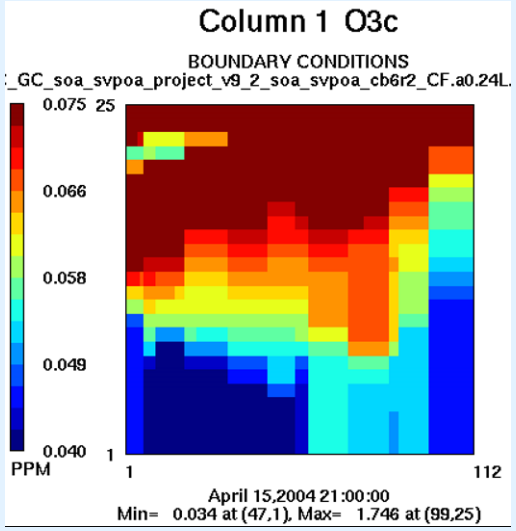
Vertical Profile of GEOS-Chem concentrations

- Ozone concentrations for January, April, August at upper layers show values over 2 ppm

January	April	August
		

- Performed initial CAMx 36-km and 12-km inert tracer runs to investigate the BCON influence on surface concentrations for selected species:
  - O3, dust (CCRS, FCRS), SO2, PSO4, sea salt (NA, PCl)

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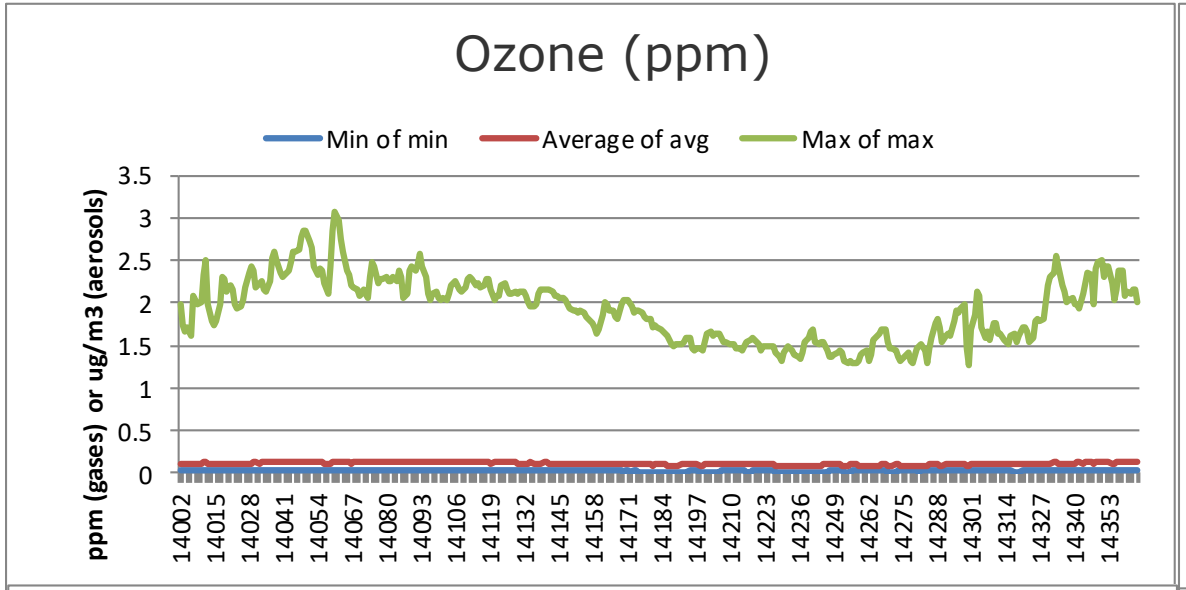
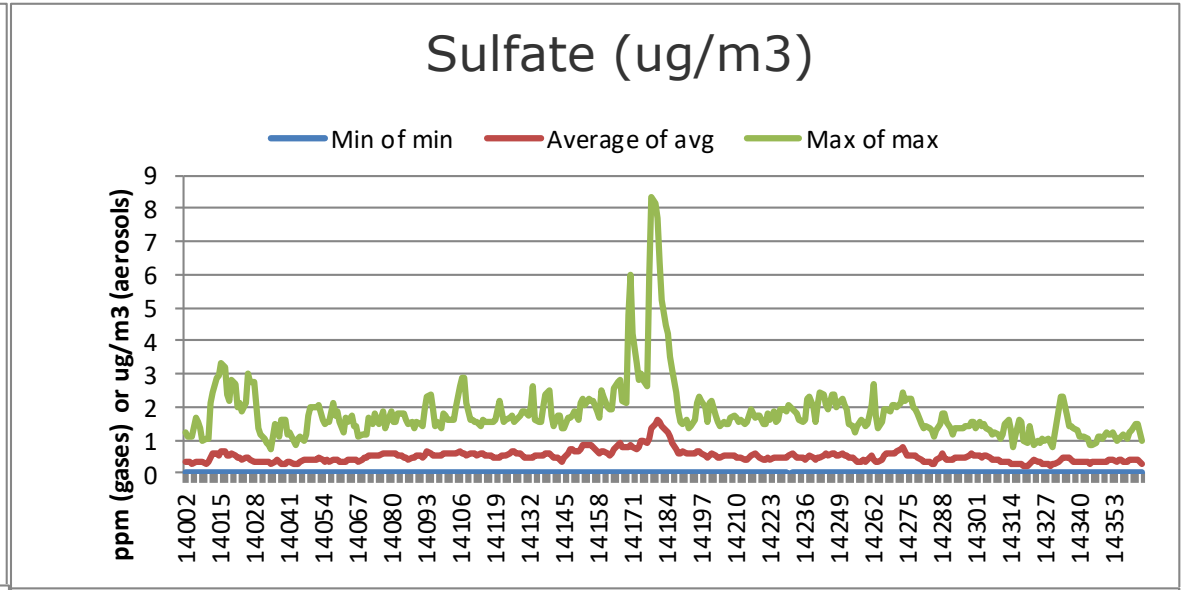
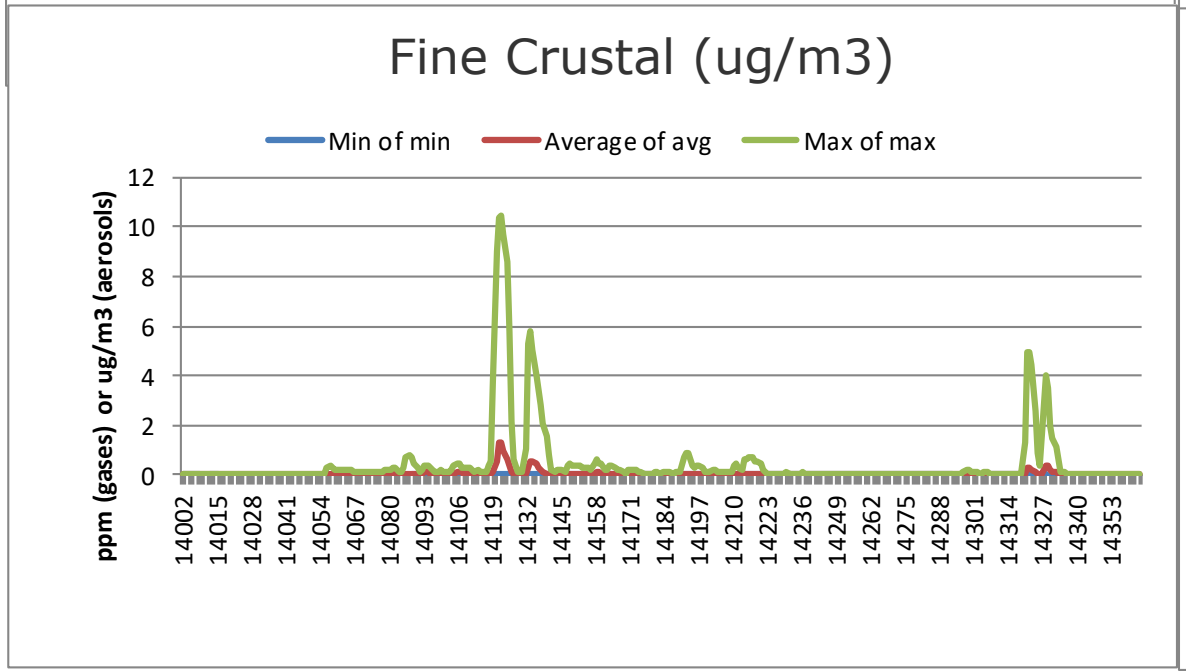
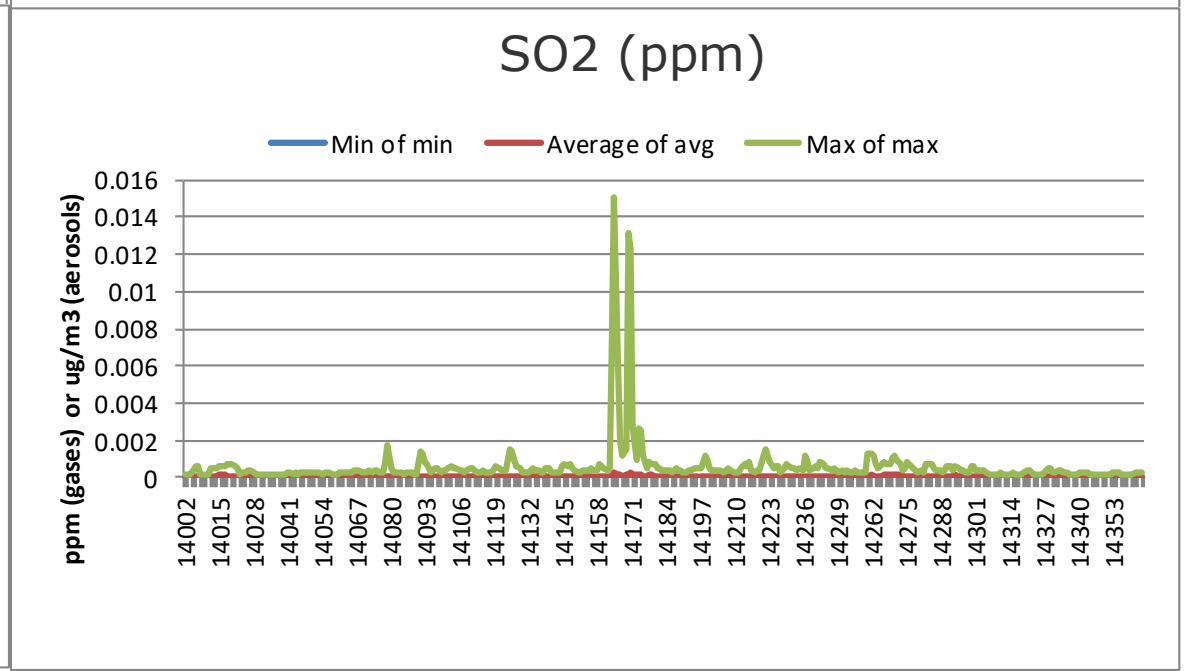
Max, Min, AVG WEST BC 36-km 36US1 Domain



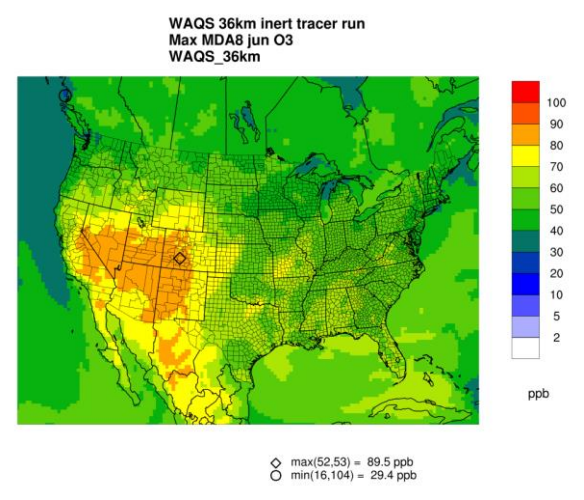
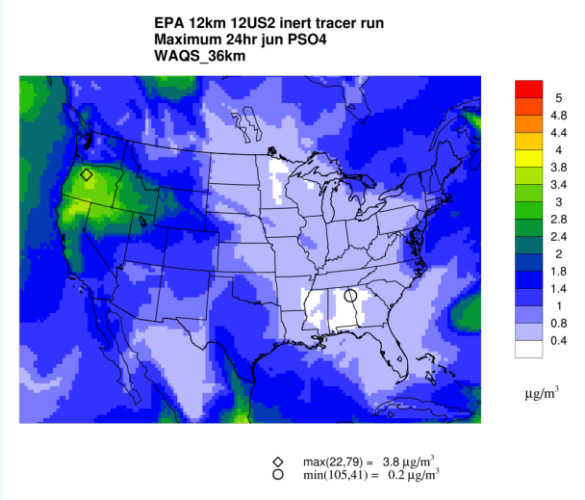
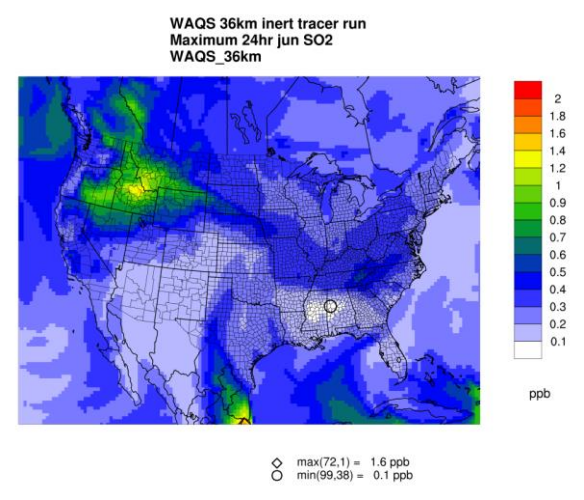
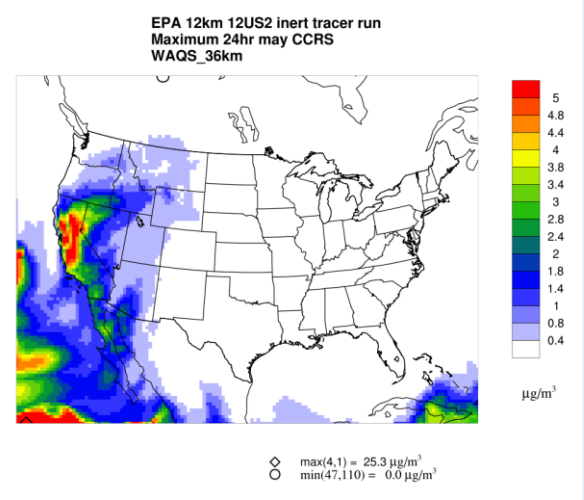






Inert Tracer Sensitivity Simulation Results

- MDA for ozone and daily max concentrations for sulfate, SO2, dust and sea salt

Ozone - June	PSO4 – June	SO2 - June	CCRS - May
			

- Ozone BC tracer concentrations > 90 ppb in western US in the summer (June, July August)
- Sulfate BC tracer concentrations are ~ 4 $\mu g/m^3$ in Northern CA, WA in June and July
- SO_2 BC tracer concentrations are ~ 2 ppb in Idaho in June
- Dust (CCRS/FCRS) BC tracer concentrations ~ 9.4 $\mu g/m^3$ in Central CA
- No issues with sea salt BC tracer concentrations since they are low (Na and Cl < 1 $\mu g/m^3$).

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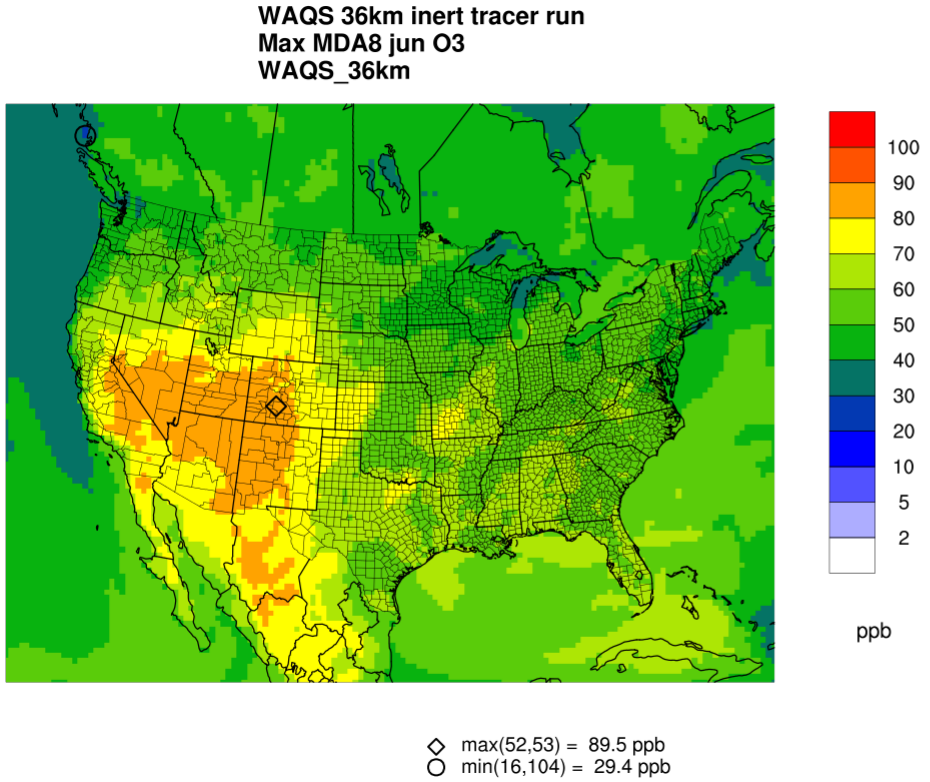
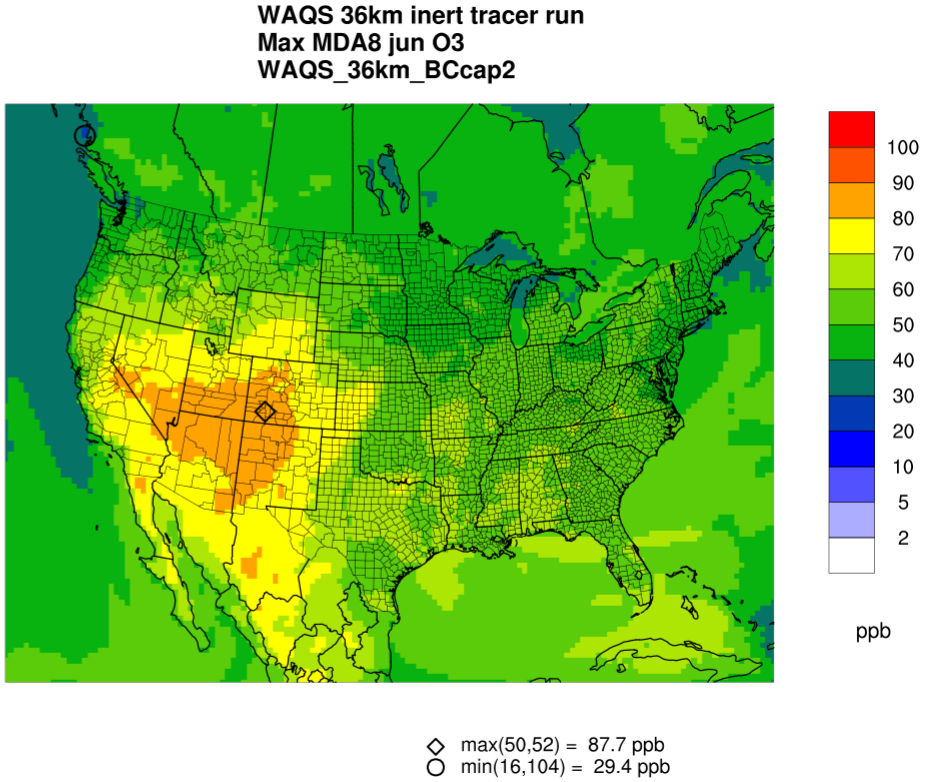
Inert Tracer Simulations with Adjusted BCON

- Performed Inert tracer simulations with initial cap values for: ozone, sulfate and SO_2
- Ozone concentrations remain high in WUS even with cap values of ≤ 0.1 ppm (100 ppb)

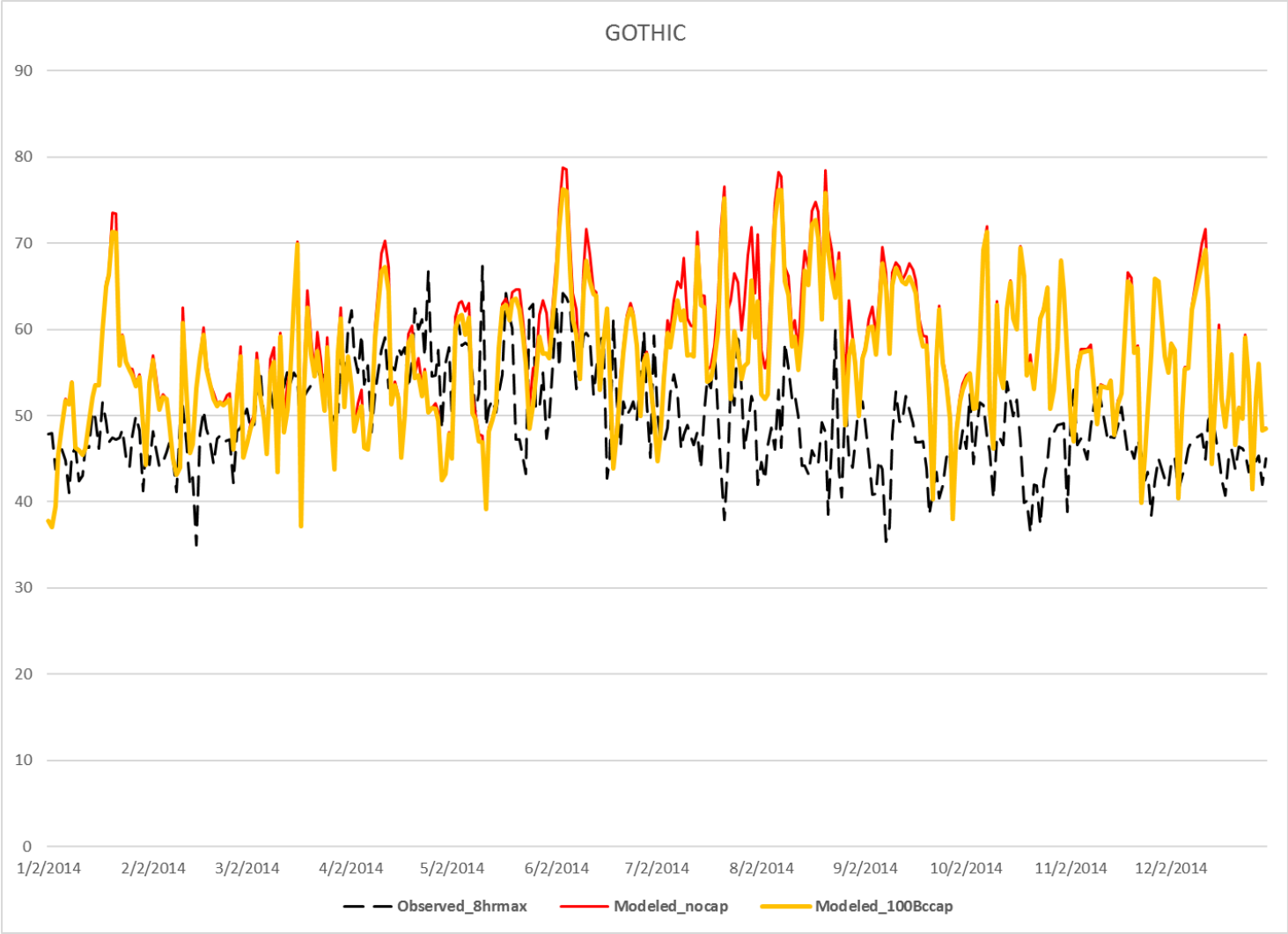
→ Ozone overprediction mainly due to overstated tropospheric ozone





Inert O3 tracer simulation with Adjusted BCON

- Inert tracer compared to CASTNET observations at Gothic, CO consistently overpredicts values
- Effect of the cap values is negligible at this site



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EPA 2014 GEOS-Chem Simulation

- Discussion with EPA/OAQPS on their 2014 GEOS-Chem run used for 2014 BCs
- 2014 GEOS-Chem run out-of-the-box
  - Noticed systematic ozone overestimation tendency
- EPA moved on to 2016 GEOS-Chem simulation and made numerous updates
  - GC version, HTAP emissions, NEWFINN, LNOx, no volcano eruption emissions
  - Reduced ozone overestimation tendency
  - Ultimately went with CMAQ-HEMI for 2016 modeling platform BCs
- EPA's 2014 GEOS-Chem was run with volcano eruption emissions
  - GEOS-Chem uses climatological volcano eruption emissions that included large eruption in Jun/Jul 2009 that adversely affected 2014 36US1 domain SO2/SO4 BCs
- EPA offered to rerun 2014 GEOS-Chem for Jun/Jul w/o volcano eruptions
  - Although affected timing and out-of-scope, too important not to fix Jun/Jul BCs

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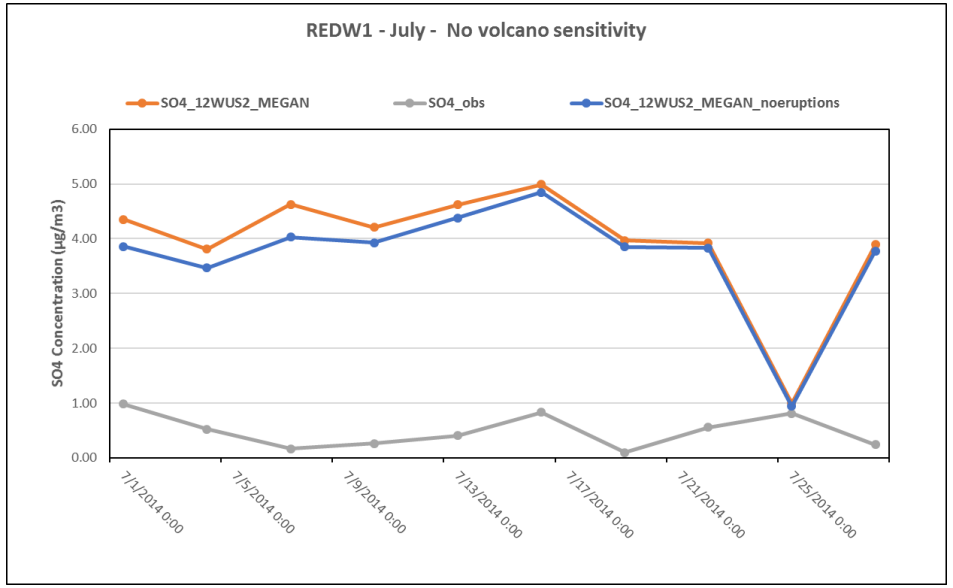
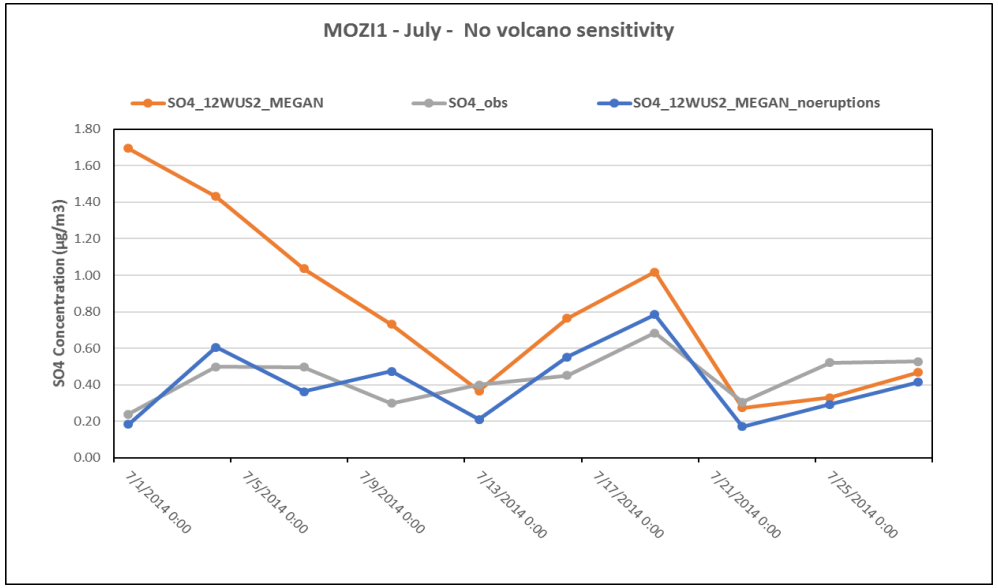
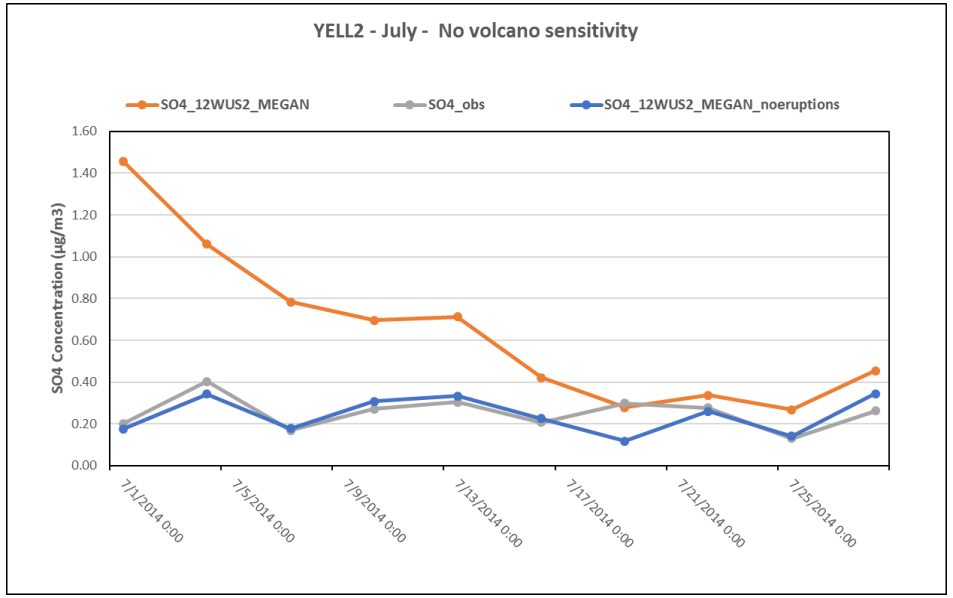
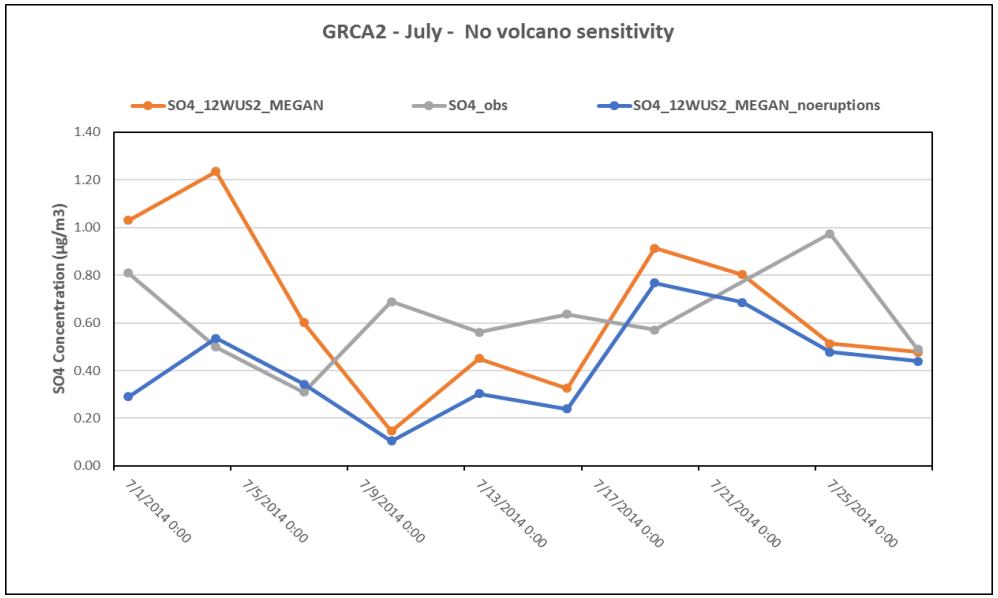
Effect of Eruptions vs. No Eruptions in Boundary Conditions (July)









- Updated GEOS-Chem concentrations with no eruptions for June and July correct the over-predictions in summer

Adjustments to Boundary Concentrations

- Boundary concentrations are adjusted using a maximum cap value

Species	Adjustment
O3	Cap values to <= 0.5 ppm
CCRS	No adjustment
FCRS	No adjustment
PSO4	Cap values to <= 2 $\mu g/m^3$
SO2	Cap values to <= 0.006 ppm
NA, Cl	No adjustment

- June and July use the updated GEOS-chem concentrations without volcano contributions (no eruptions)
  - Means the PSO4/SO2 caps have little effect

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Meteorological Sensitivity

WAQS 12-km 12WUS2 vs. EPA 12-km 12US2 WRF Meteorology

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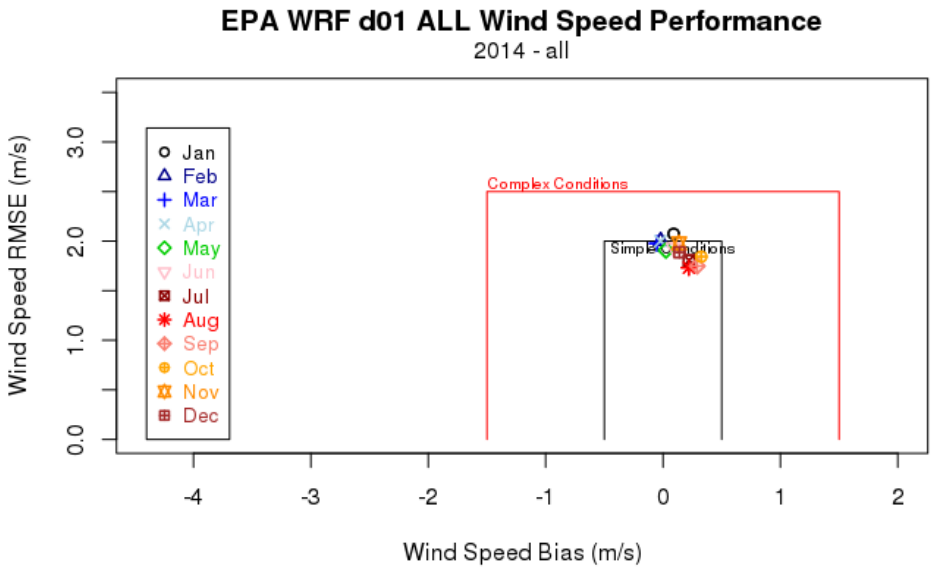
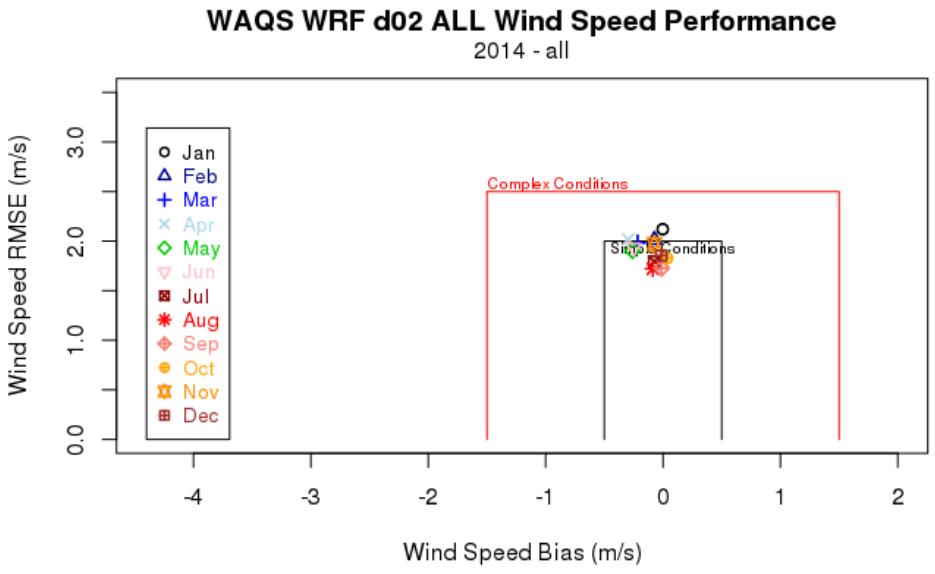
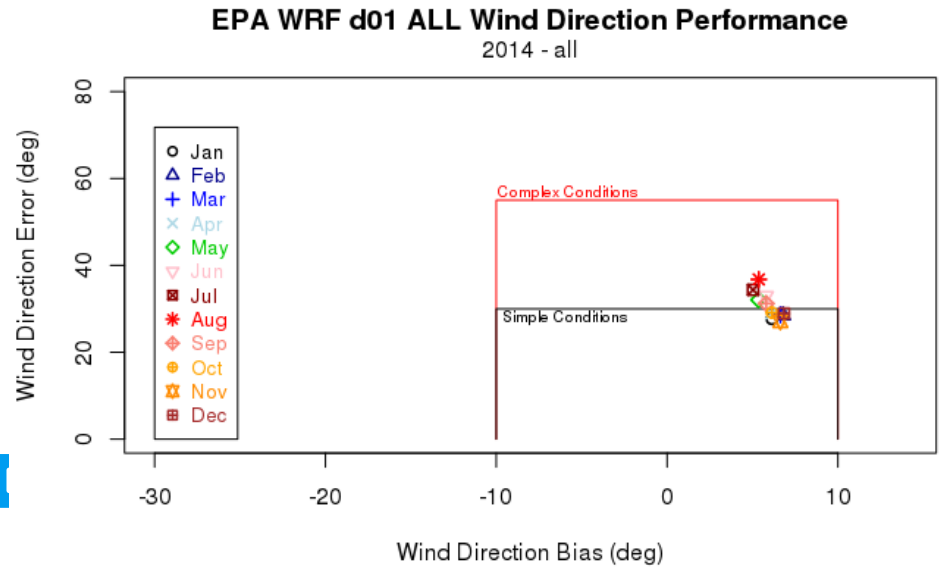
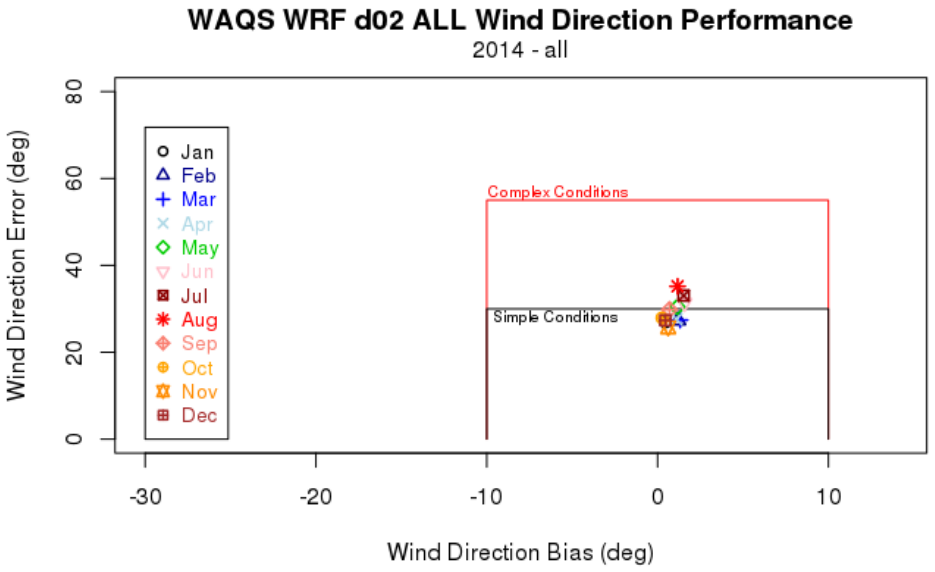
EPA vs. WAQS 12-km WRF Performance - Winds in Western US









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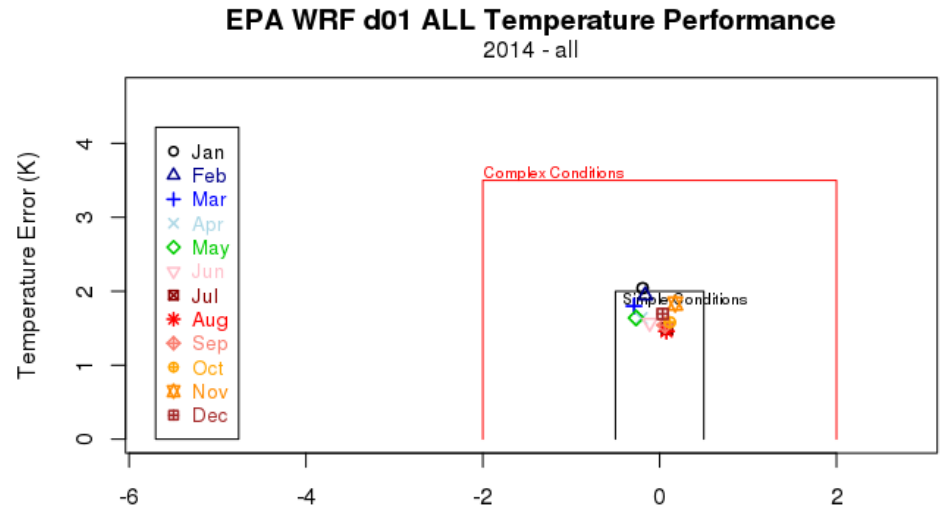
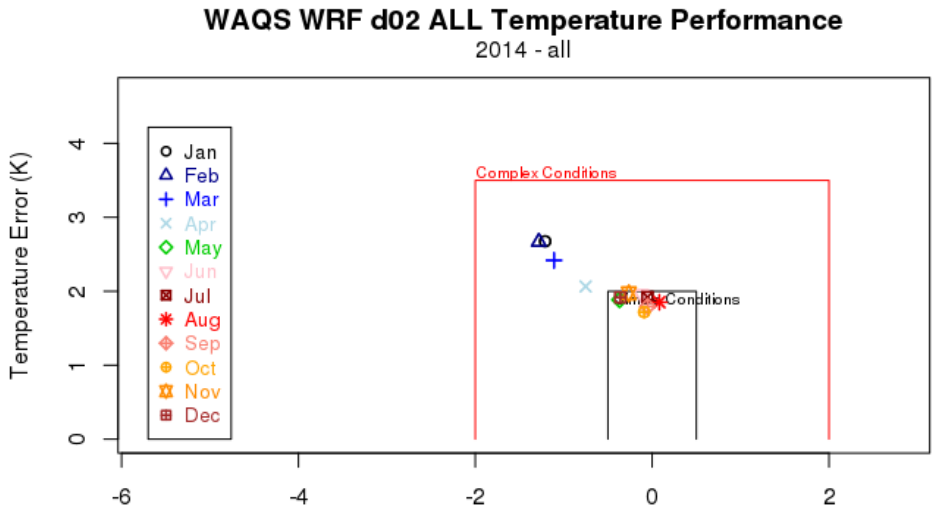
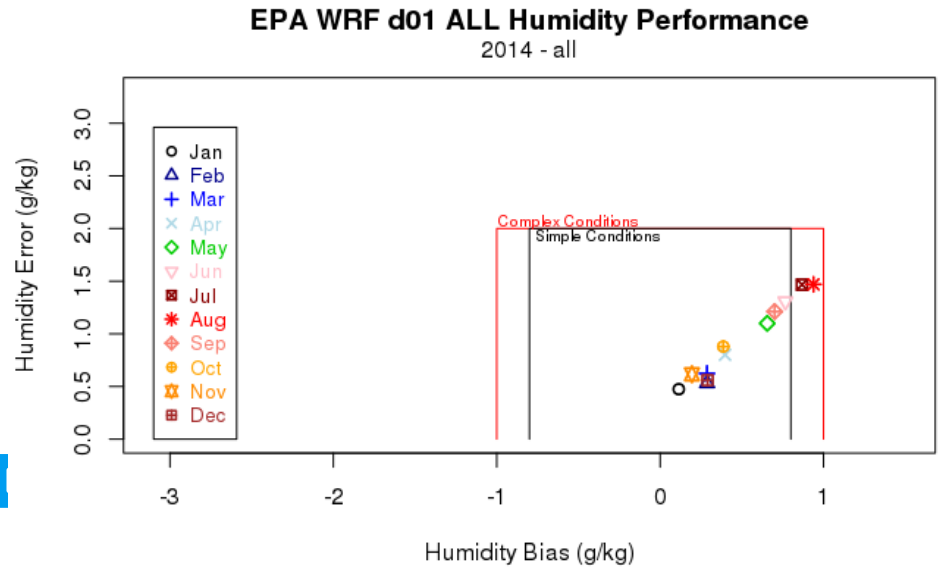
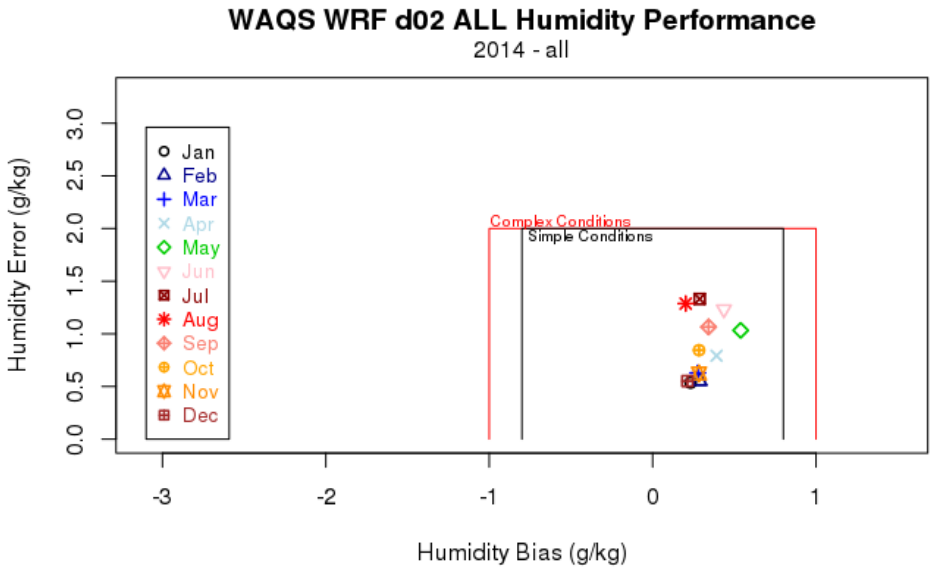
EPA vs. WAQS 12-km WRF Performance - T & RH in Western US





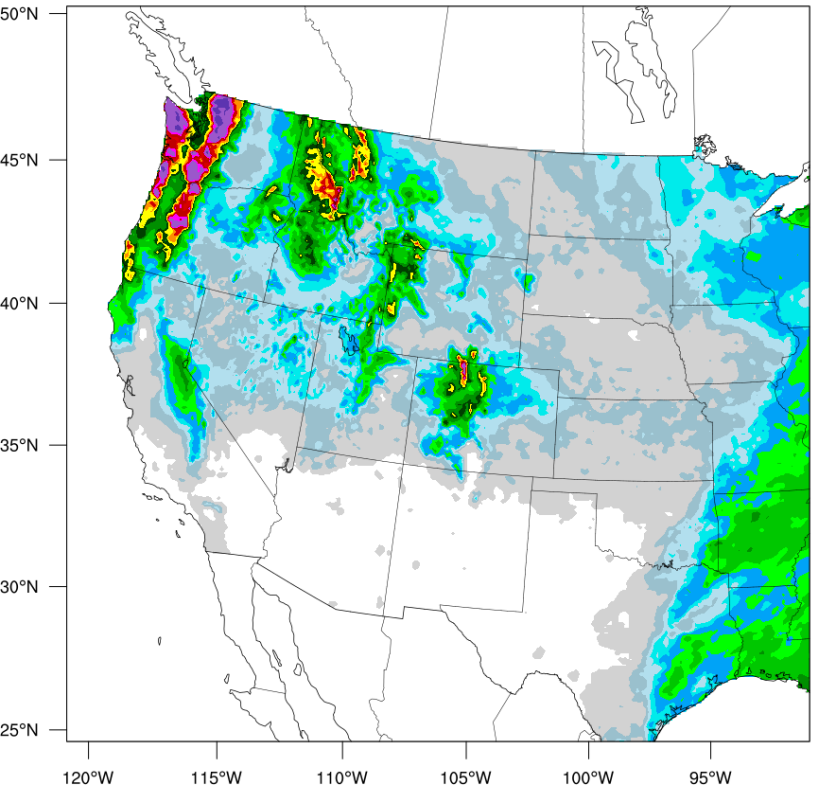




EPA vs. WAQS 12-km WRF Performance – Jan Precipitation US

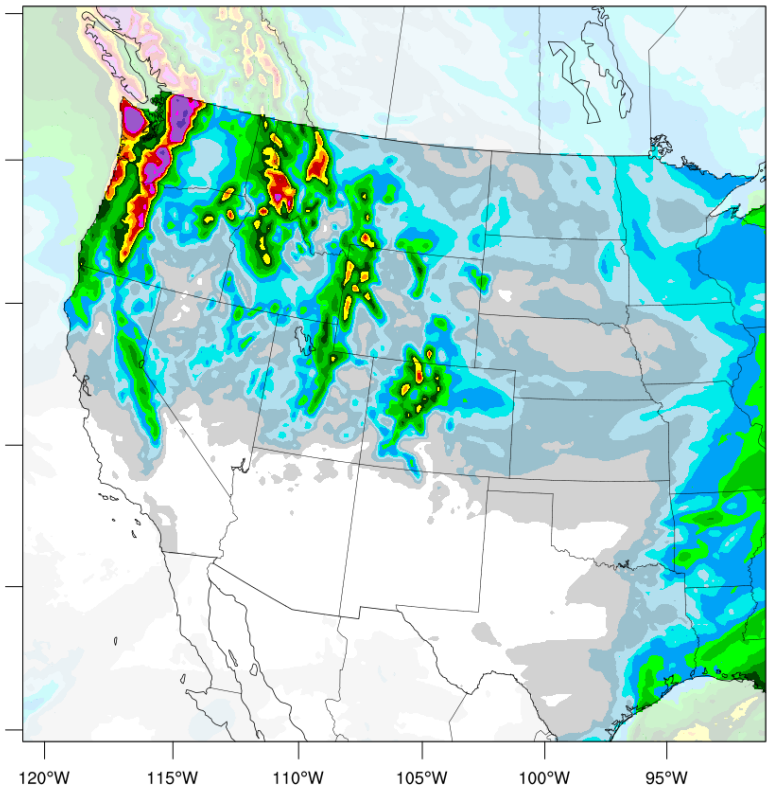
PRISM (obs)

Total PRISM Precipitation for 2014-01
Contiguous U.S. Statistics: 10th=0.000 Median=0.394 Average=0.891 90th=2.124



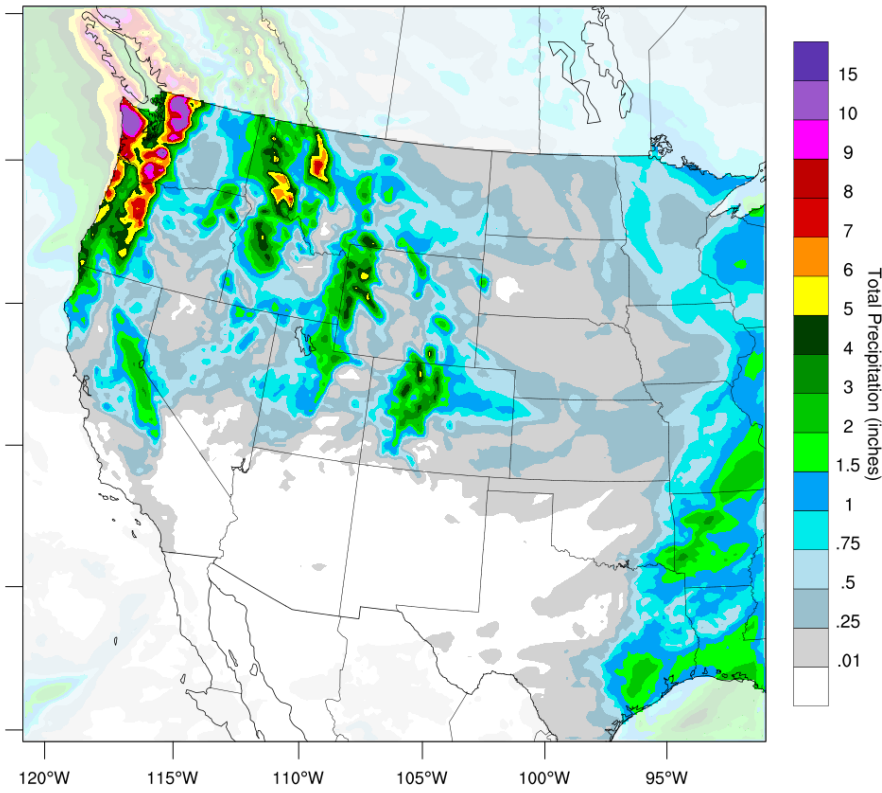
EPA WRF

Total WRF Precipitation (EPA) for 2014-01
WRF Domain Statistics: 10th=0.00 Median=0.48 Average=0.95 90th=2.46
Contiguous U.S. Statistics: 10th=0.00 Median=0.47 Average=0.88 90th=2.00



WAQS WRF

Total WRF Precipitation (WAQS) for 2014-01
WRF Domain Statistics: 10th=0.00 Median=0.37 Average=0.82 90th=2.10
Contiguous U.S. Statistics: 10th=0.00 Median=0.35 Average=0.75 90th=1.77



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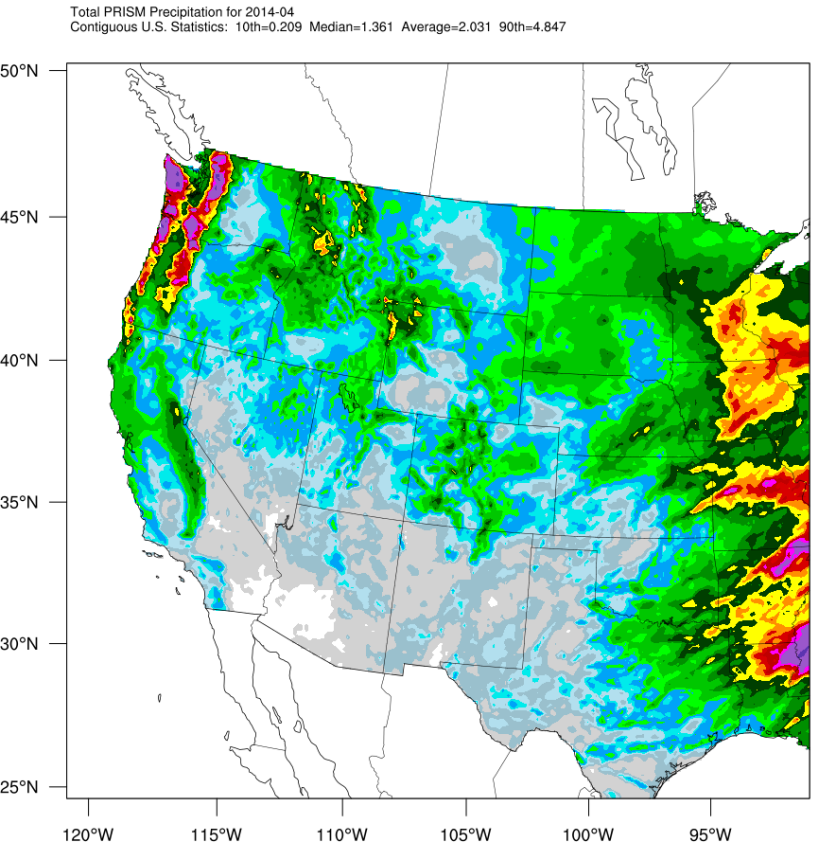
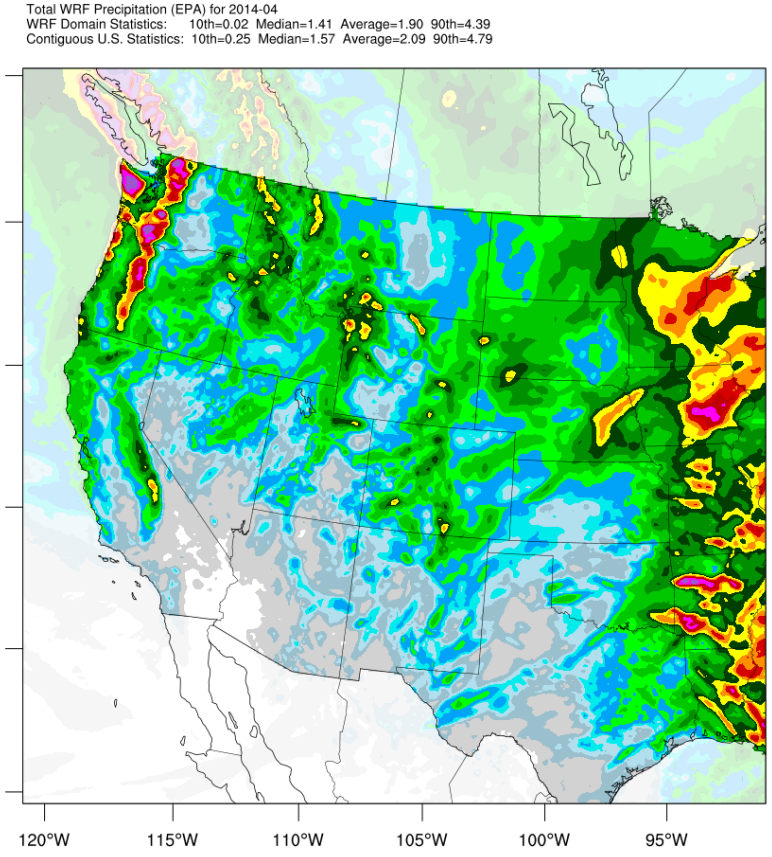
EPA vs. WAQS 12-km WRF Performance – Apr Precipitation US

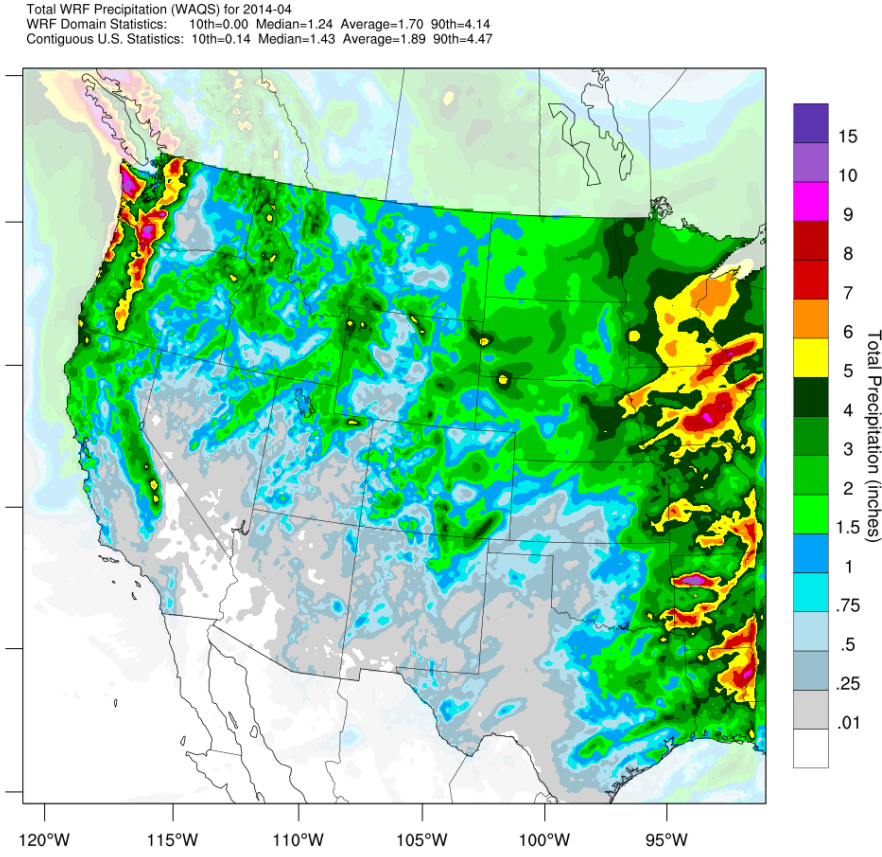
PRISM (obs)



EPA WRF



WAQS WRF



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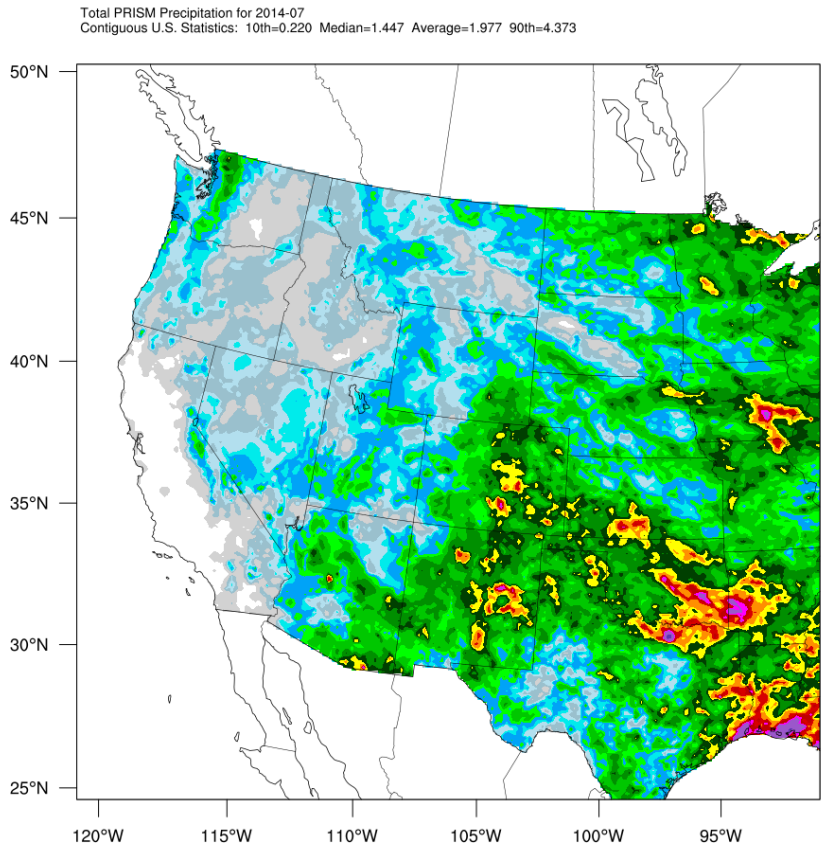
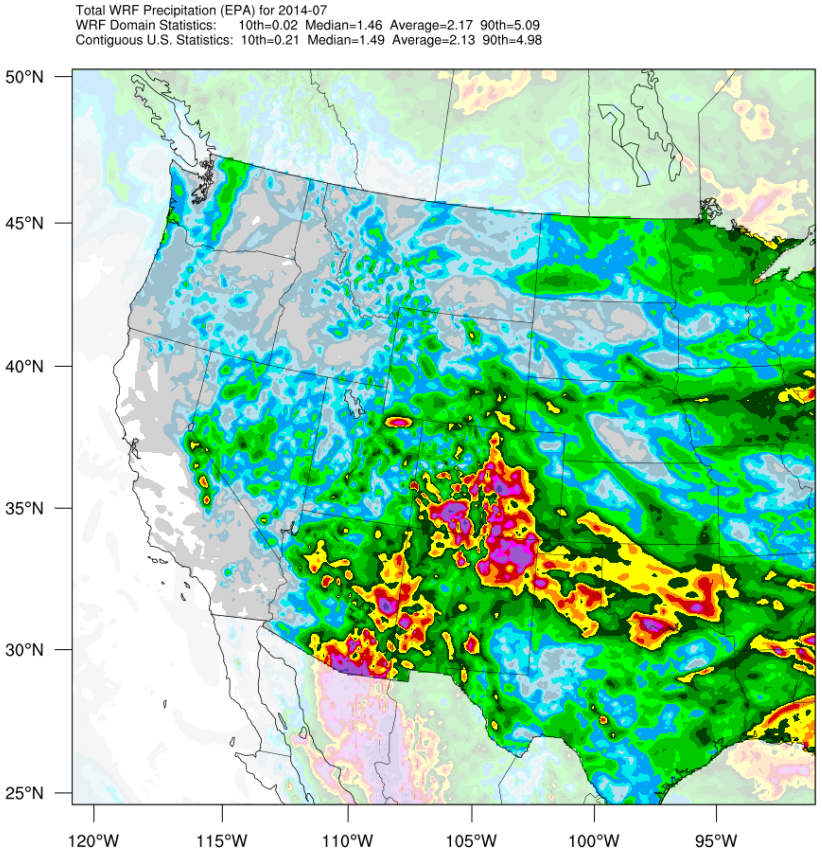
EPA vs. WAQS 12-km WRF Performance – Jul Precipitation US

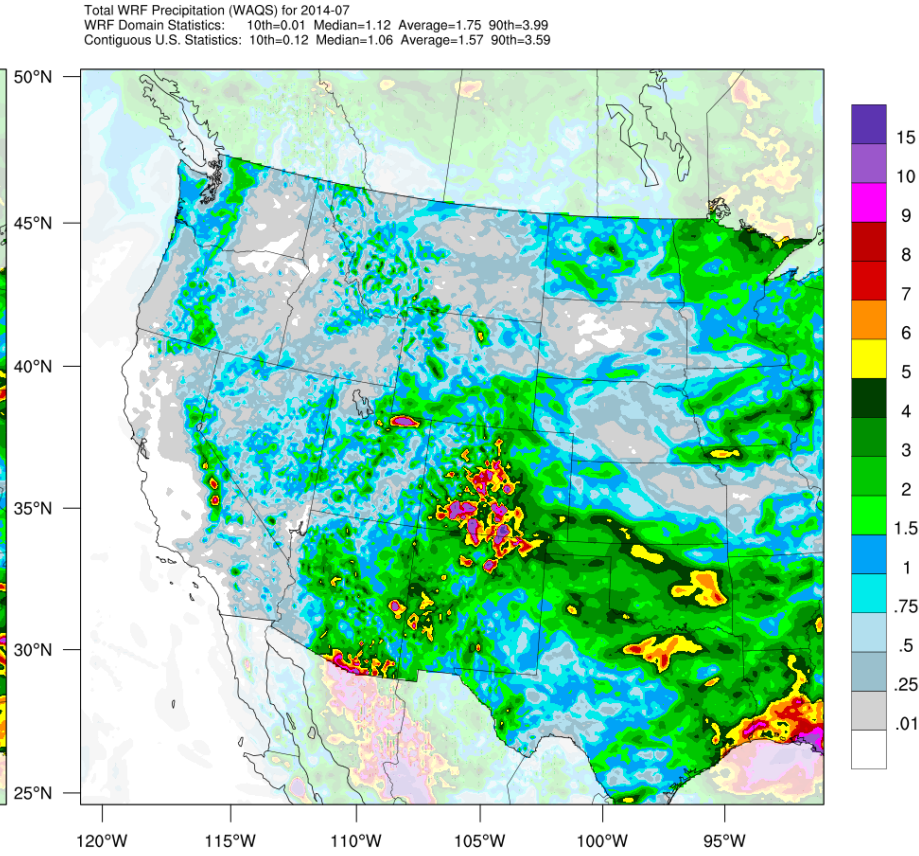
PRISM (obs)



EPA WRF



WAQS WRF



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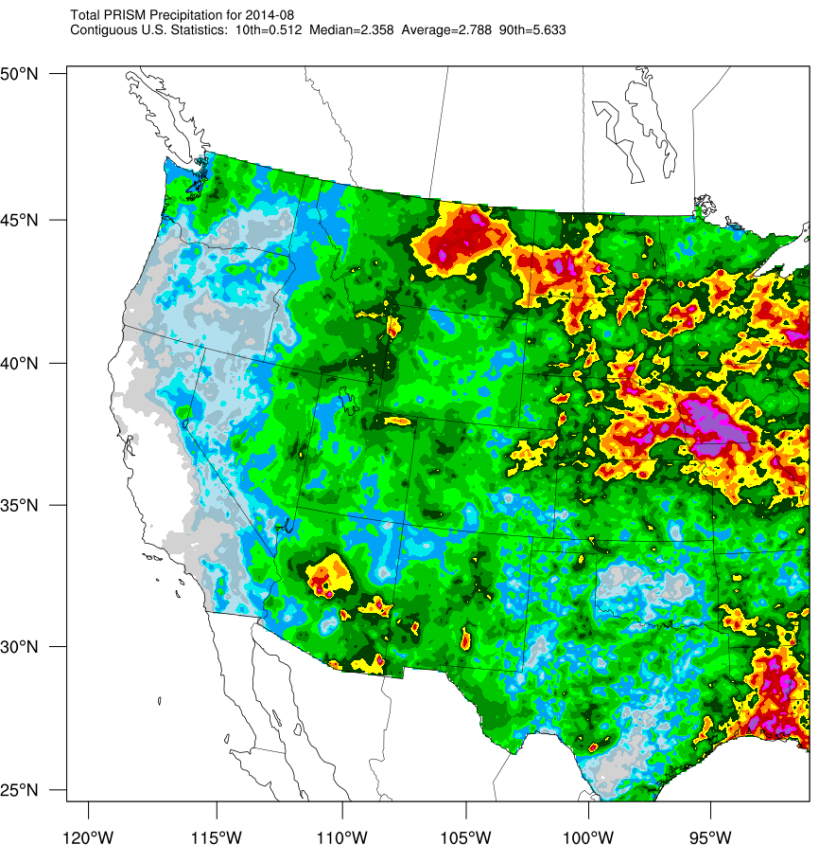
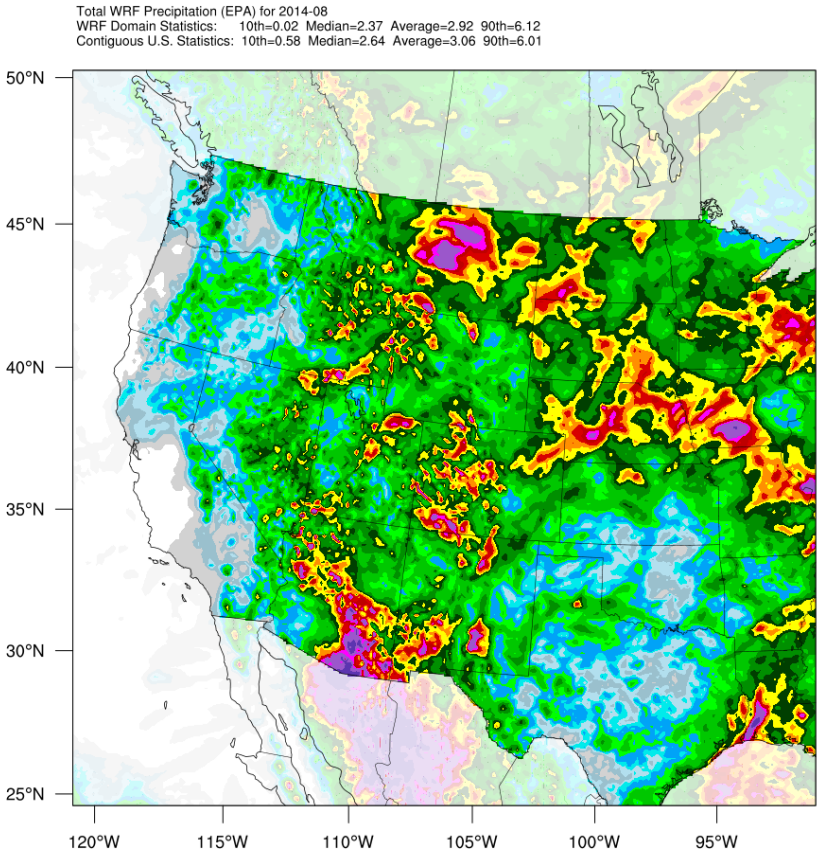
EPA vs. WAQS 12-km WRF Performance – Aug Precipitation US

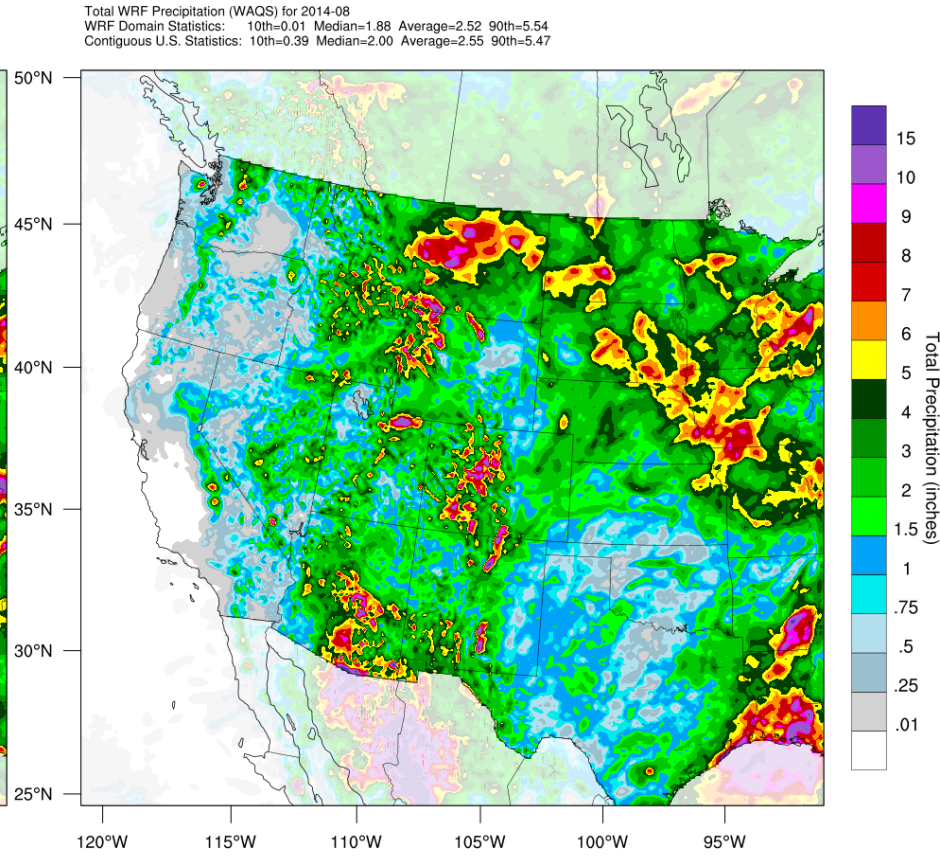
PRISM (obs)



EPA WRF



WAQS WRF



RAMBOLL

EPA vs. WAQS 12-km WRF Performance – Conclusions

- Similar performance, but varies by location, month and meteorological variable
- Across all surface meteorological sites in Western U.S.:
  - WAQS WRF has slightly better Wind performance than EPA WRF
  - EPA WRF has slightly better Temperature performance than WAQS WRF
  - WAQS WRF has slightly better Humidity performance than EPA WRF
- WRF Precipitation performance using PRISM Data:
  - EPA and WAQS WRF have similar monthly/daily patterns and amounts of precipitation as PRISM
  - WRF simulates winter precipitation better than summer
  - EPA WRF overstates summer (convective) precipitation compared to WAQS WRF
- Thousands of WRF MPE products delivered to IWDW:
  - Surface meteorological performance down to Western State and individual sites
  - Monthly and daily average PRISM precipitation performance using PRISM

RAMBOLL

CAMx Configuration: Meteorological Sensitivity

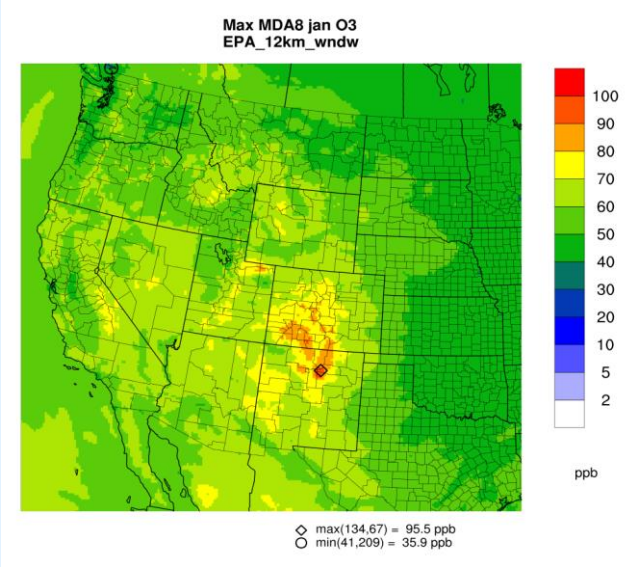
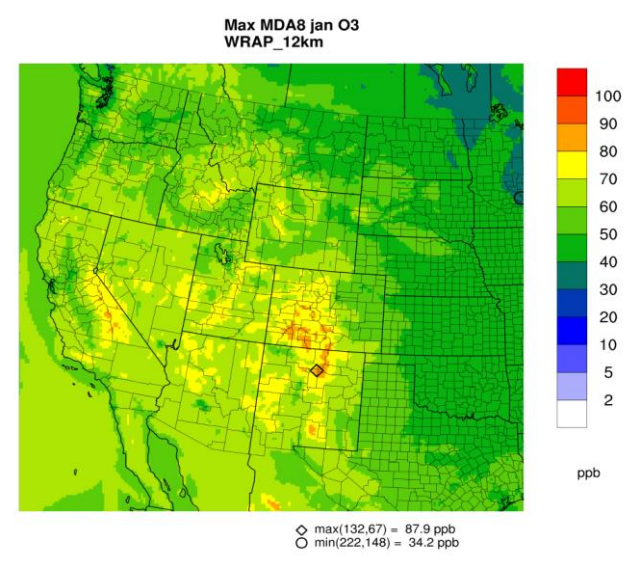
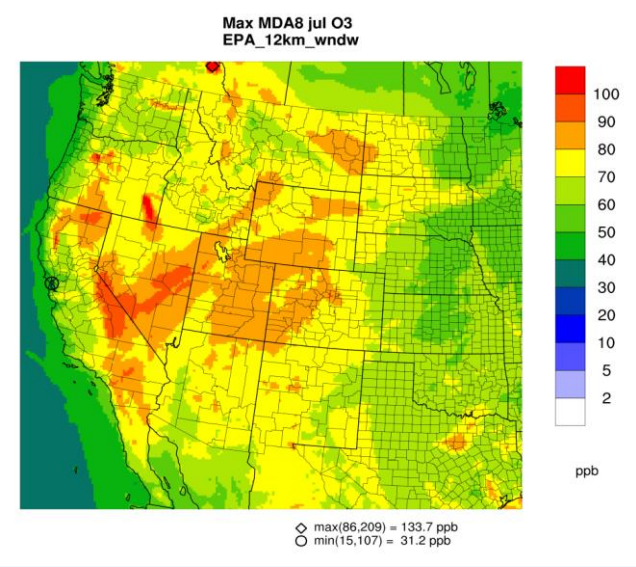
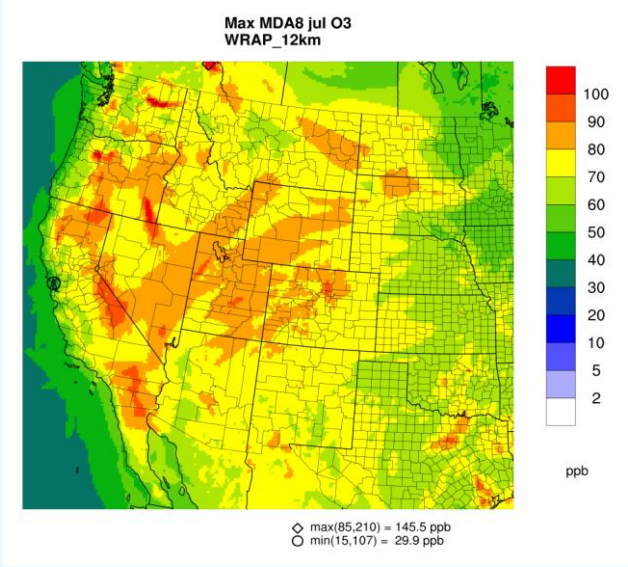
- Meteorological Sensitivity Simulation: Only meteorology and domains are different; all other aspects are kept consistent or identical

	EPA Met	WAQS Met
Modeling Domain	12US2	12WUS2
Boundary Conditions	Interpolated 36US1	36US1
Biogenic Emissions	MEGAN	
Fire/Anthro Emissions	2014 NEI	
Advection Solver	PPM	
Chemistry Solver	EBI	
Plume-in-Grid	GREASD	

RAMBOLL

Meteorological Sensitivity: Surface Ozone

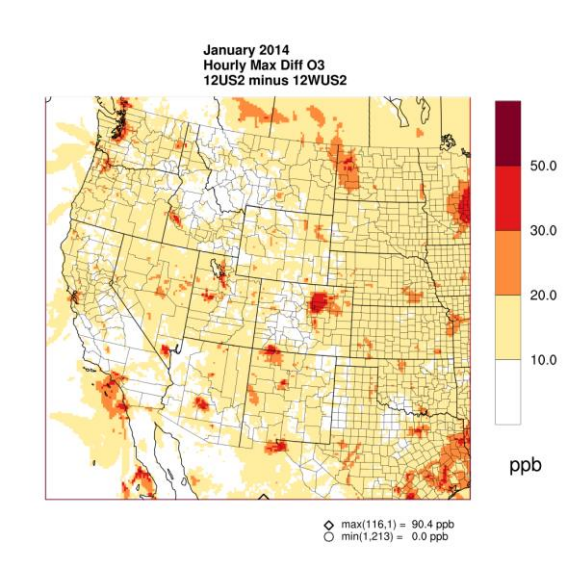
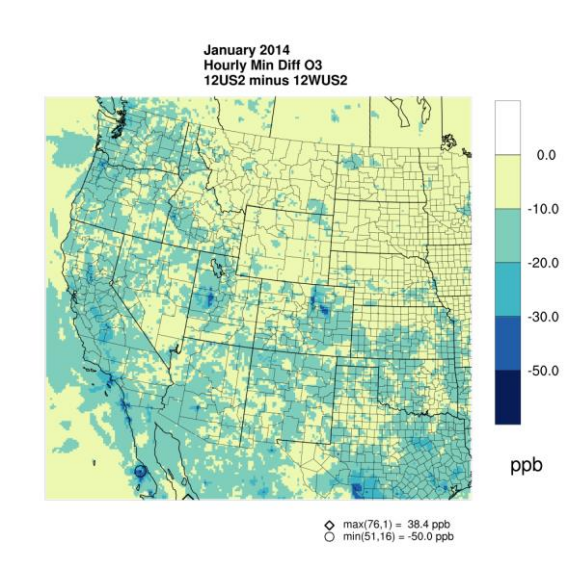
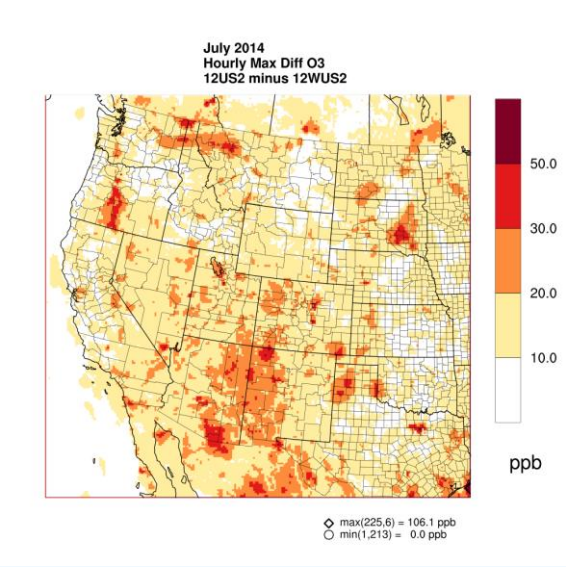
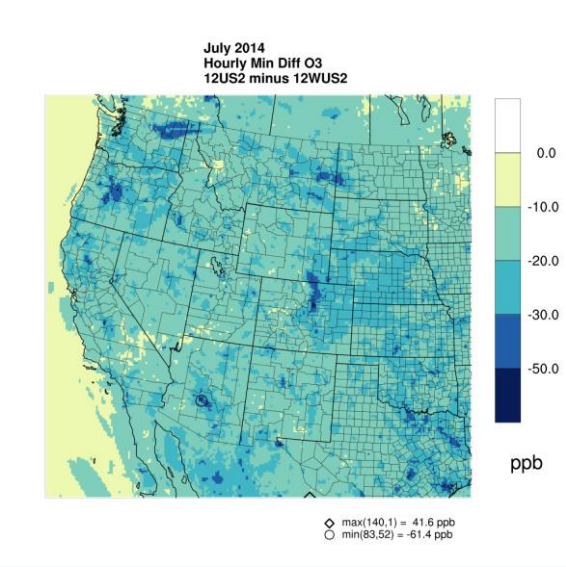
- Maximum daily 8-hr average ozone concentrations
- Similar spatial distributions
- July shows ozone plumes most likely from fires

	EPA Met	WAQS met
Jan		
July		

RAMBOLL

Meteorological Sensitivity: Surface Ozone Differences

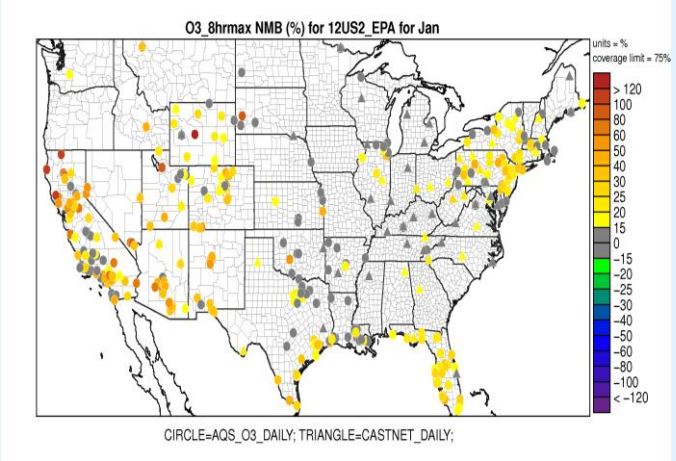
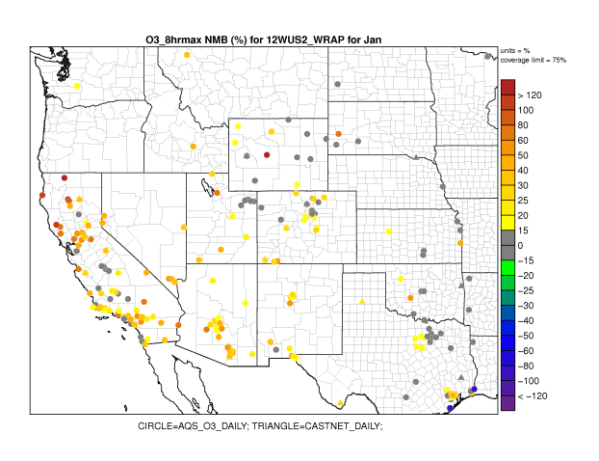
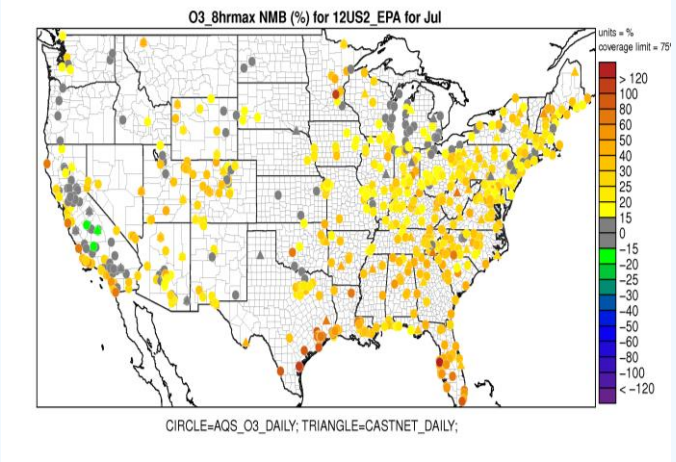
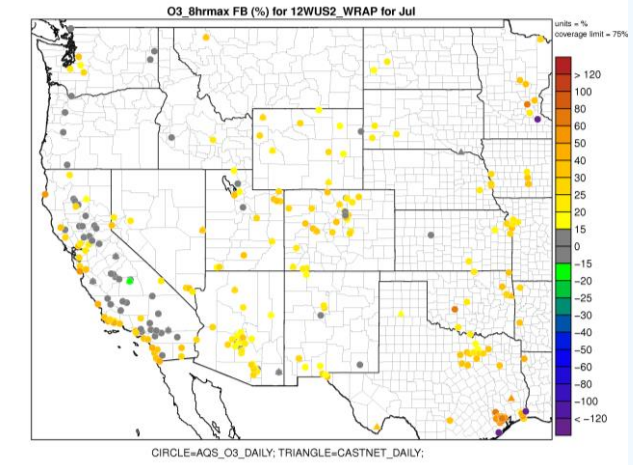
- Maximum differences in hourly concentrations
- First Column indicates when EPA met is higher than WAQS met
- Second column indicates when WAQS met is higher
- Simulations are at least 10 to 20 ppb different
- WAQS met leads to higher ozone in July

	MAX Diff	MIN Diff
Jan		
July		

RAMBOLL

Meteorological Sensitivity: Ozone Bias Overlay

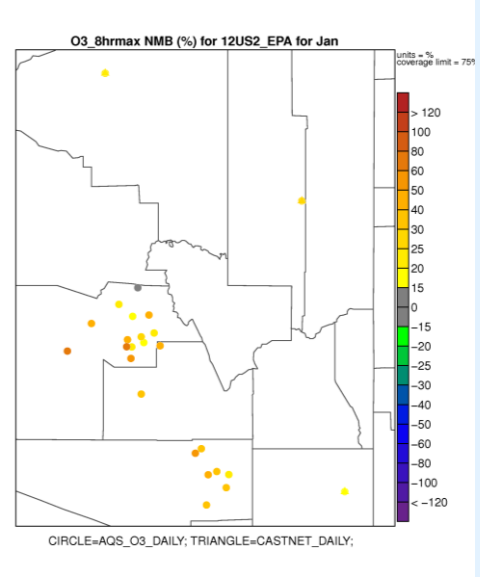
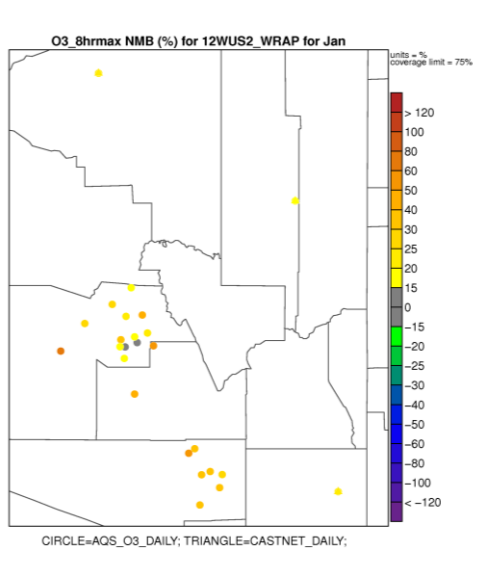
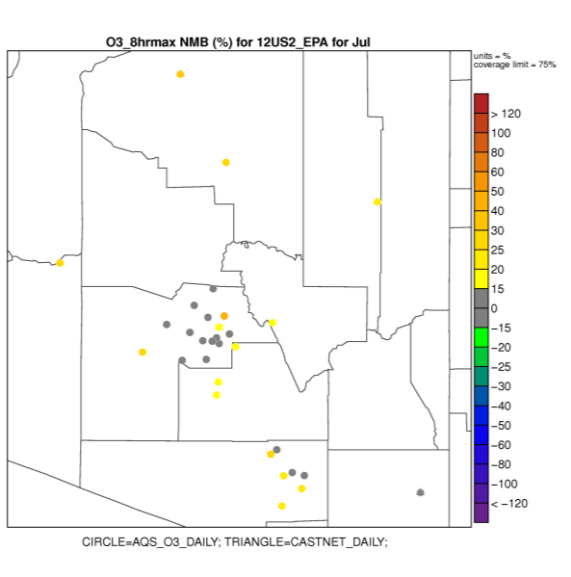
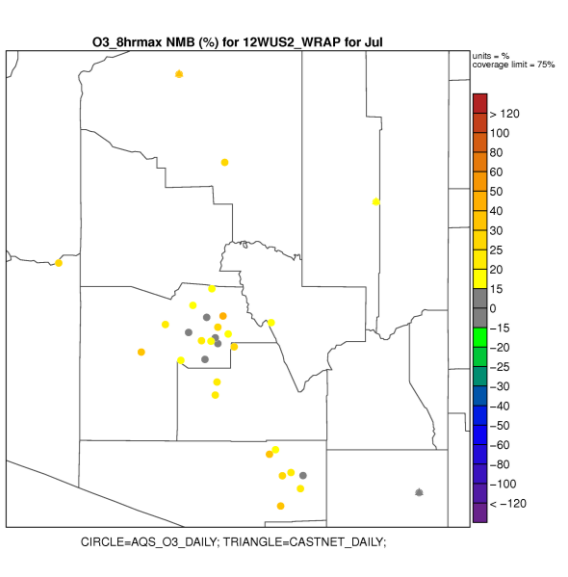
- Both simulations lead to ozone over-predictions in both January and July

	EPA Met	WAQS met
Jan		
July		

RAMBOLL

Meteorological Sensitivity: Arizona Ozone Bias Overlay

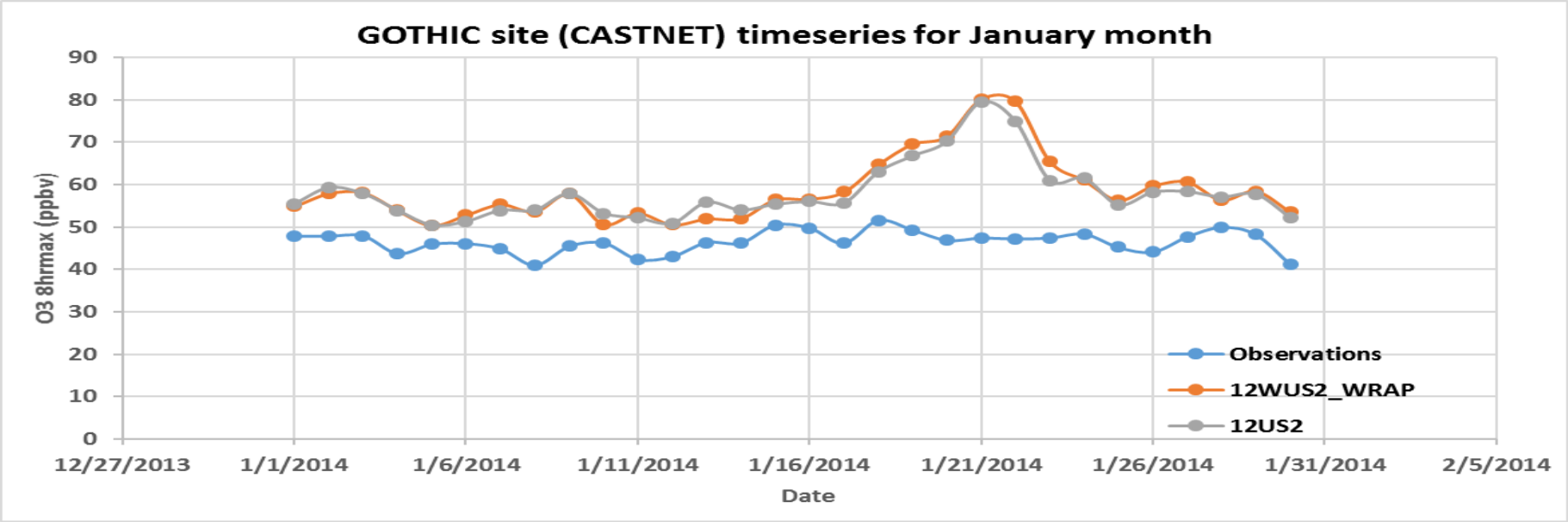
- Overlay plot shows similar performance for both in January
- EPA Met shows better performance in July

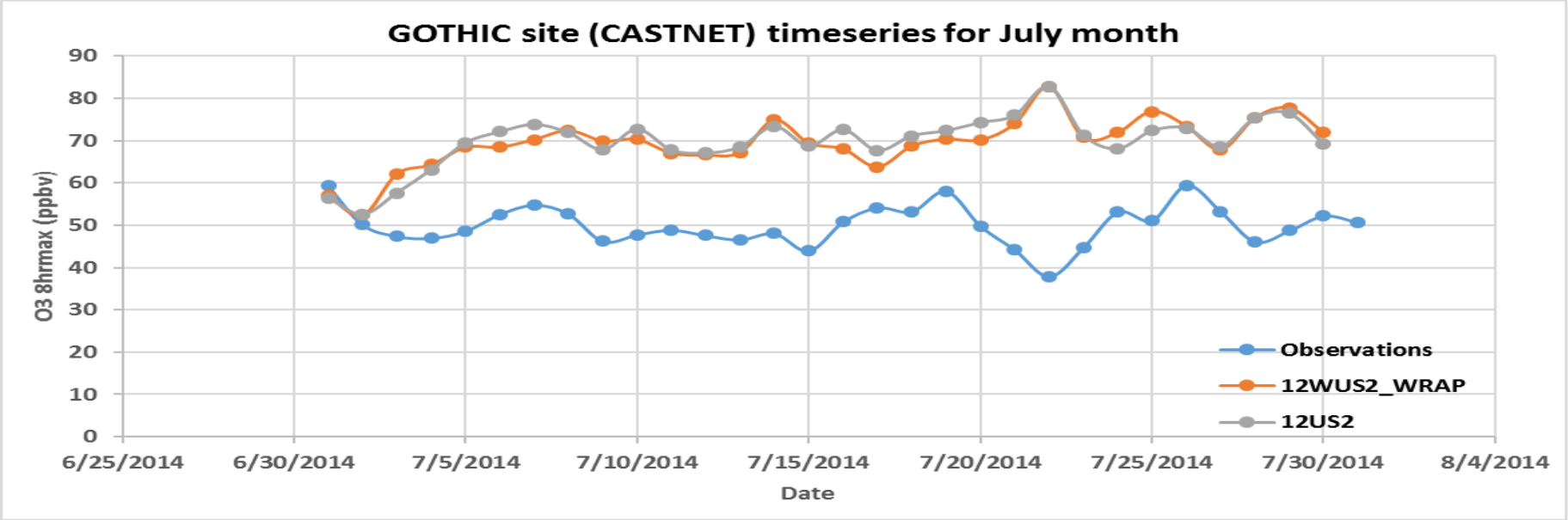
	EPA Met	WAQS Met
Jan		
July		

RAMBOLL

Meteorological Sensitivity: Ozone Timeseries

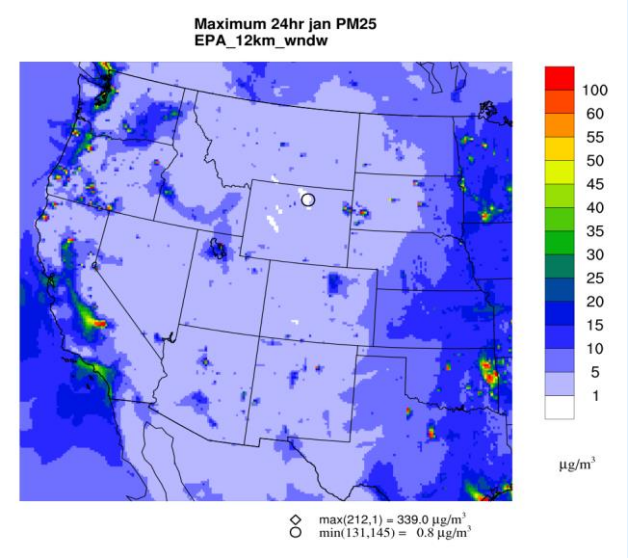
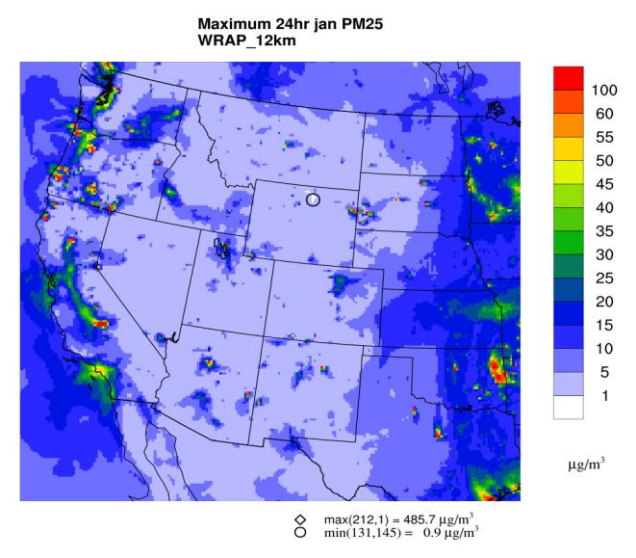
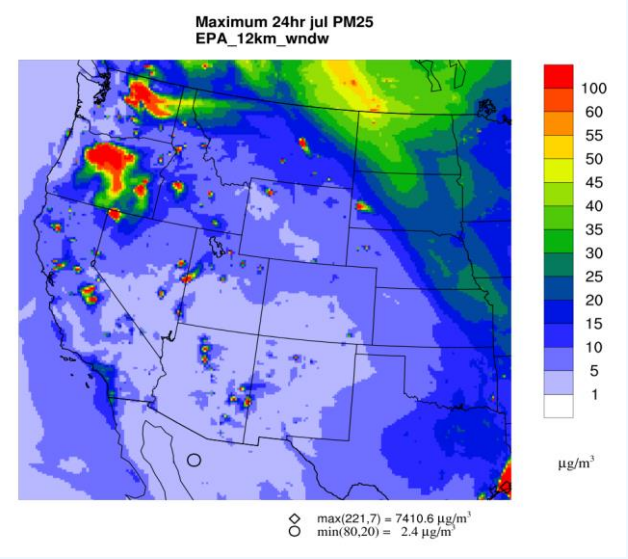
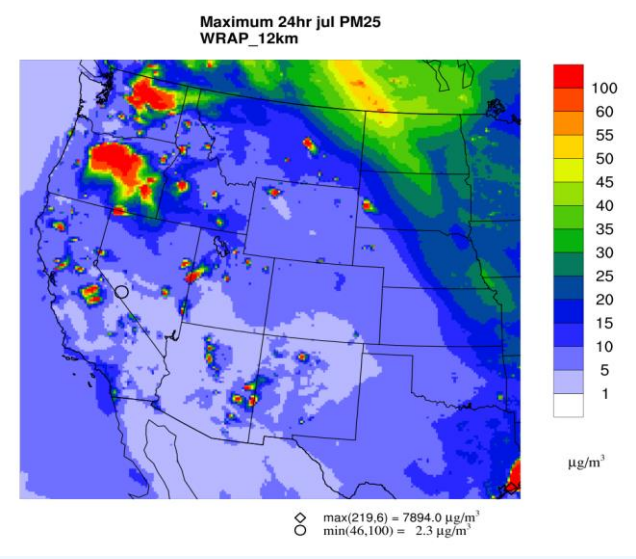
- Simulations consistently overpredict ozone concentrations at high altitude site





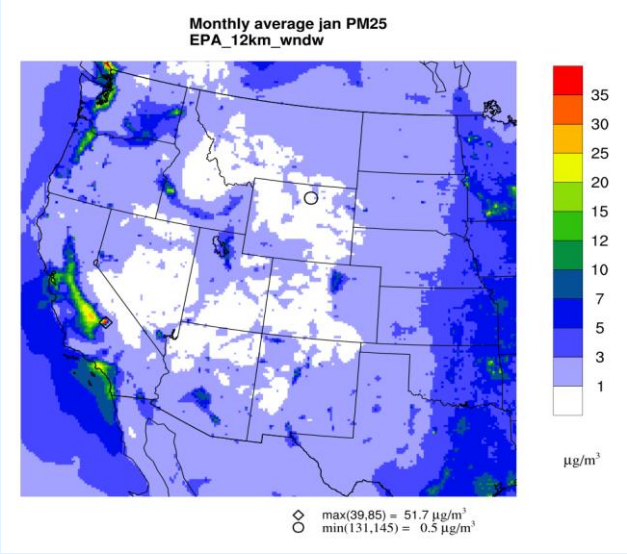
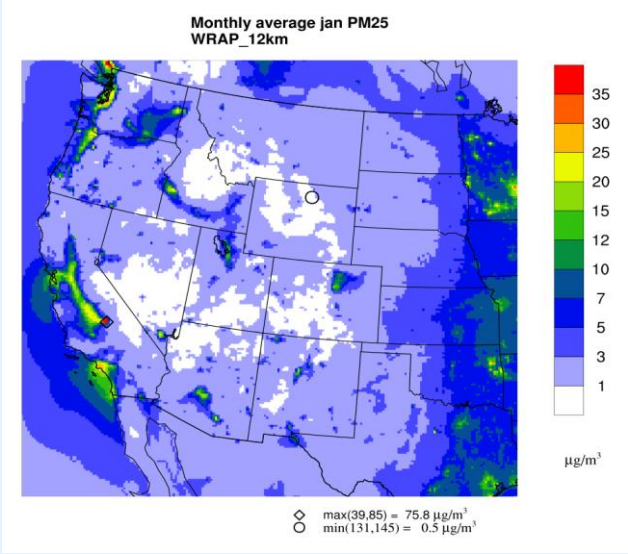
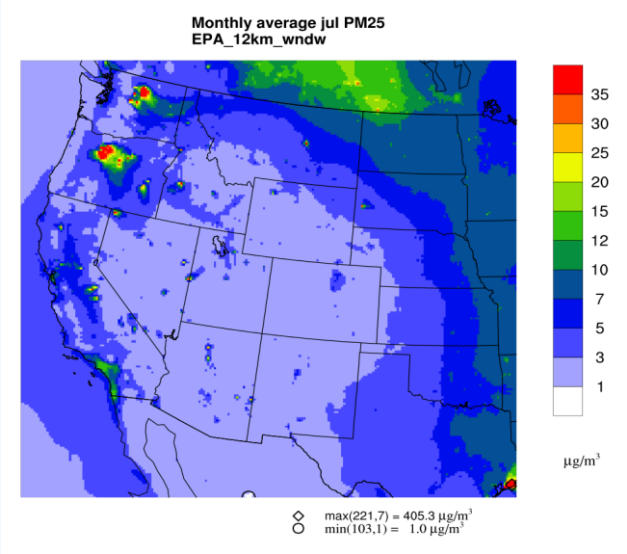
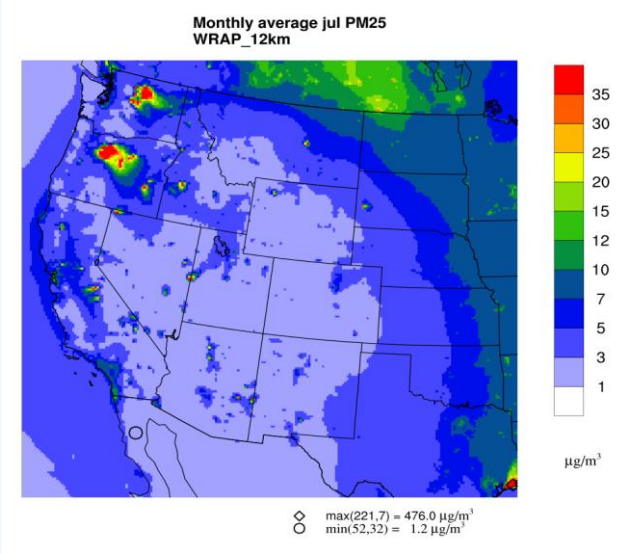
RAMBOLL

Meteorological Sensitivity: Surface PM2.5 Maximum

	EPA Met	WAQS Met
Jan		
July		

RAMBOLL

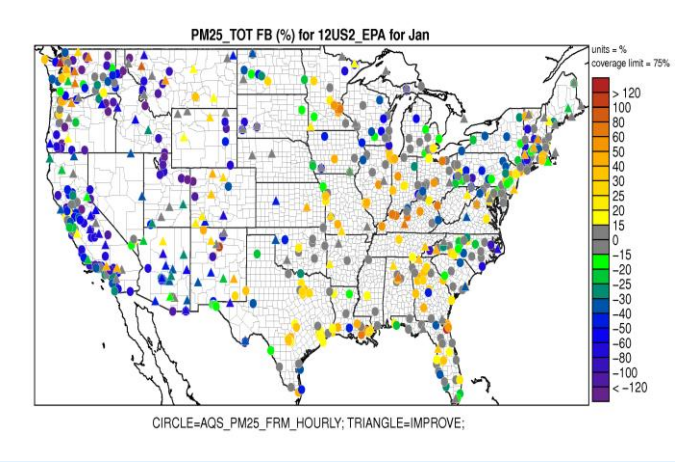
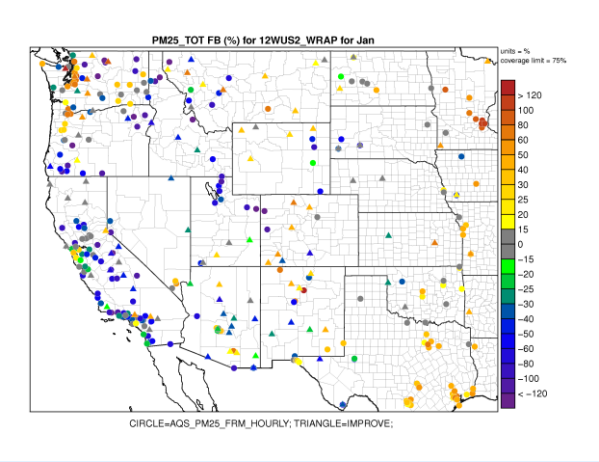
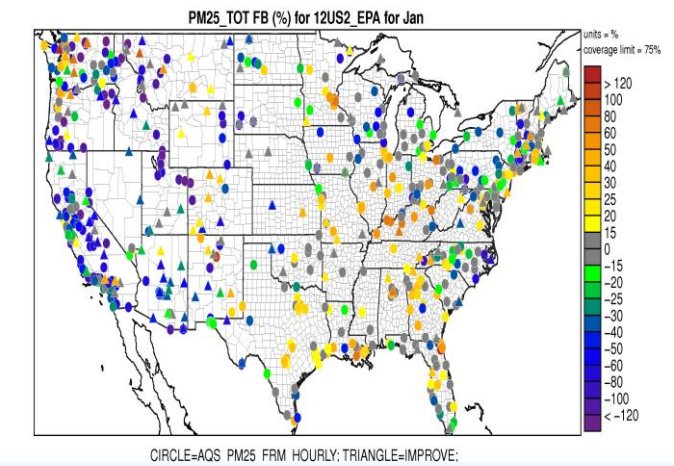
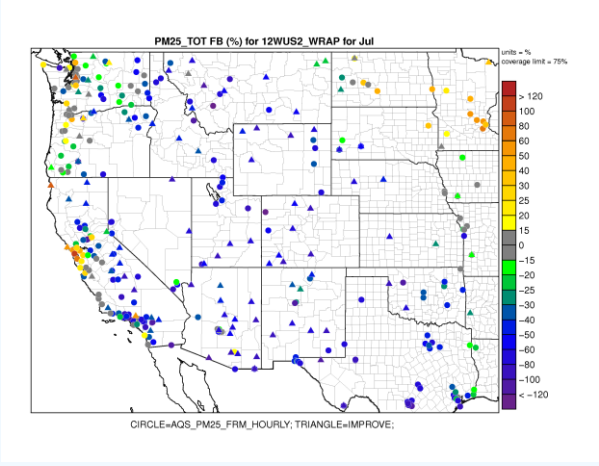
Meteorological Sensitivity: Surface PM2.5 Average

	EPA Met	WAQS Met
Jan		
July		

RAMBOLL

Meteorological Sensitivity: PM2.5 Bias Overlay

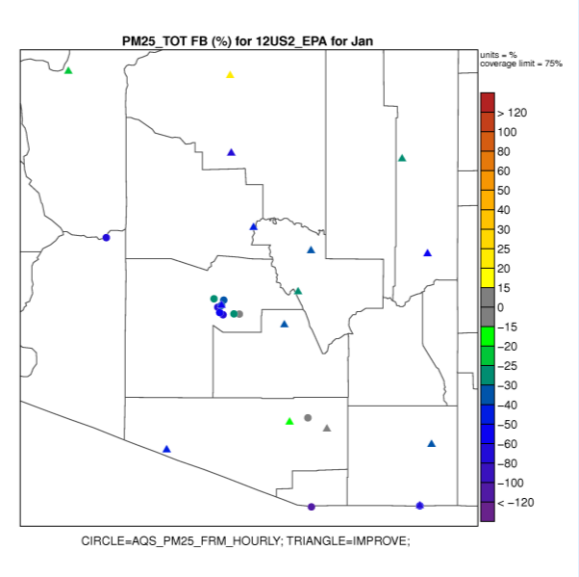
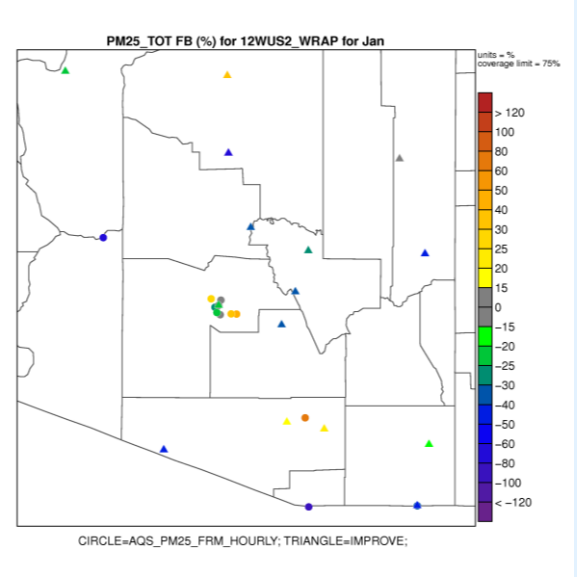
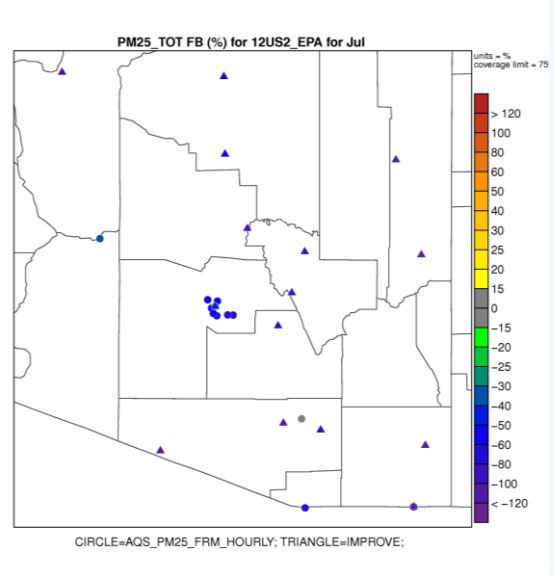
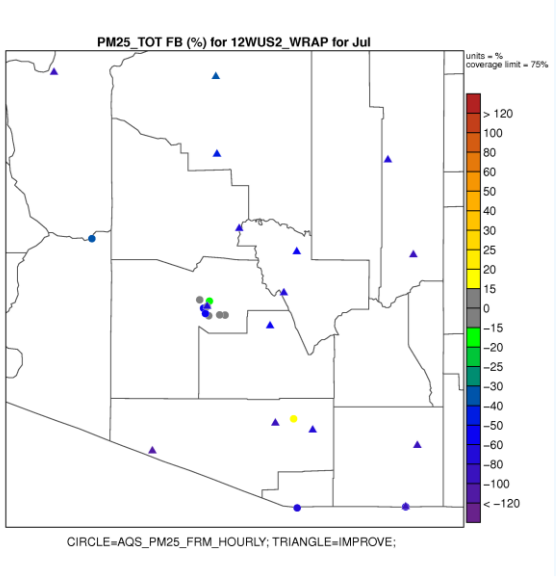
- Both simulations tend to underpredict total PM2.5

	EPA Met	WAQS Met
Jan		
July		

RAMBOLL

Meteorological Sensitivity: Arizona PM2.5 Bias Overlay

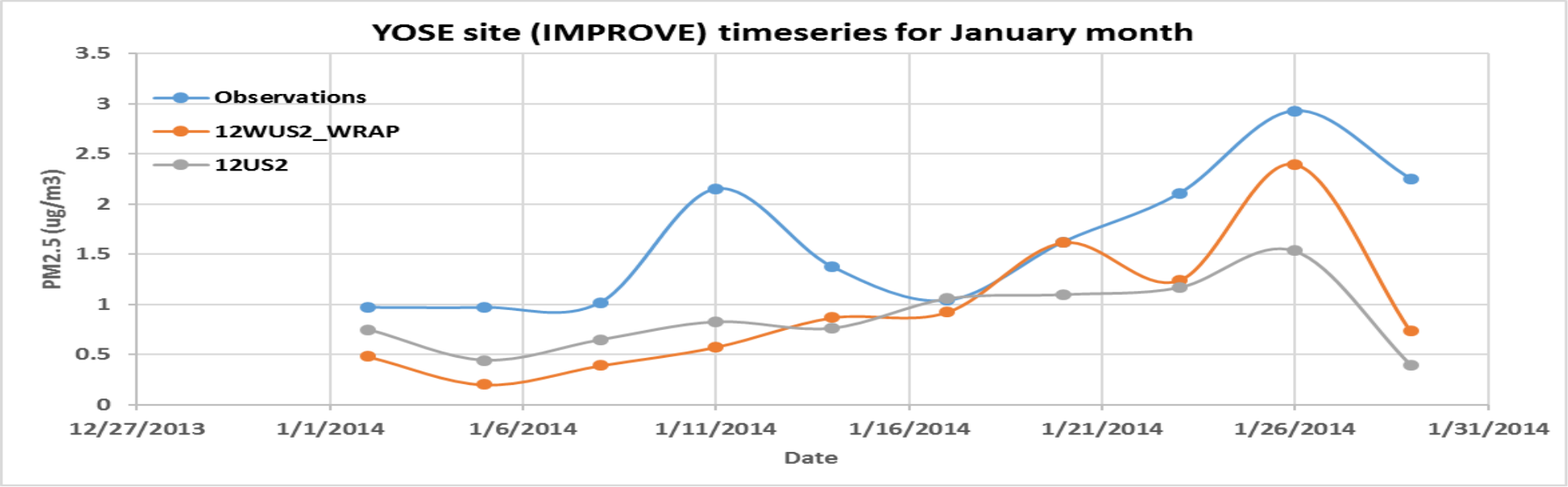
- PM2.5 under-predictions. Only exception is WAQS Met in January

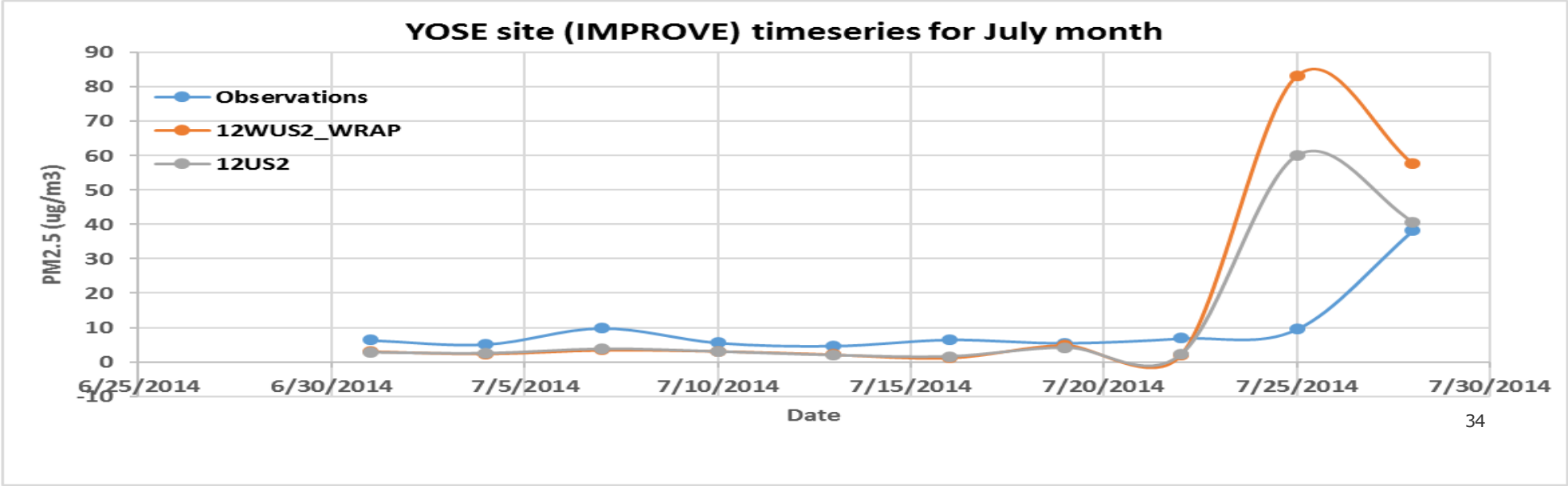
	EPA Met	WAQS Met
Jan		
July		

RAMBOLL

Meteorological Sensitivity: PM2.5 Timeseries

- Both Simulations overpredict concentrations on July 25.

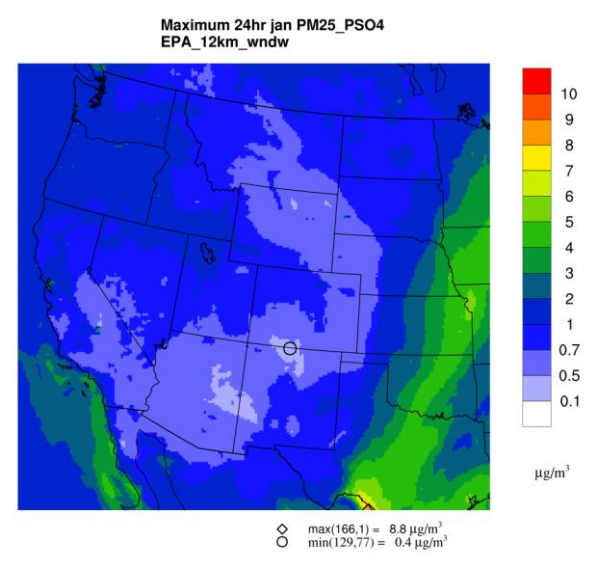
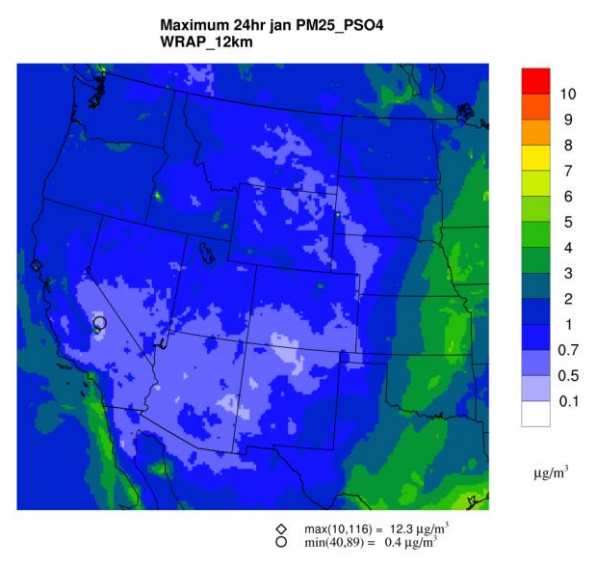
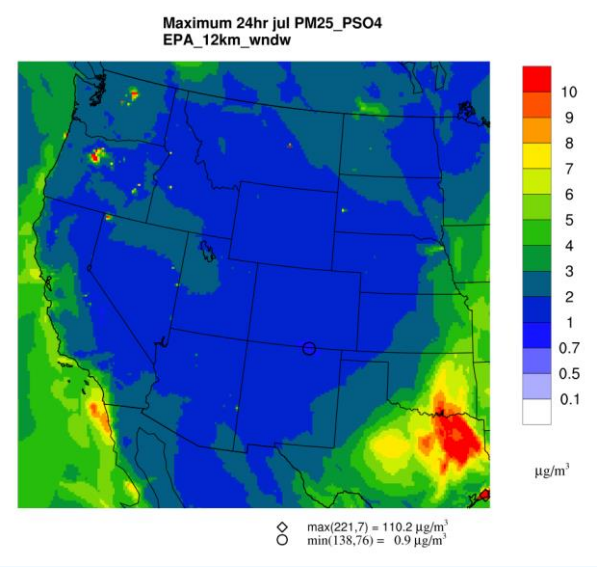
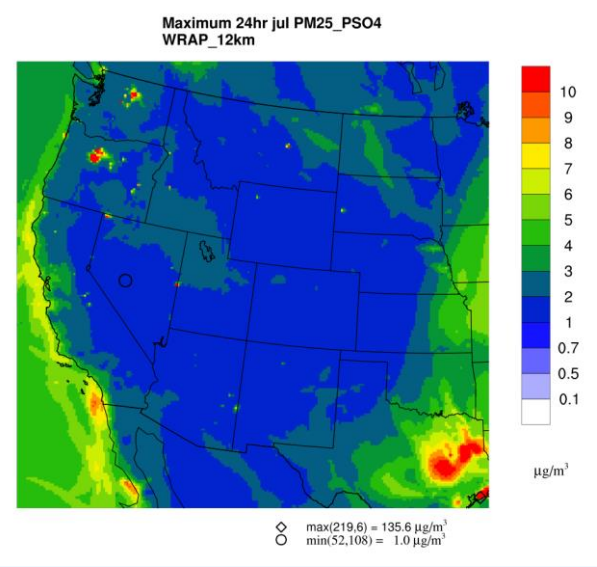




RAMBOLL

Meteorological Sensitivity: Surface Sulfate

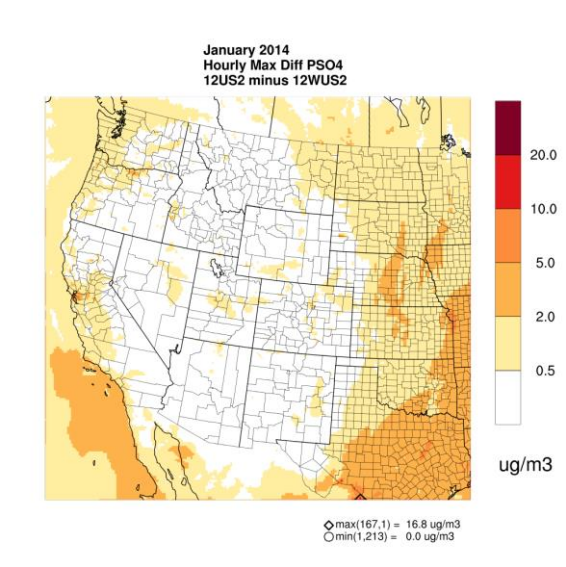
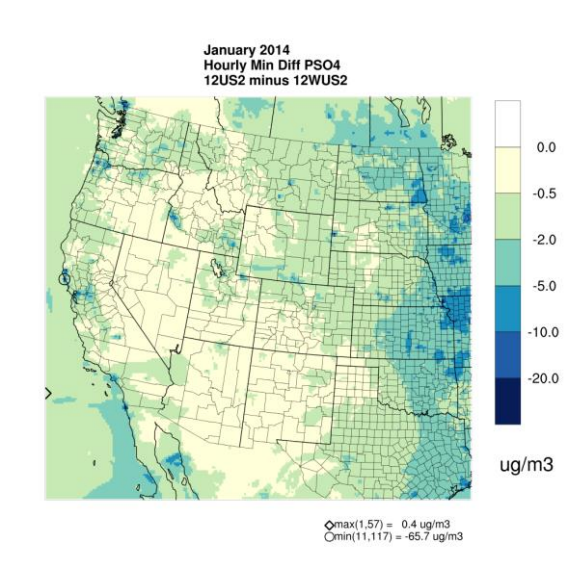
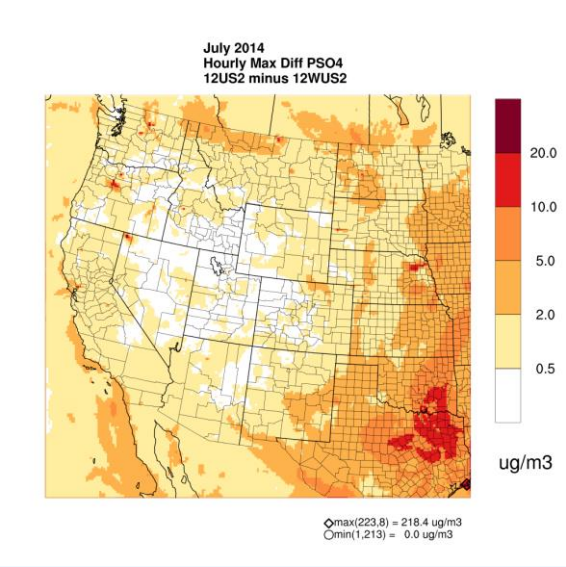
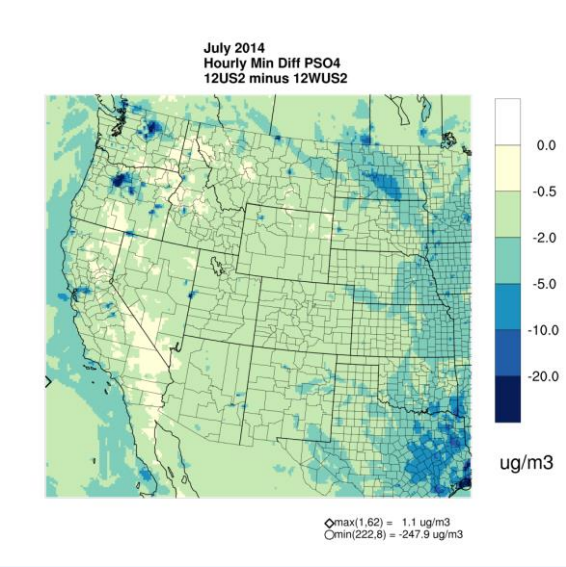
- Maximum from daily (24-h) average concentrations
- Sulfate in July shows significant contributions from sea salt and DMS emissions
- Sulfate also high near fires

	EPA Met	WAQS Met
Jan		
July		

RAMBOLL

Meteorological Sensitivity: Surface Sulfate Differences

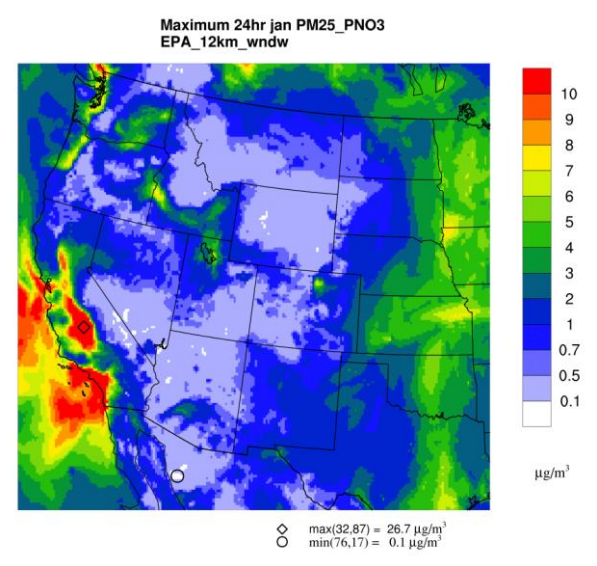
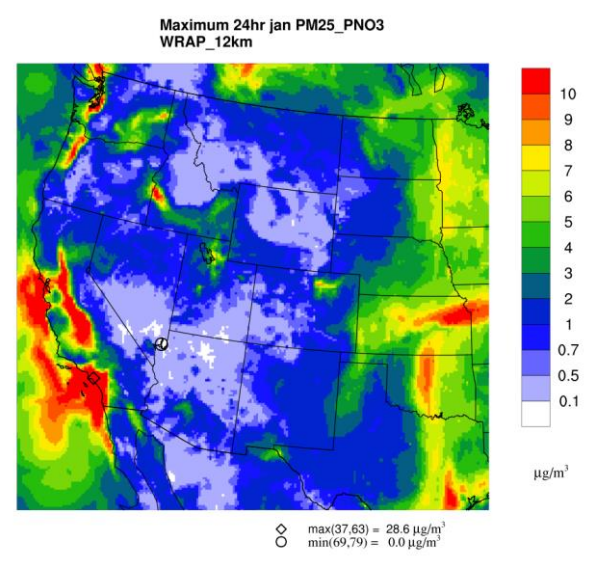
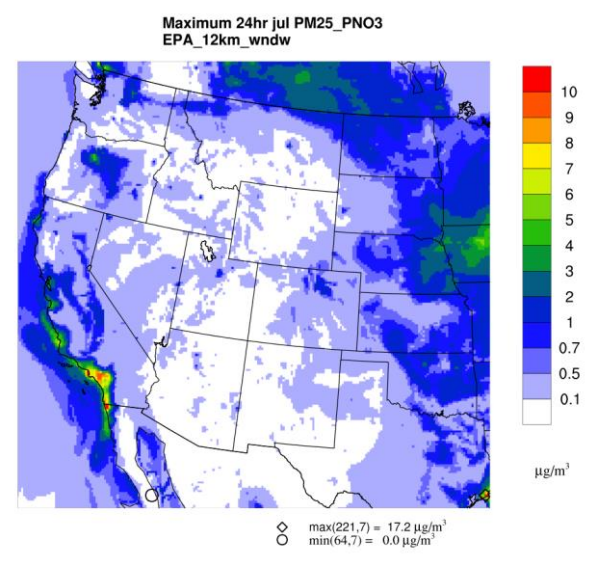
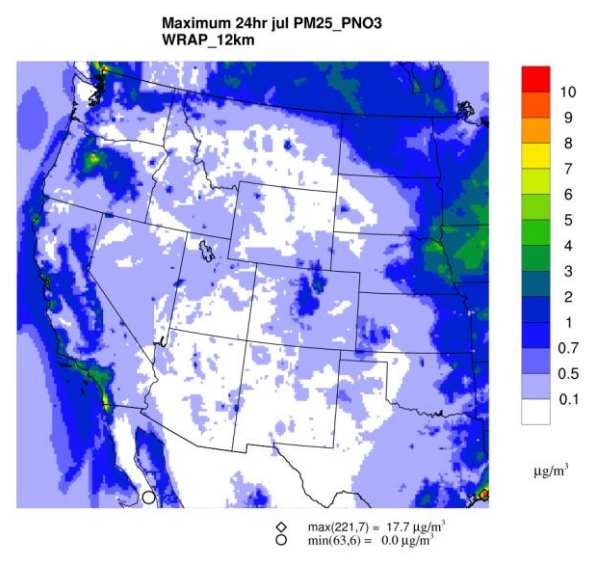
- Differences in hourly concentrations
- WAQS met leads to higher sulfate in July

	MAX Diff	MIN Diff
Jan		
July		

RAMBOLL

Meteorological Sensitivity: Surface Nitrate

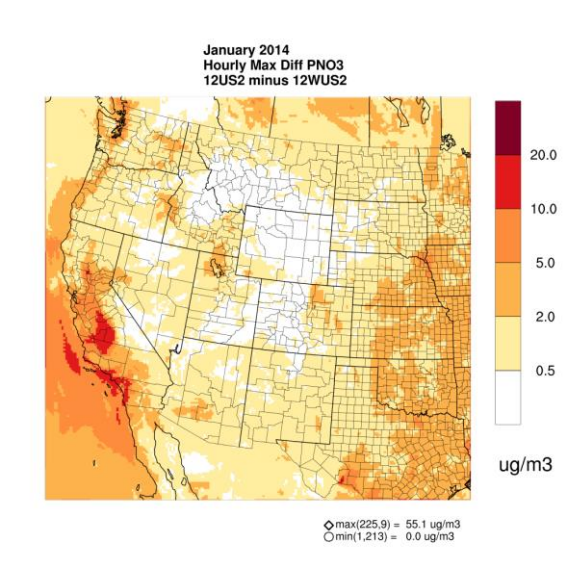
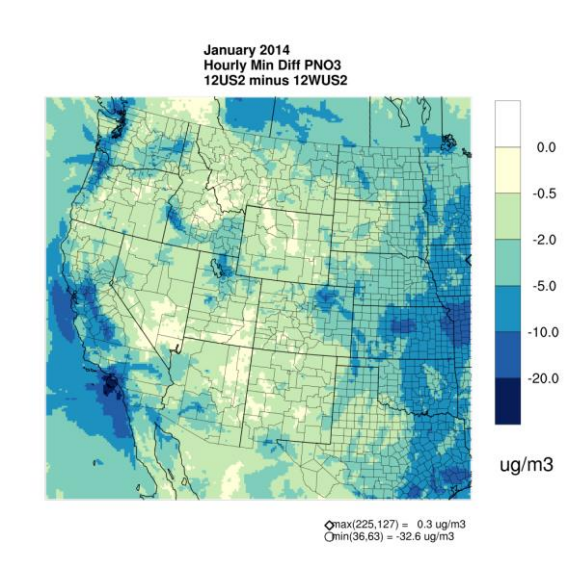
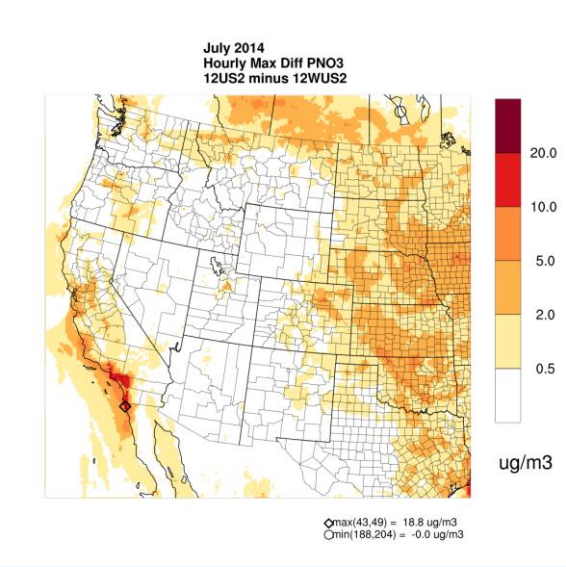
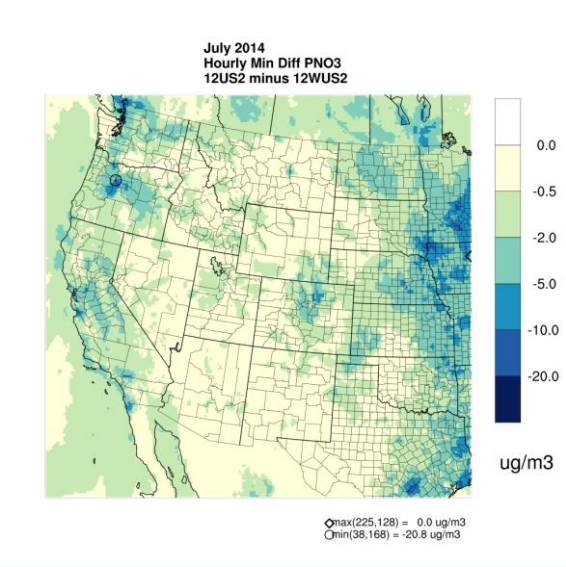
- Maximum from daily (24-h) average concentrations
- Nitrate is high in Central CA in January
- WAQS met show high nitrate in Kansas. Not as pronounced with EPA met
- Nitrate low in July

	EPA Met	WAQS Met
Jan		
July		

RAMBOLL

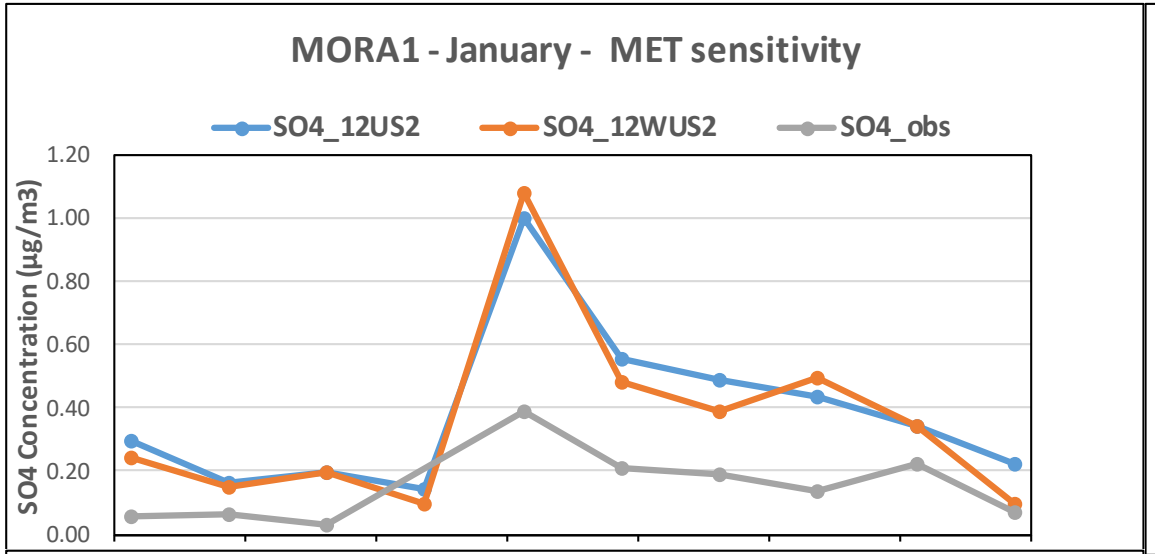
Meteorological Sensitivity: Surface Nitrate Differences

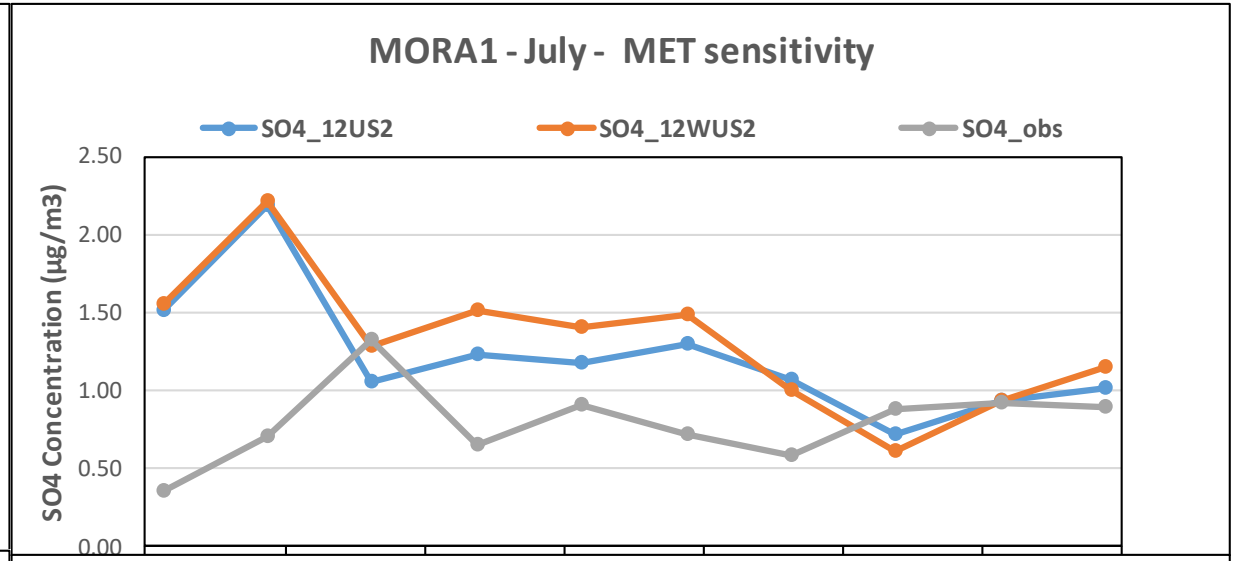
- Differences in hourly concentrations
- WAQS met leads to higher nitrate in January

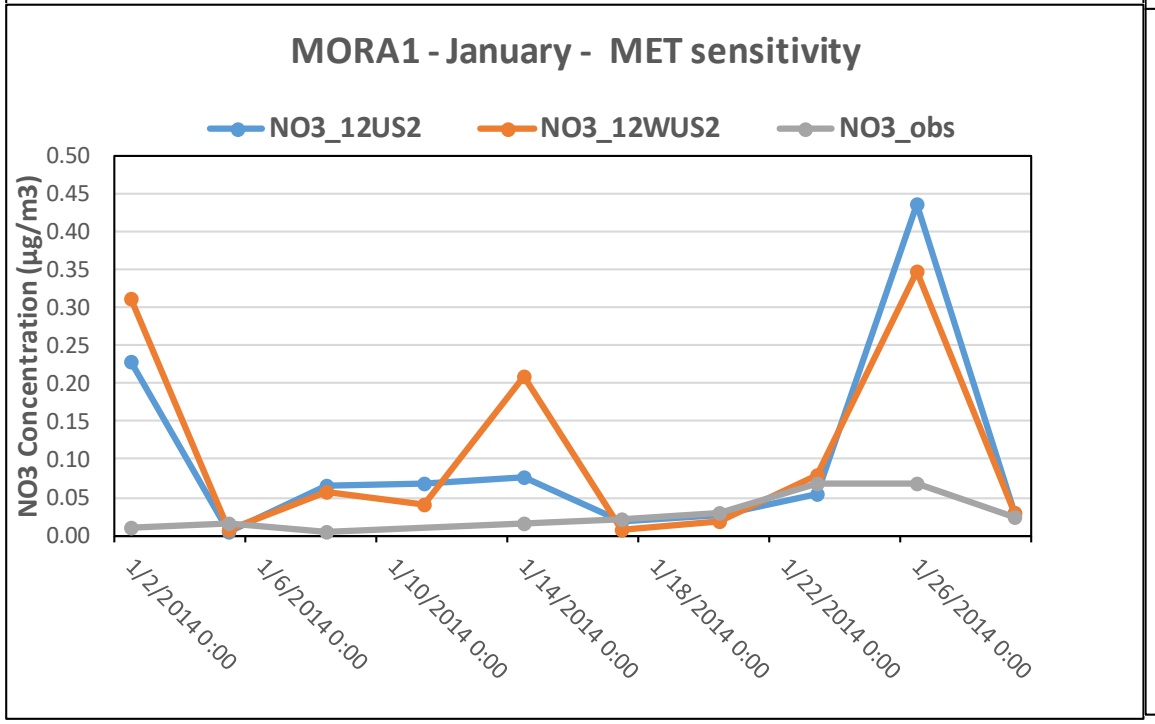
	MAX Diff	MIN Diff
Jan		
July		

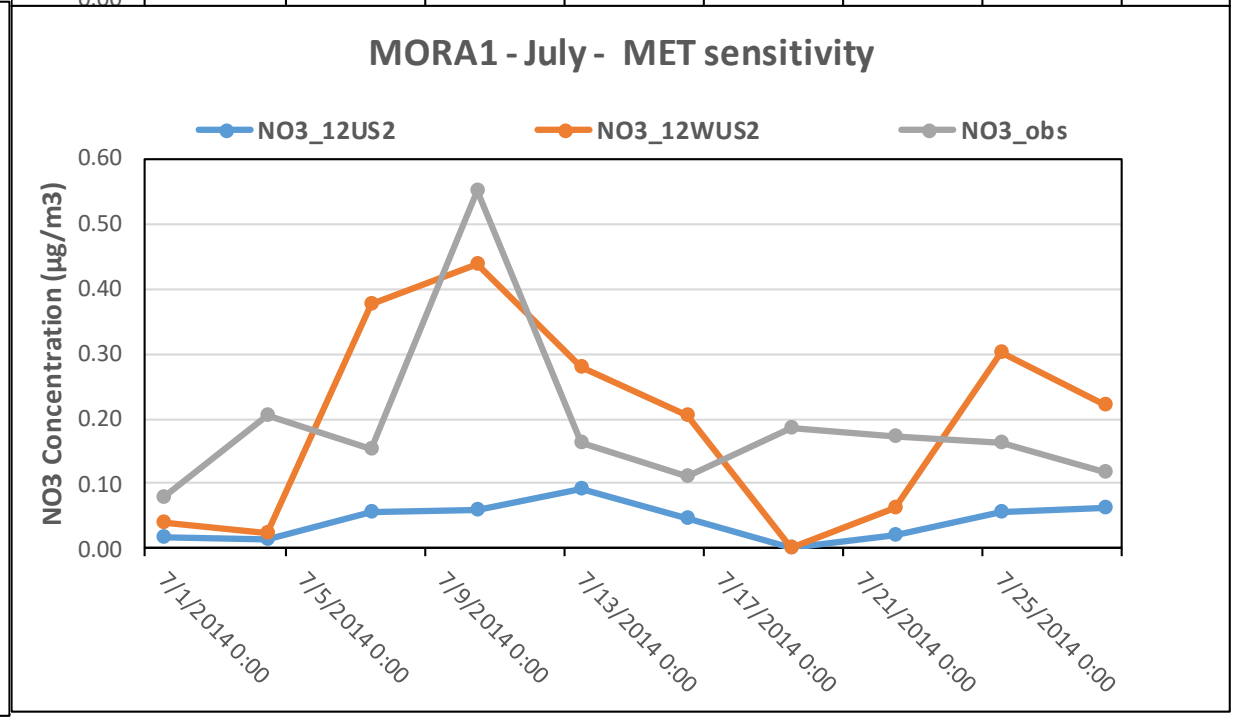
RAMBOLL

WRF SENSITIVITY - MOUNT RAINIER WA – SO4 & NO3

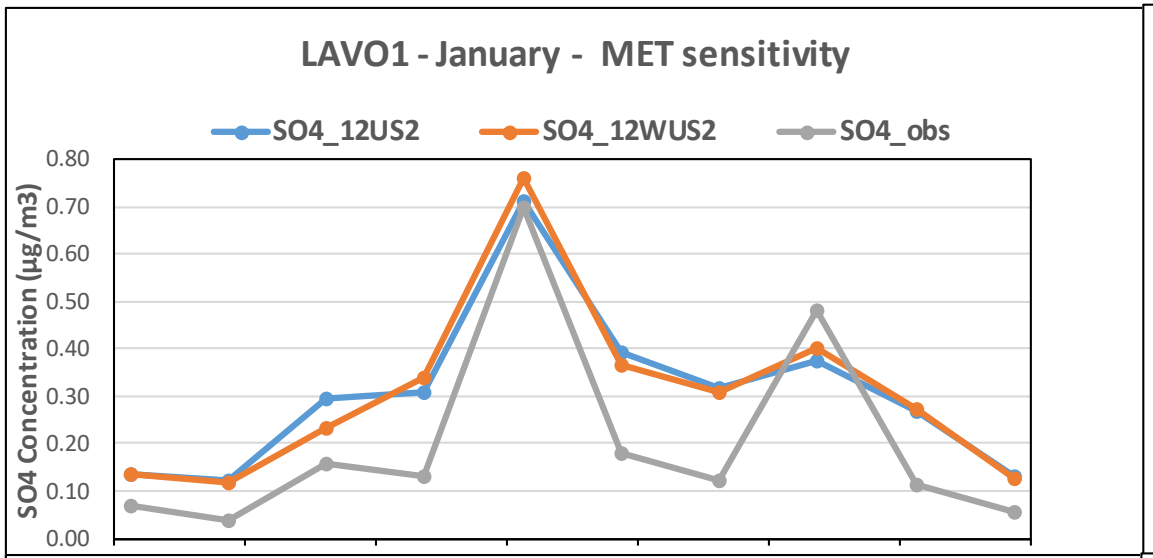


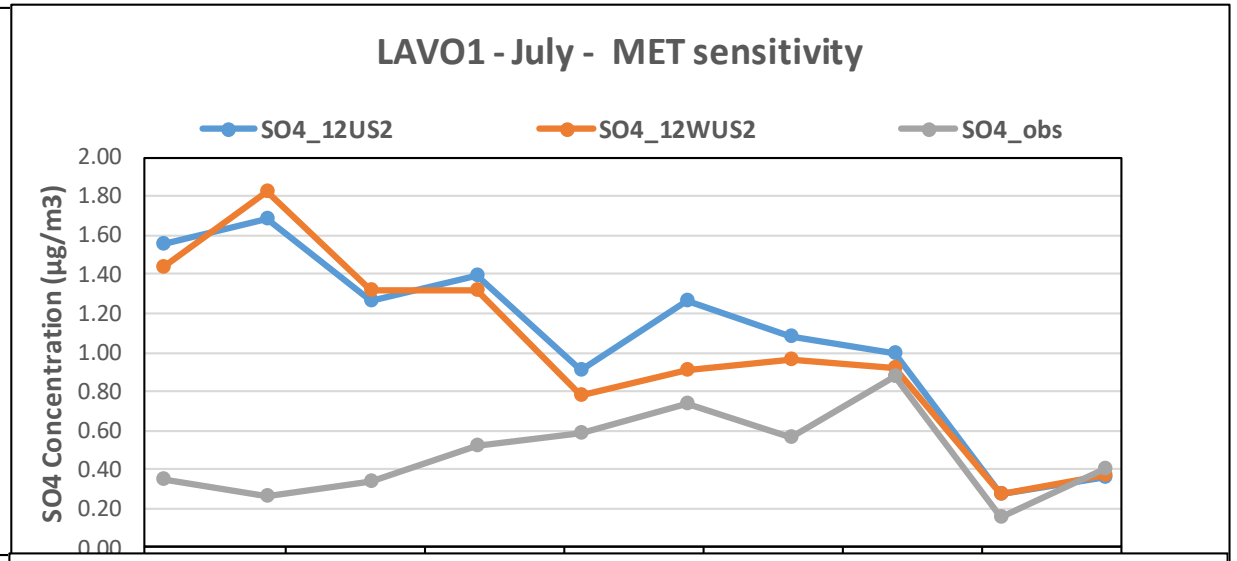


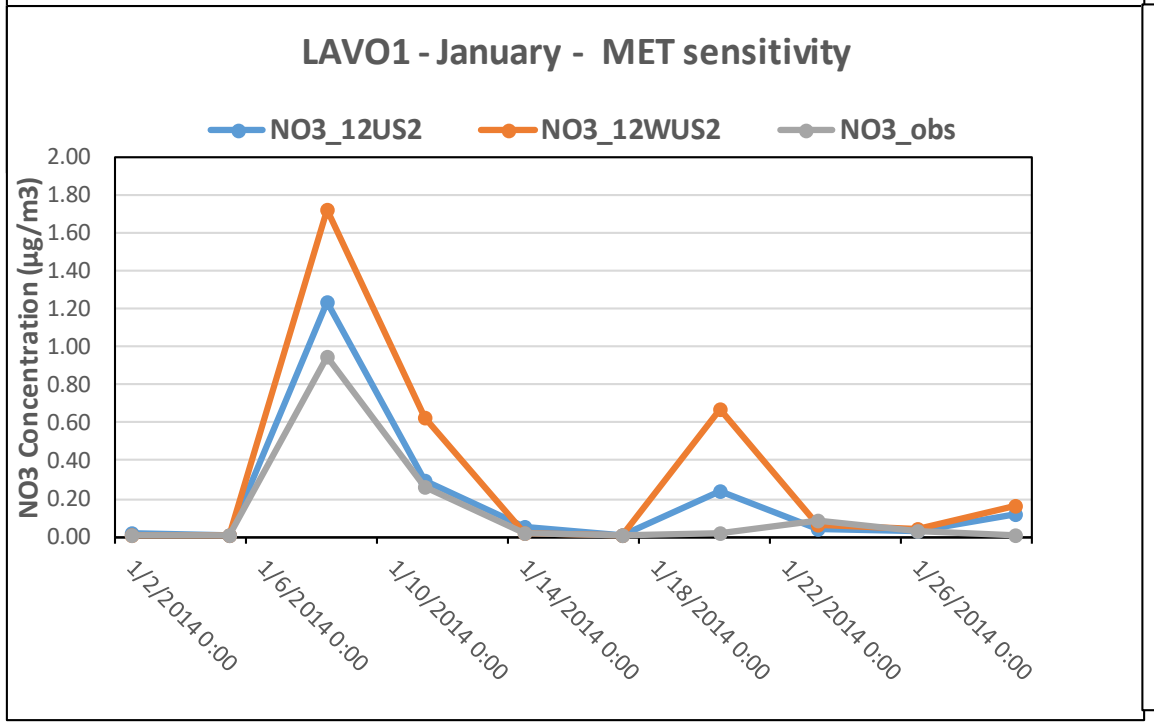


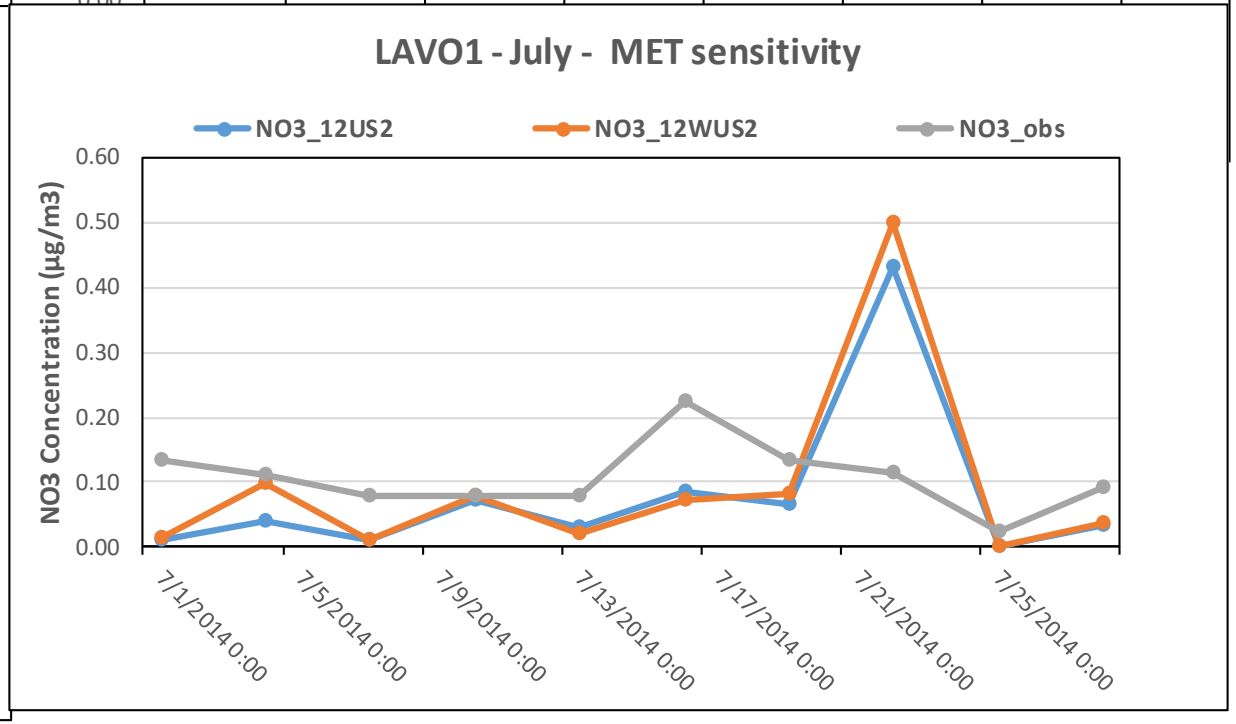


WRF SENSITIVITY – LASSEN VOLCANIC CA – SO4 & NO3

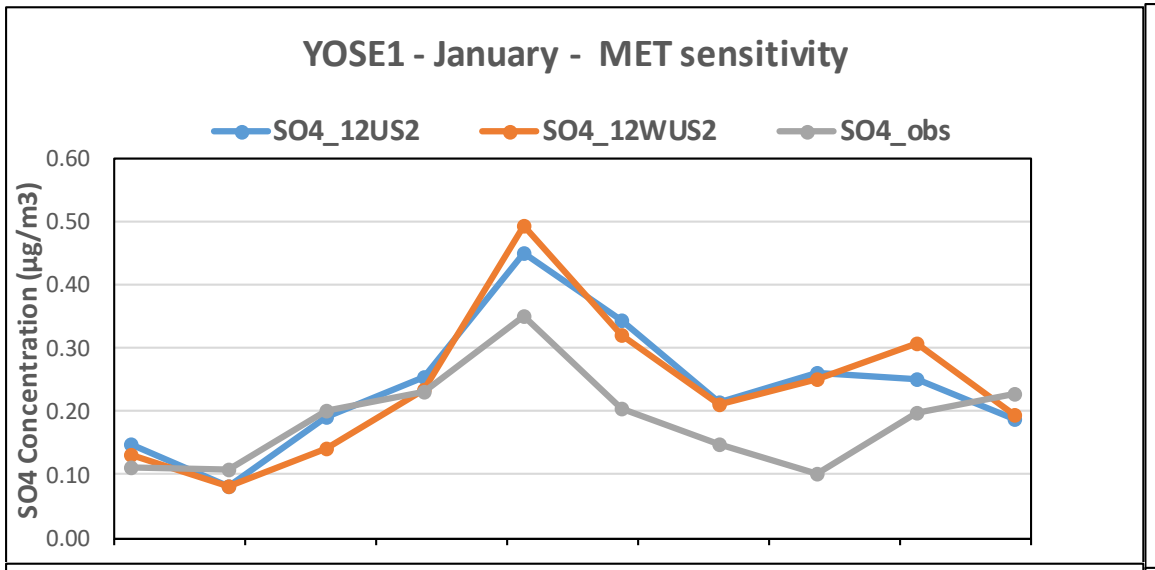


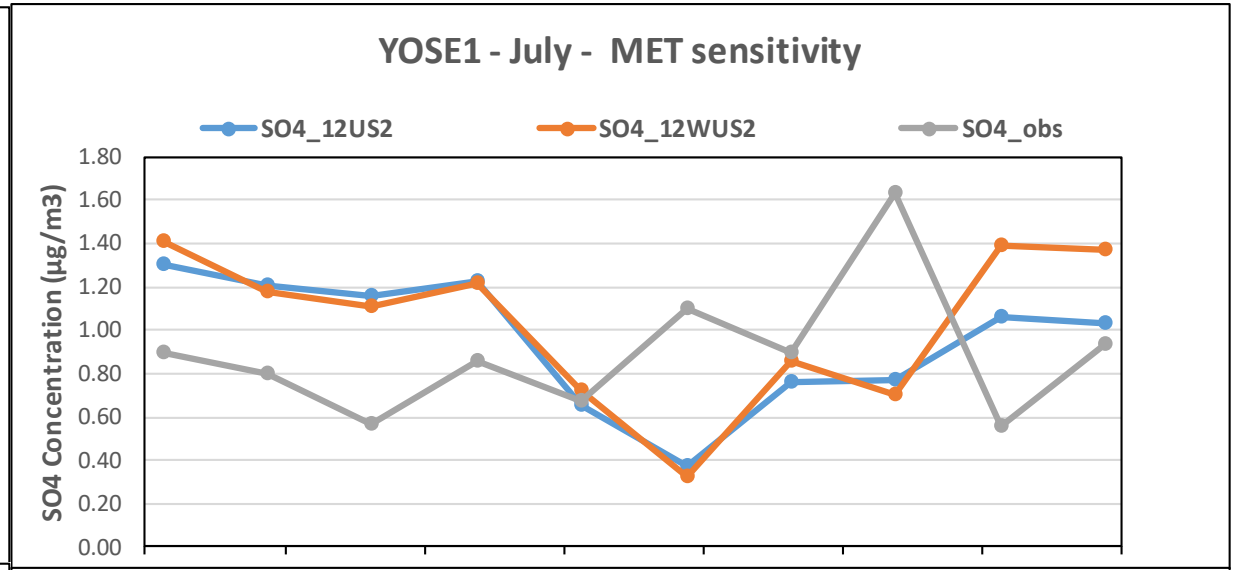


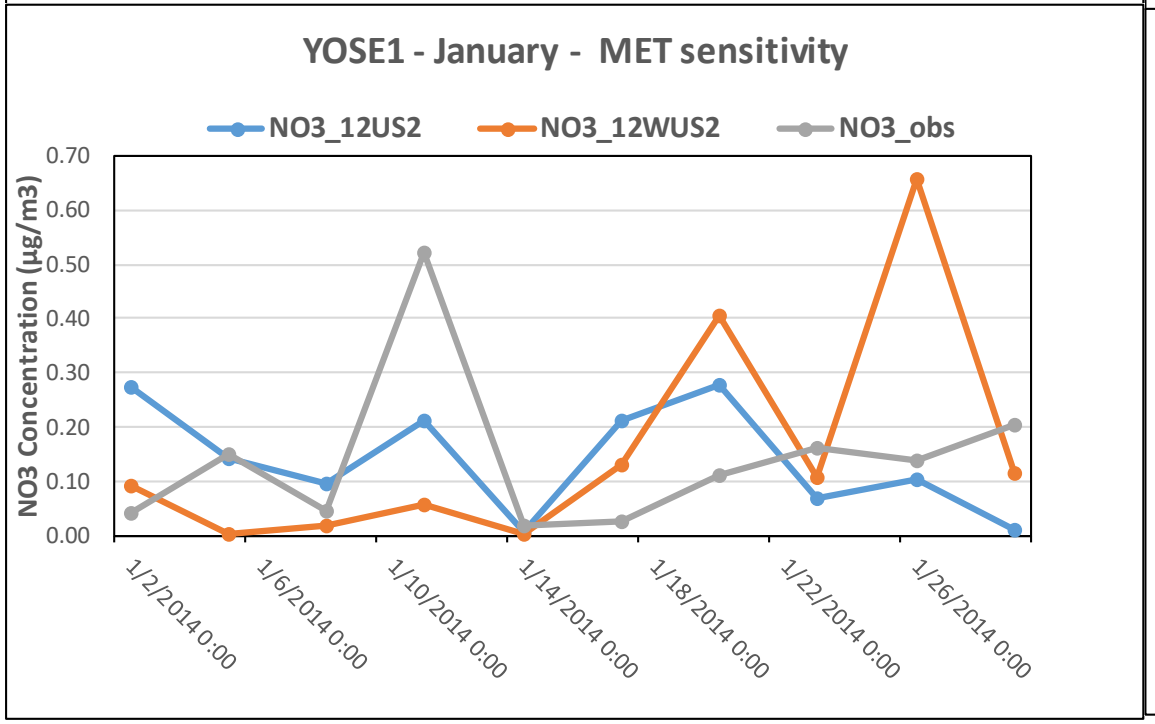


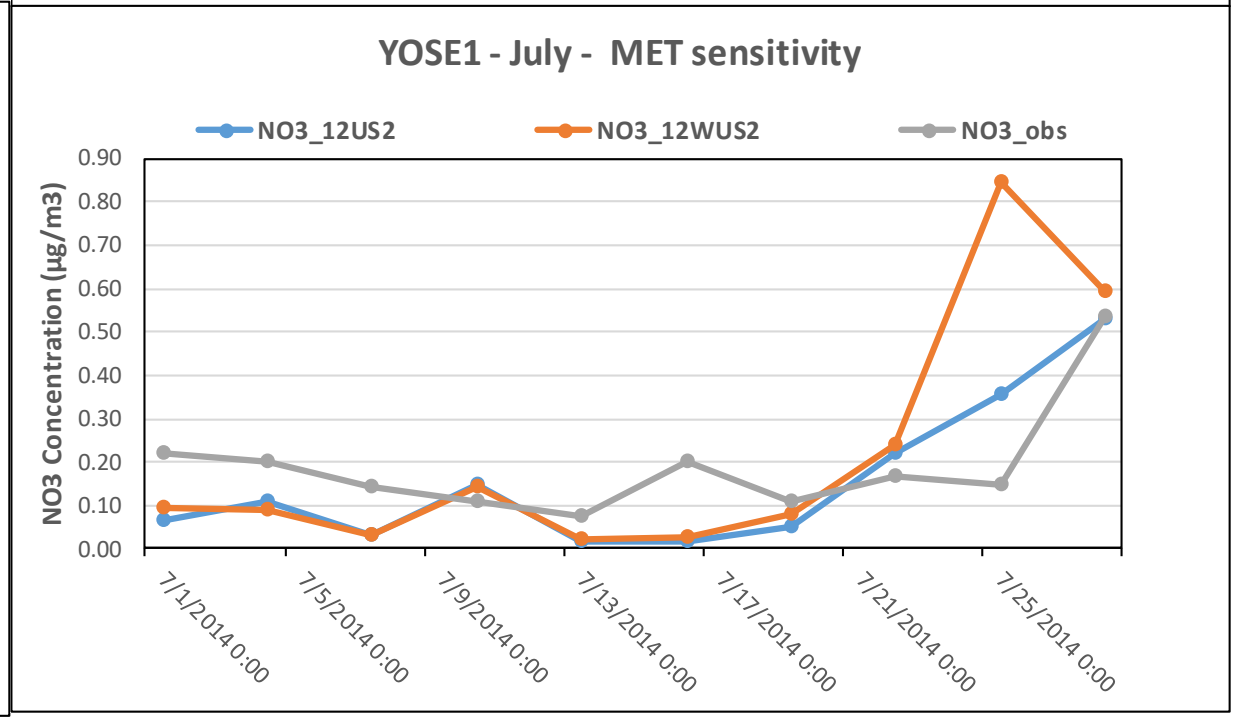


WRF SENSITIVITY – YOSEMITE CA – SO4 & NO3

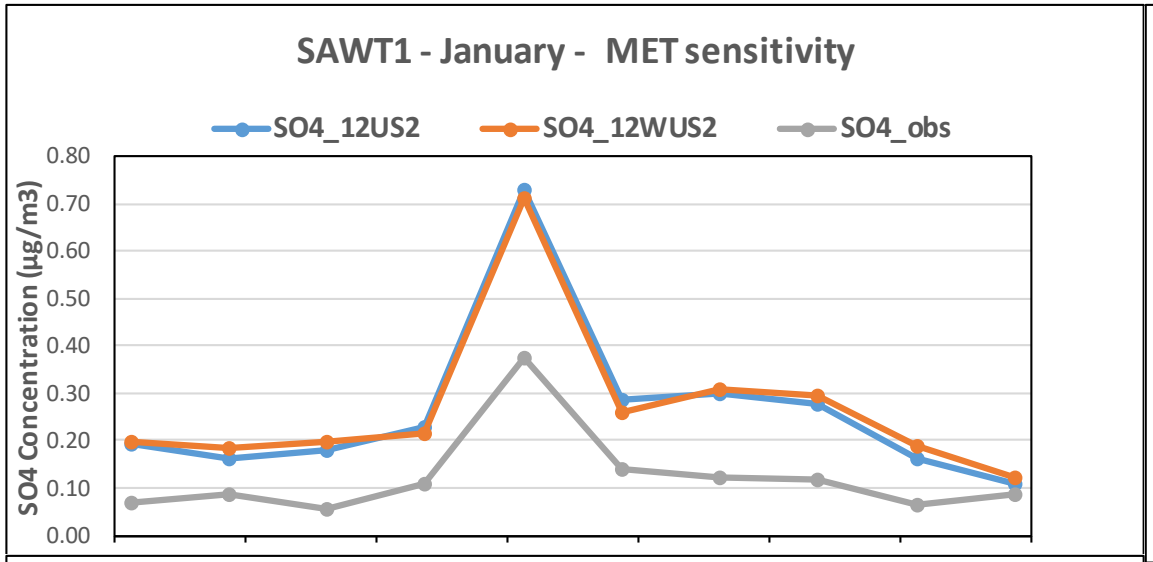


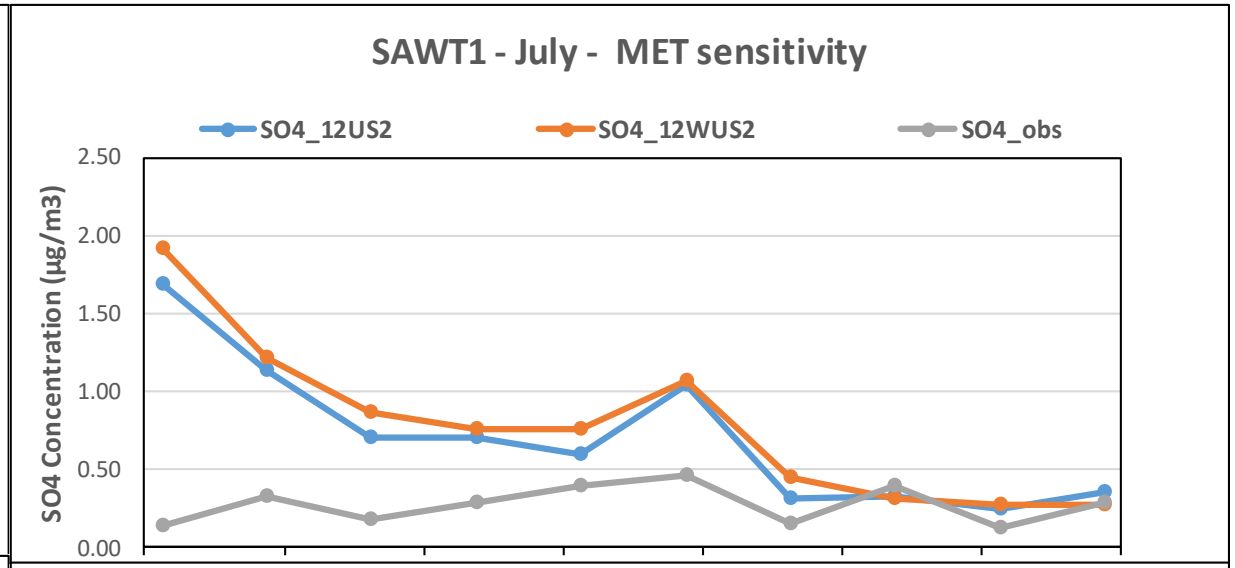


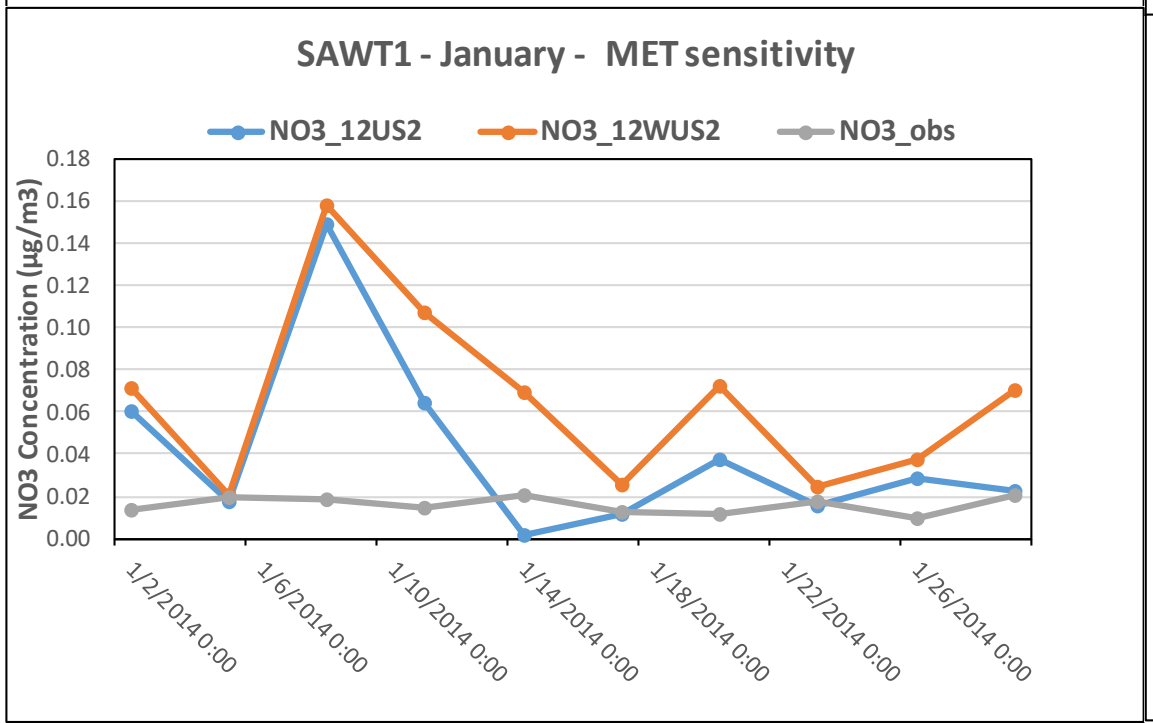


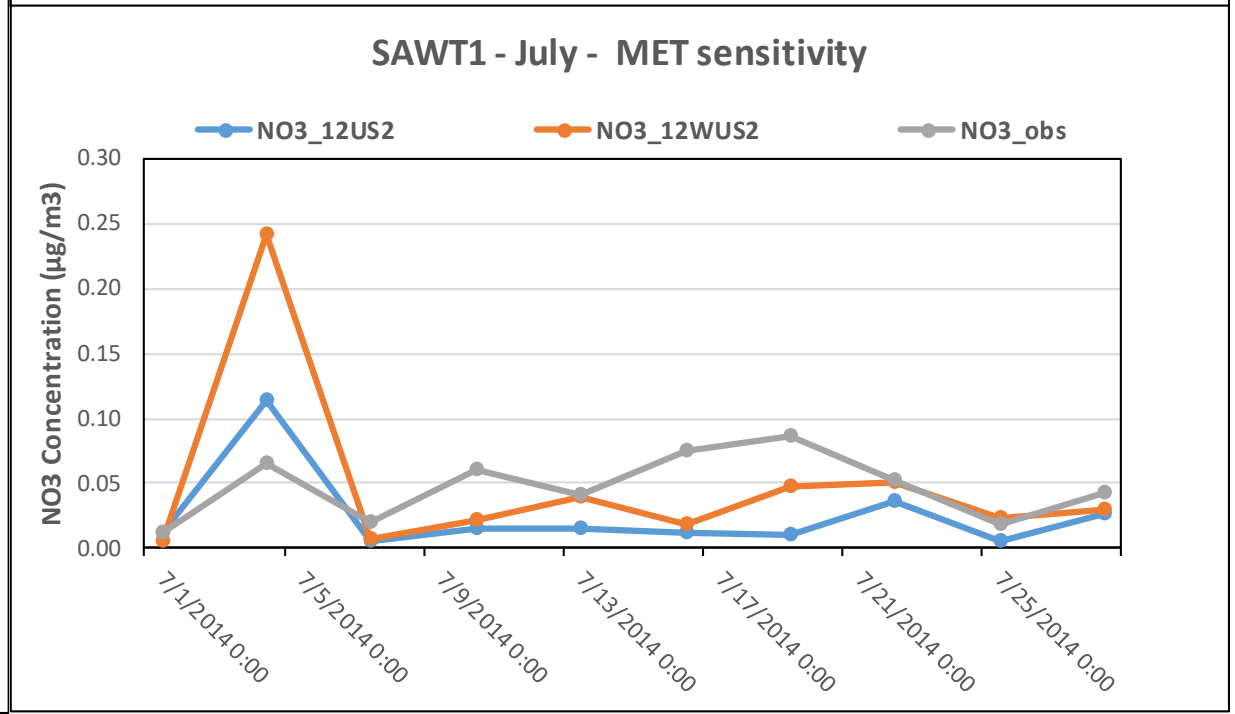


WRF SENSITIVITY – SAWTOOTH ID – SO4 & NO3

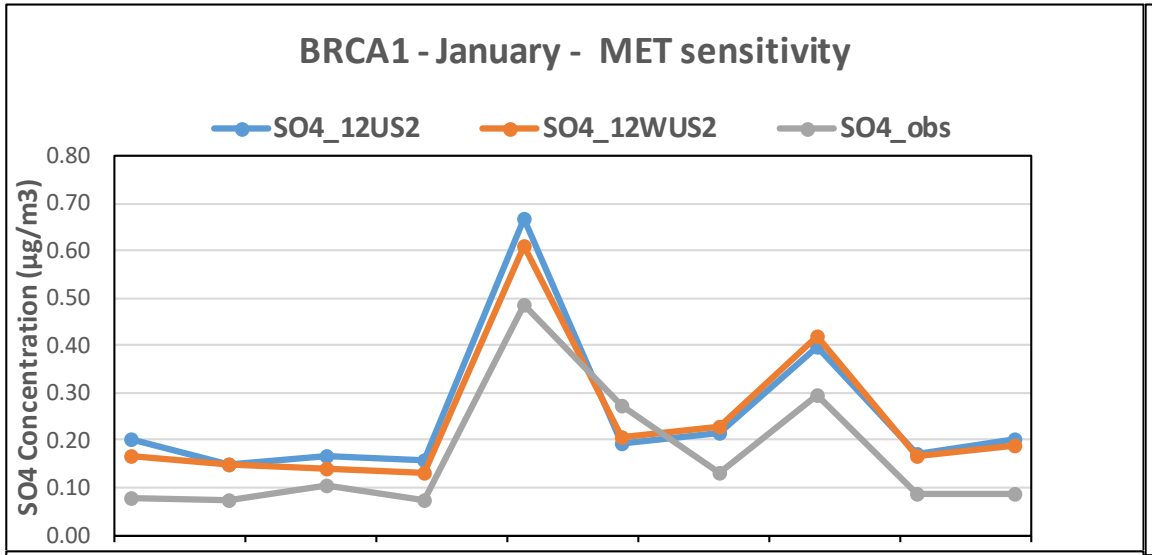


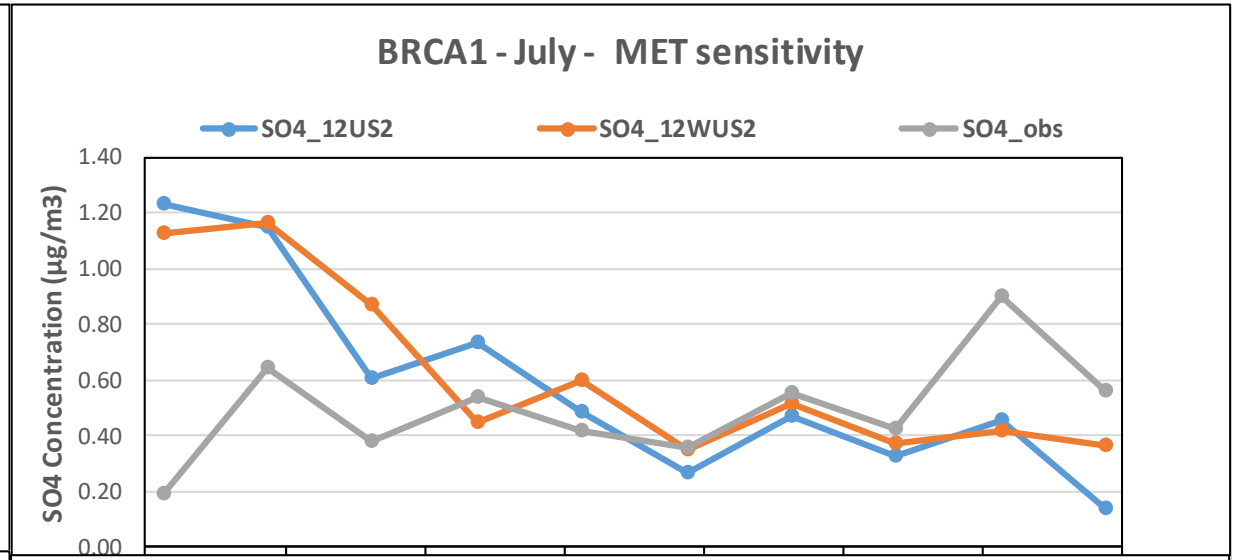


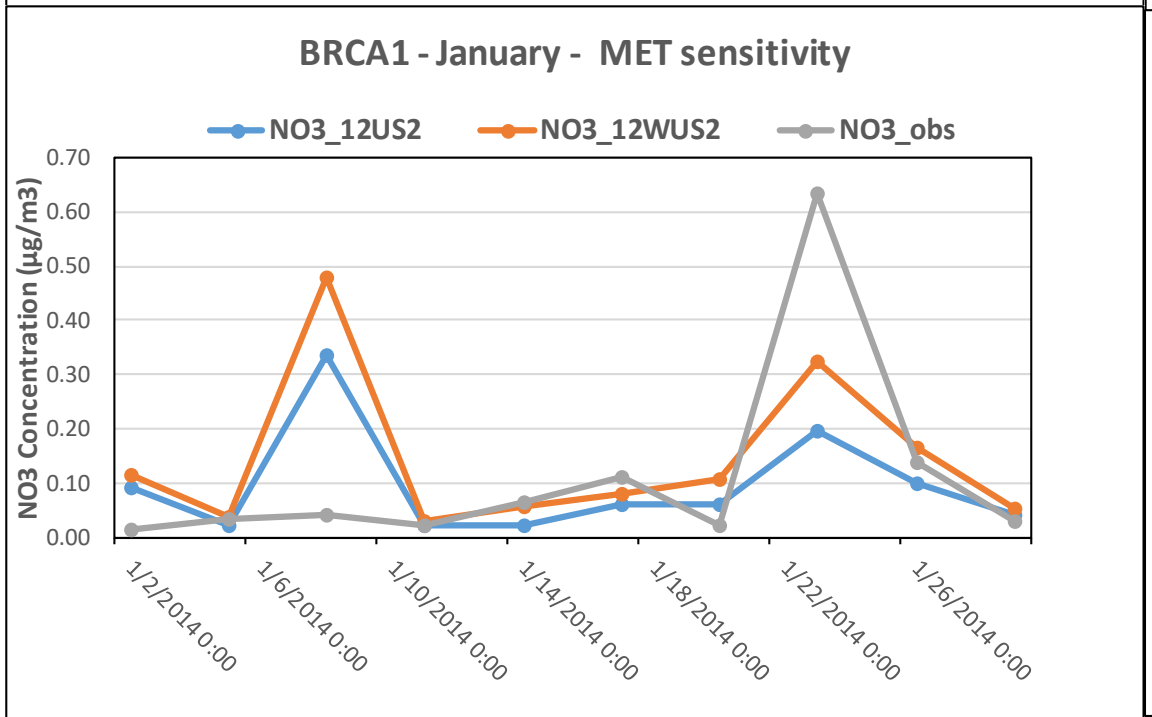


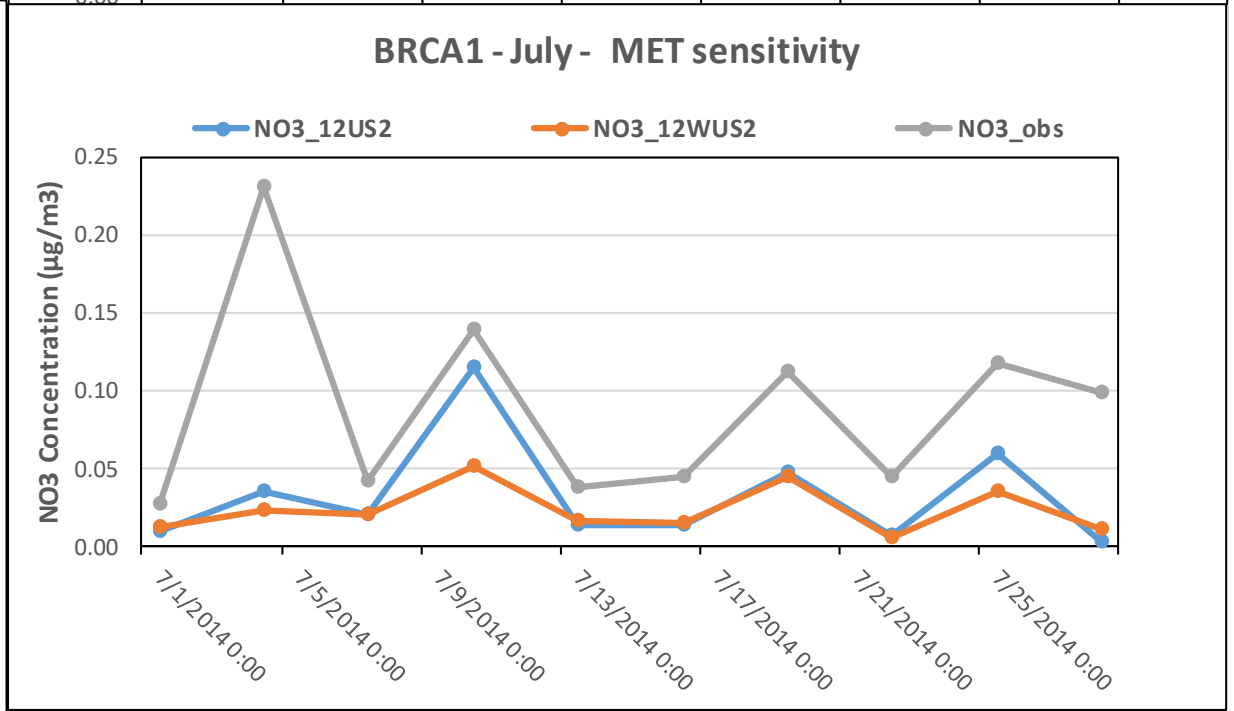


WRF SENSITIVITY – BRYCE CANYON UT – SO4 & NO3

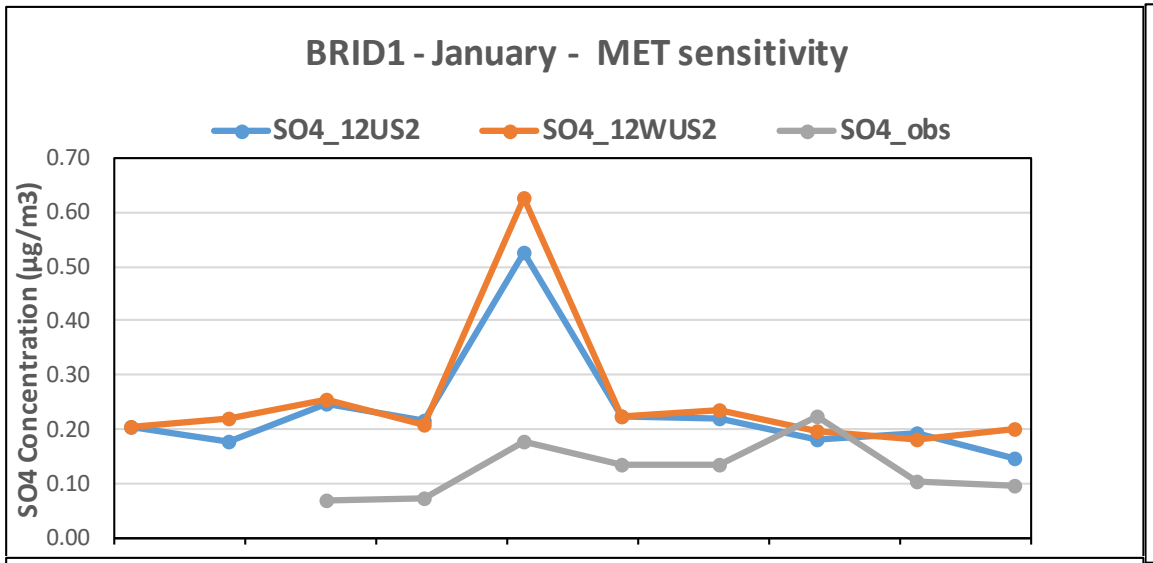


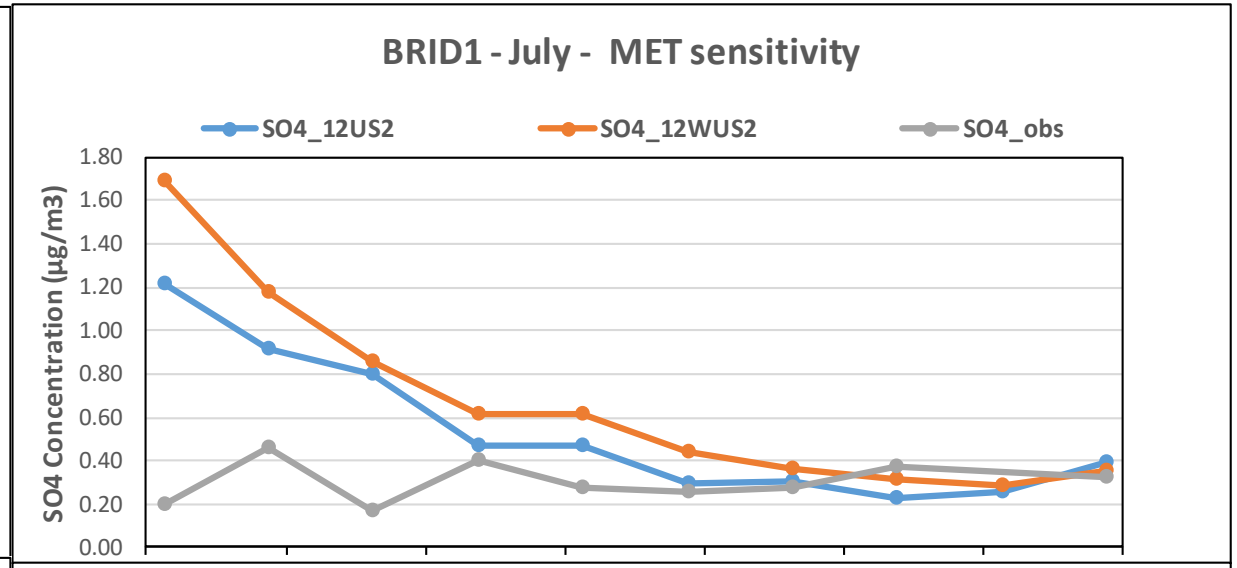


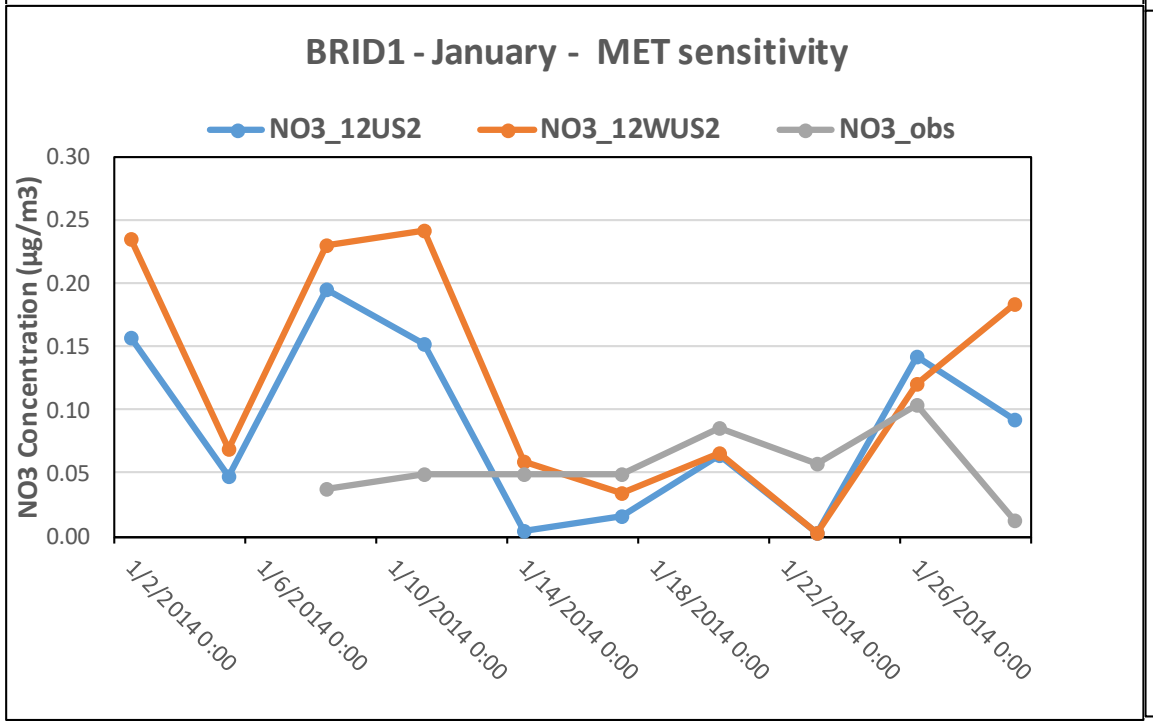


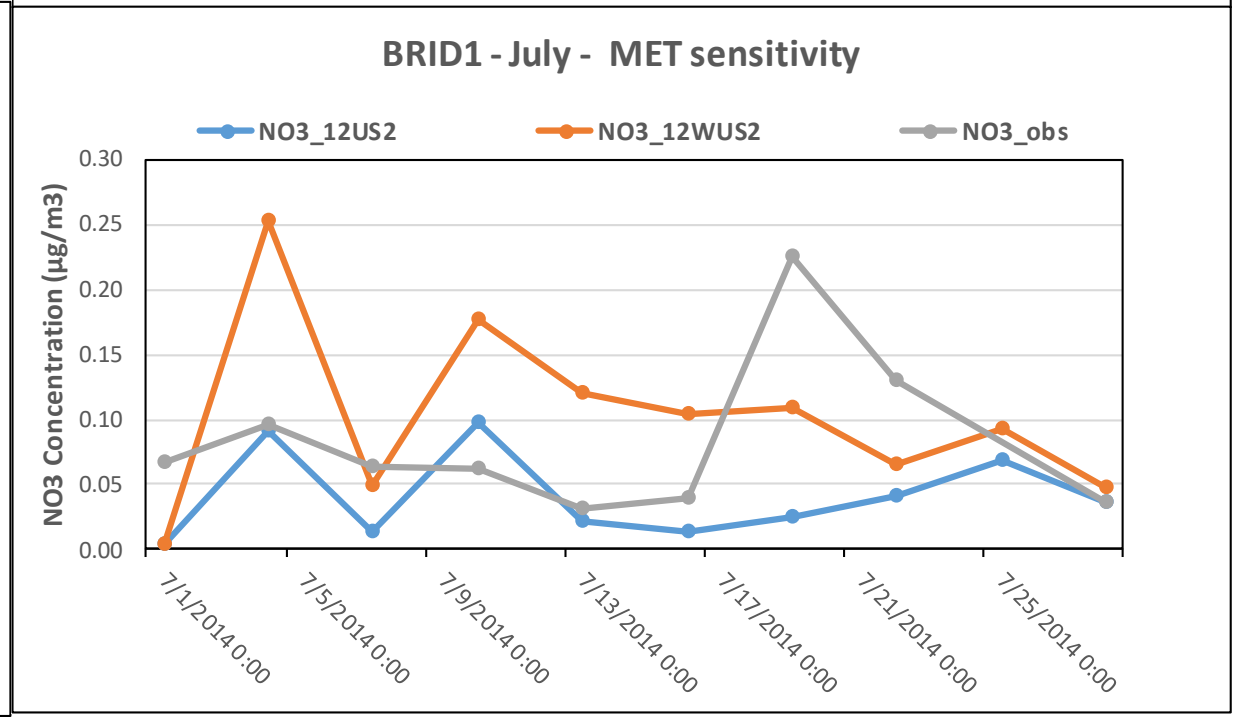


WRF SENSITIVITY – BRIDGER WY – SO4 & NO3

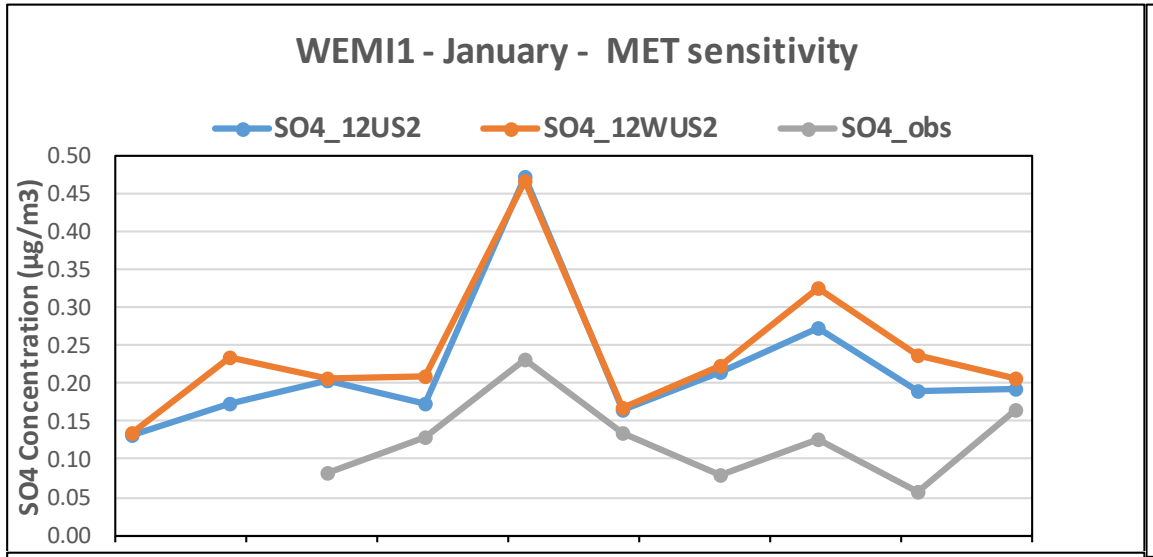


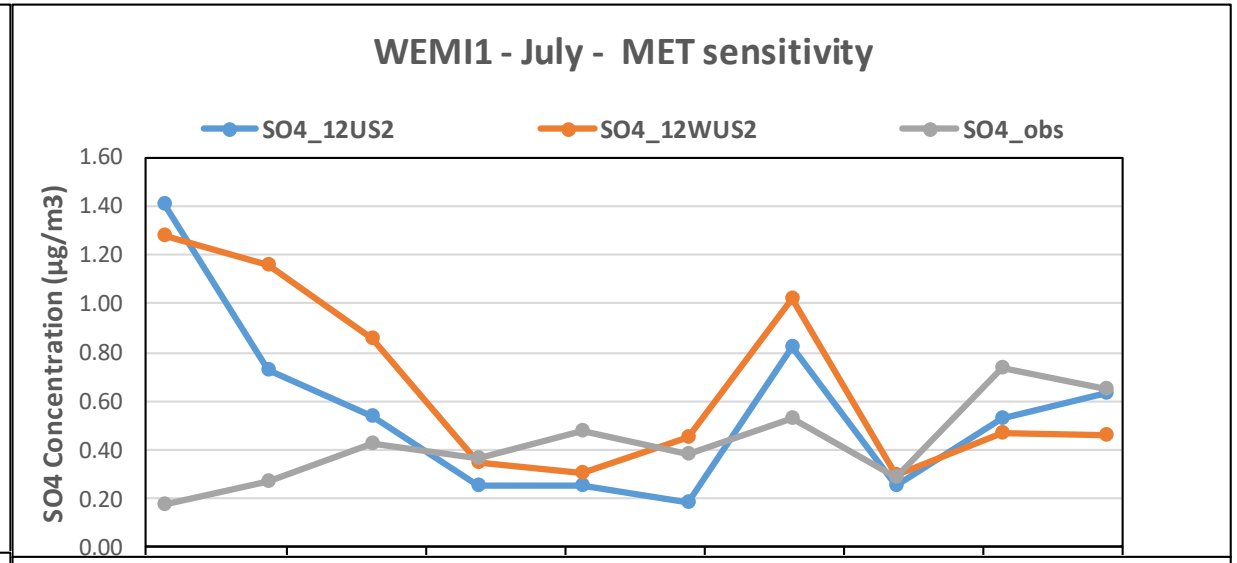


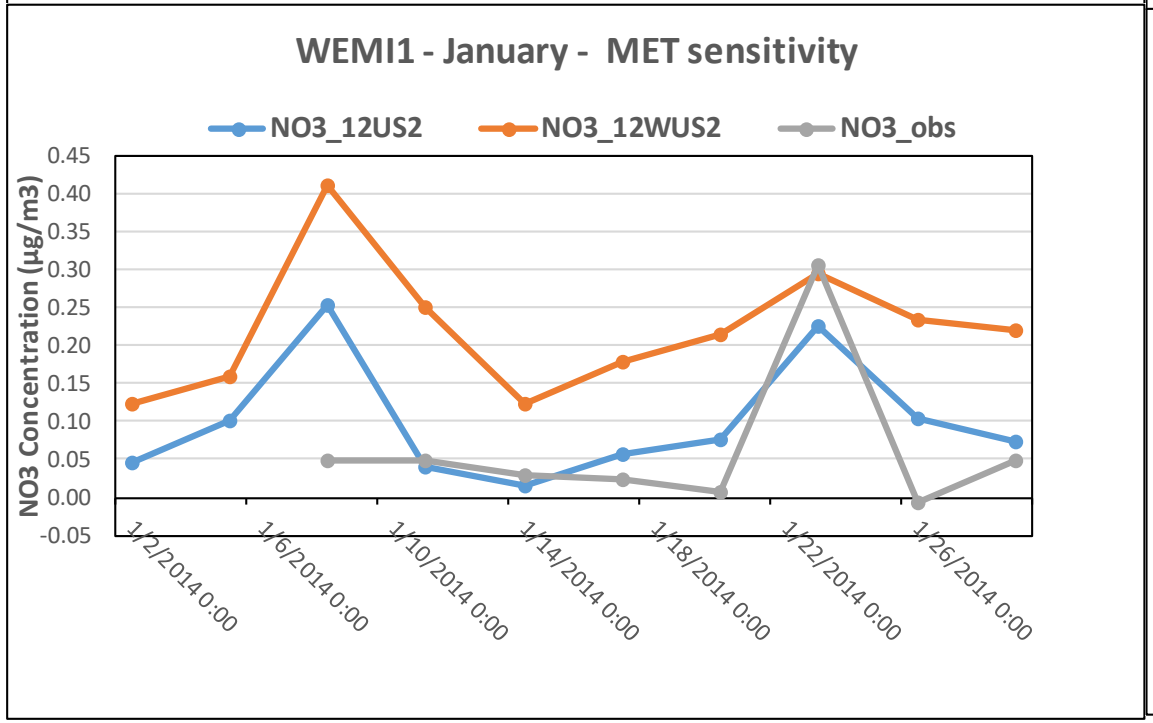


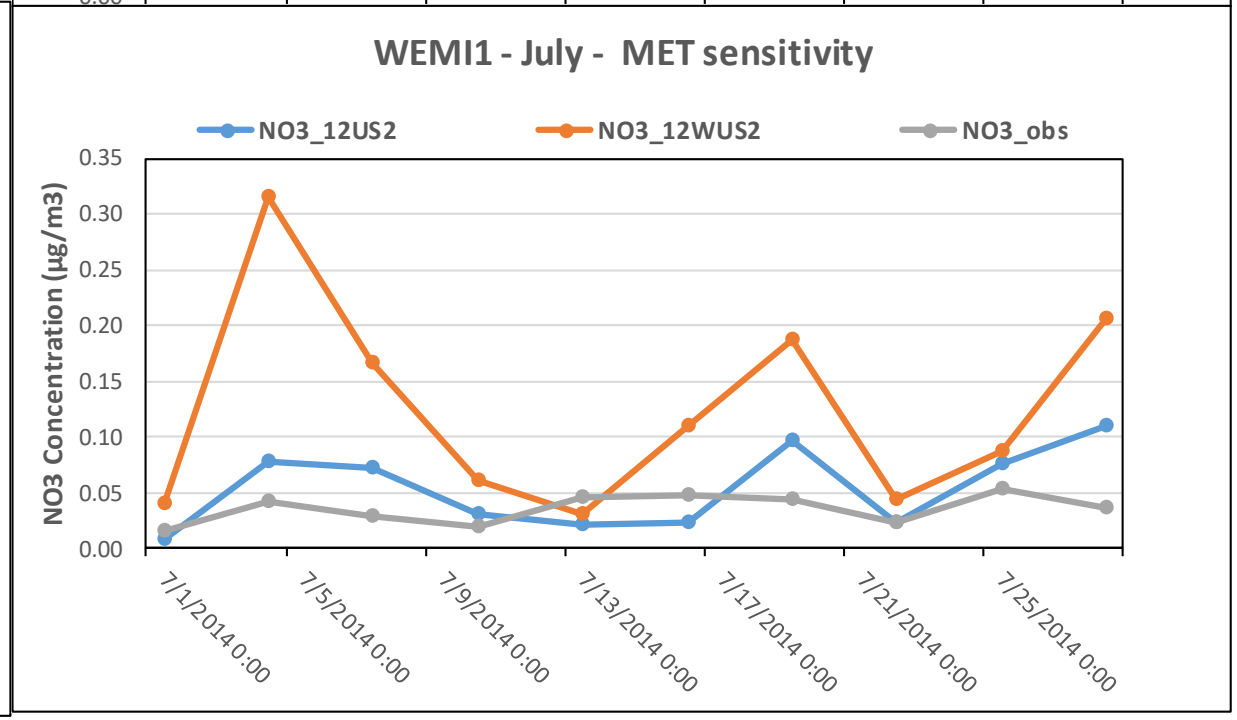


WRF SENSITIVITY – WEMINUCHE CO – SO4 & NO3

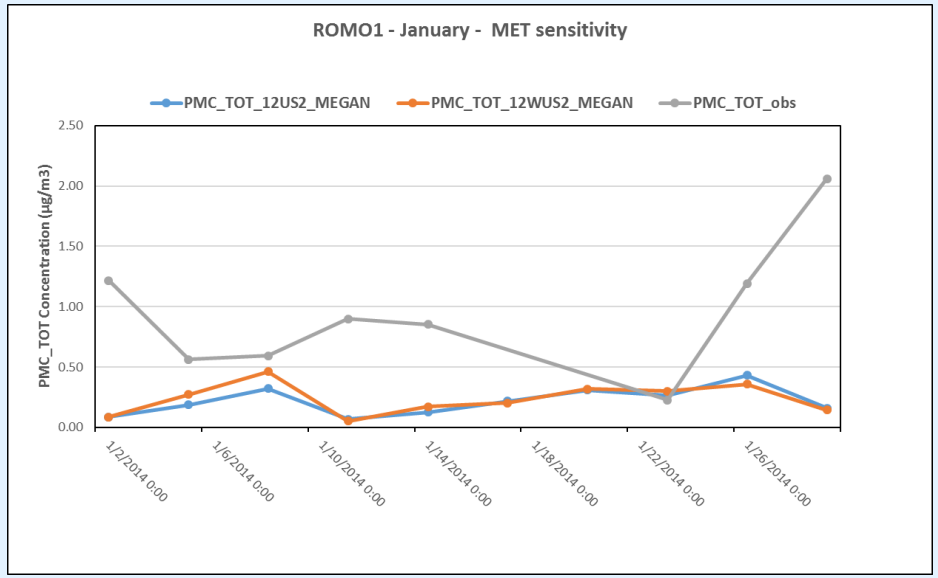
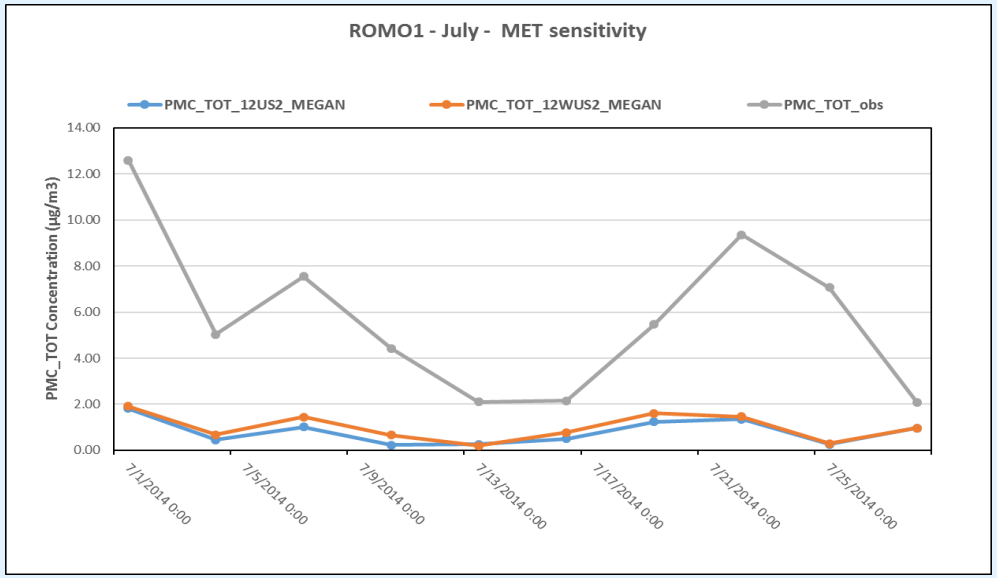
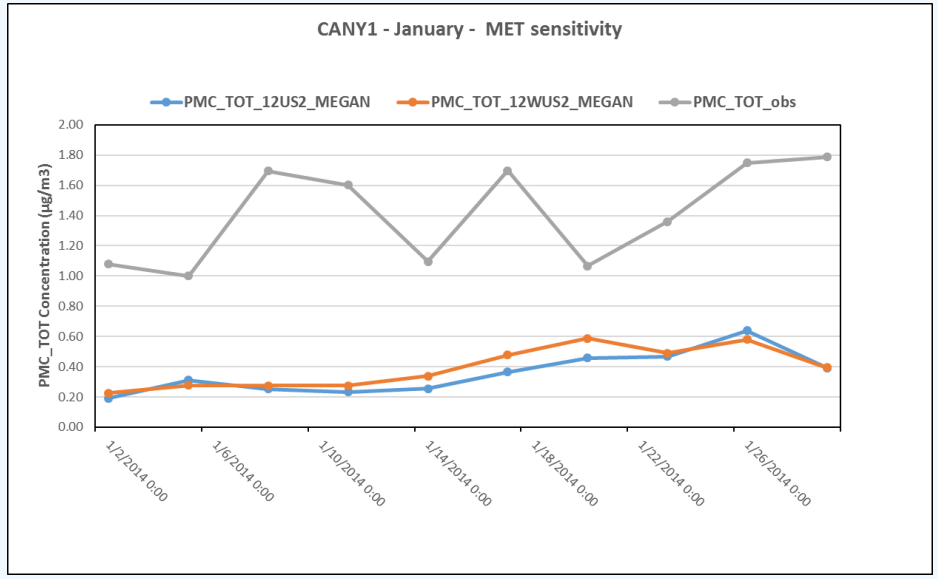
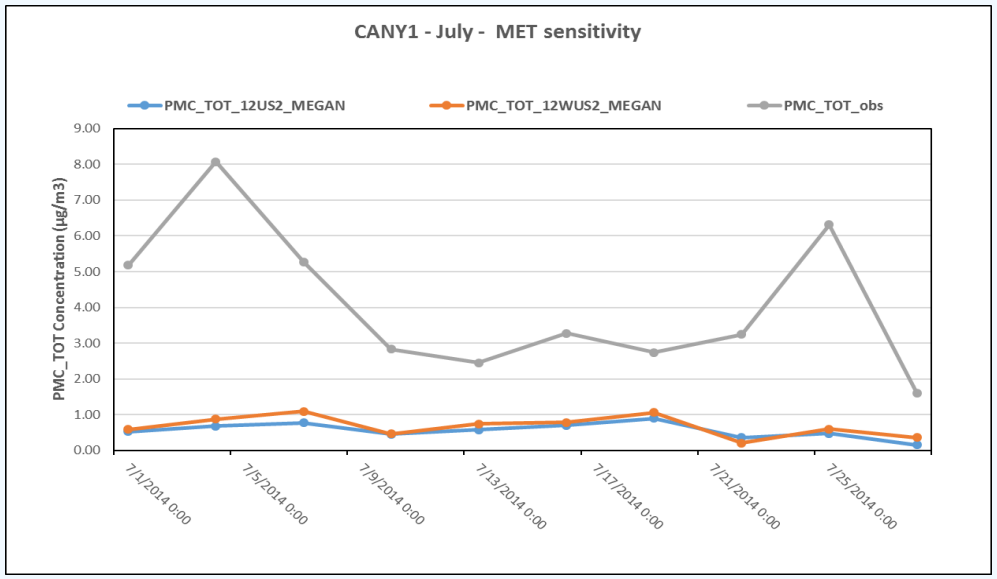




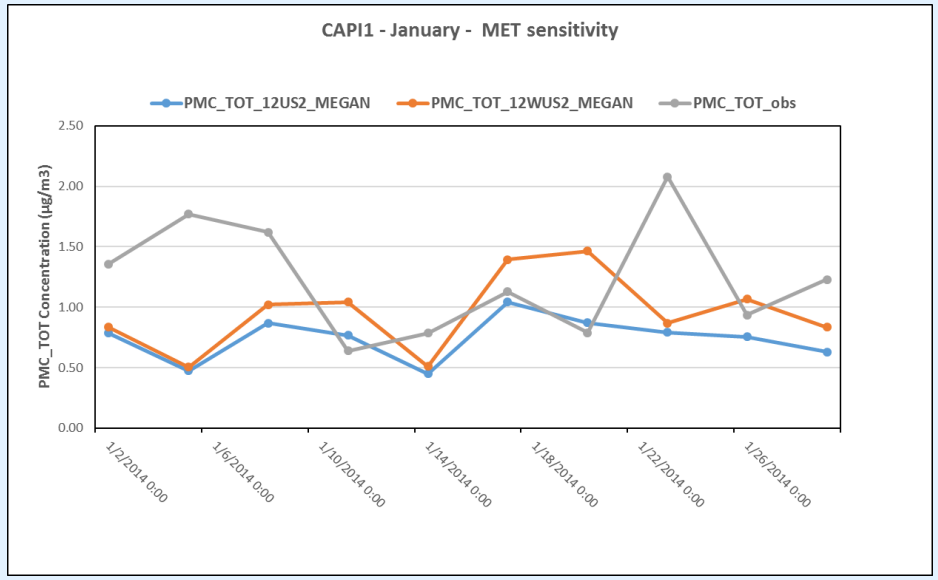
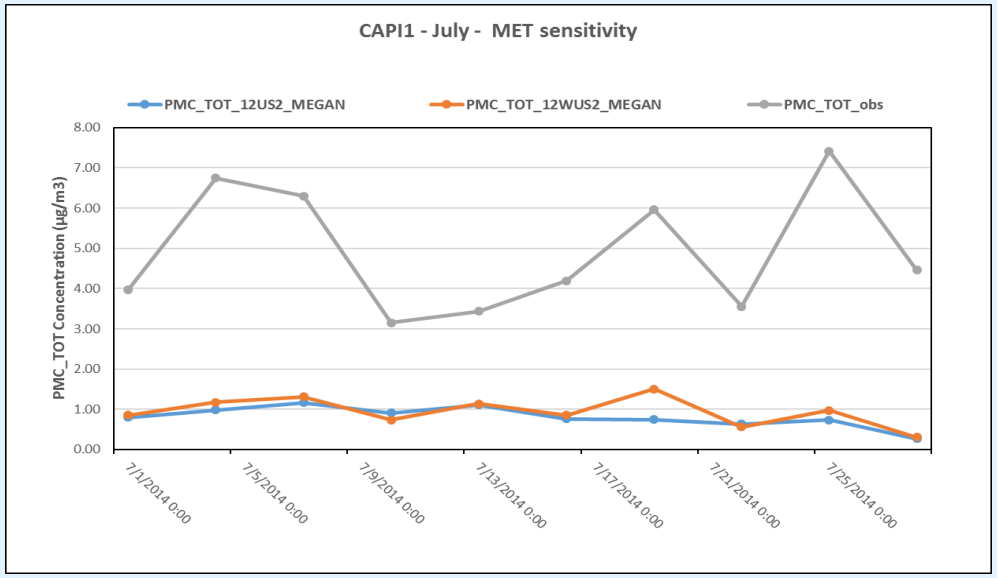
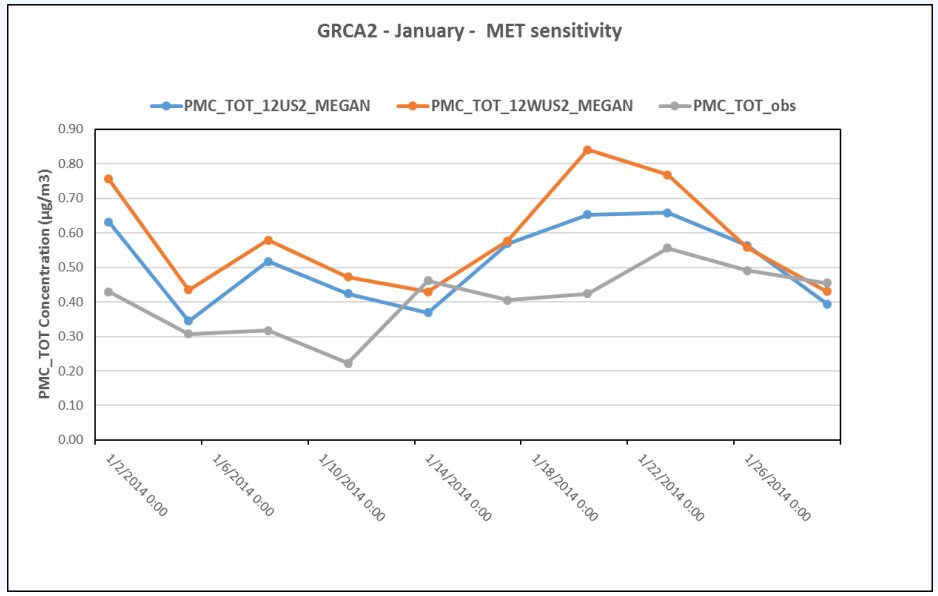
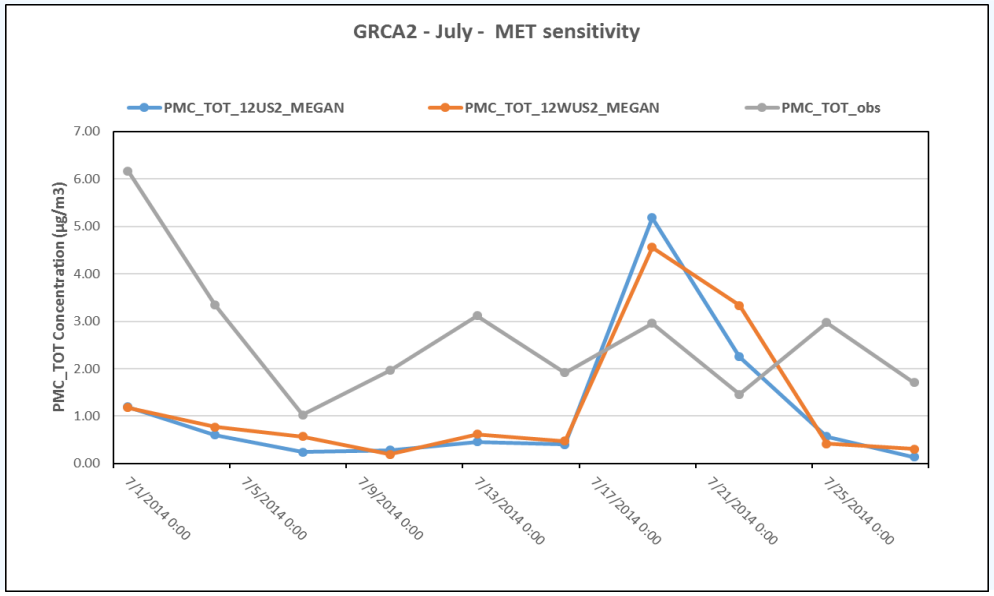




Meteorological Sensitivity: CM comparison

	Jan	Jul
ROMO1		
CANY1		

Meteorological Sensitivity: CM comparison

	Jan	Jul
CAPI1		
GRCA2		

Meteorological Sensitivity: Ozone Statistics - AQS

January	NMB		NME	
	EPA Met	WAQS Met	EPA Met	WAQS Met
AZ	31.8	29.0	31.9	30.5
CA	29.0	34.5	32.7	36.6
CO	28.8	18.2	29.8	23.6
ID	48.4	47.7	48.4	47.7
MT	50.5	43.9	51.0	45.7
NM	36.4	26.0	36.8	27.7
ND	4.7	-2.1	8.3	9.1
NV	54.2	41.7	54.2	42.6
SD	27.0	20.5	30.5	27.2
UT	19.9	15.6	26.1	25.4
WA	17.3	19.8	17.4	20.3
WY	50.7	42.0	50.7	42.1

July	NMB		NME	
	EPA Met	WAQS Met	EPA Met	WAQS Met
AZ	15.6	21.1	20.1	23.3
CA	10.2	14.5	21.2	22.6
CO	18.2	23.7	20.6	25.1
ID	10.5	14.8	16.2	18.4
MT	44.1	44.8	44.1	46.4
NM	24.8	24.7	25.1	24.9
ND	12.6	19.5	14.6	19.5
NV	34.4	34.9	34.4	34.9
SD	19.0	26.7	20.0	26.9
UT	20.5	22.5	23.4	24.3
WA	15.3	19.6	18.2	22.0
WY	22.9	25.2	24.1	25.6

Ozone performance at AQS sites in WRAP states (green indicates better performance):

- WAQS Met has better performance in January than EPA Met
- EPA Met has better performance in July than WAQS Met

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Meteorological Sensitivity: PM2.5 Statistics - IMPROVE

January	FB		FE	
	EPA Met	WAQS Met	EPA Met	WAQS Met
AZ	-34.9	-20.5	43.8	37.6
CA	-23.4	-11.1	48.3	48.4
CO	2.1	22.7	53.1	60.2
ID	-44.3	-39.1	56.1	52.2
MT	11.6	27.4	49.6	54.3
NM	-3.9	7.9	39.2	40.4
ND	-13.7	8.6	43.9	43.1
NV	-36.1	-32.4	51.2	52.3
SD	-6.8	9.4	39.1	36.8
UT	-12.8	-1.0	33.7	33.5
WA	47.2	55.3	71.7	75.4
WY	10.0	27.7	36.5	40.0
OR	-17.9	-17.3	61.3	63.5

July	FB		FE	
	EPA Met	WAQS Met	EPA Met	WAQS Met
AZ	-87.5	-71.8	93.4	78.7
CA	-31.6	-26.3	57.8	58.7
CO	-95.2	-70.2	96.8	71.8
ID	-57.4	-40.2	72.3	64.9
MT	-55.4	-54.8	63.7	64.7
NM	-83.9	-59.5	83.9	61.0
ND	-23.0	-18.5	47.5	43.8
NV	-87.8	-82.8	87.8	83.5
SD	-56.0	-58.1	62.2	61.0
UT	-80.0	-69.0	82.0	71.2
WA	-28.8	-4.1	43.6	46.1
WY	-78.1	-66.5	78.1	70.8
OR	-25.6	-18.3	46.7	44.6

PM2.5 performance at IMPROVE sites (green indicates better performance):

- January is a toss up, neither sensitivity is a clear 'winner'
- WAQS Met has better performance than EPA Met in July

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Meteorological Sensitivity: PM Sulfate Statistics - IMPROVE

January	FB		FE	
	EPA Met	WAQS Met	EPA Met	WAQS Met
AZ	15.2	20.2	34.8	34.9
CA	23.9	25.3	49.5	48.6
CO	46.7	55.3	53.1	58.2
ID	39.3	39.2	56.6	58.0
MT	57.7	66.3	70.3	75.3
NM	29.8	35.1	38.8	41.3
ND	21.7	29.8	59.3	64.5
NV	25.3	23.2	40.4	38.0
SD	9.28	13.8	45.1	48.0
UT	31.7	30.4	40.5	38.7
WA	73.5	71.9	89.3	85.2
WY	45.1	55.0	53.7	58.7
OR	59.6	54.9	69.1	65.9

July	FB		FE	
	EPA Met	WAQS Met	EPA Met	WAQS Met
AZ	-56.5	-32.2	75.2	57.6
CA	36.0	37.6	57.3	59.7
CO	0.5	29.7	58.3	60.4
ID	71.3	77.9	73.3	81.4
MT	74.6	70.5	78.8	77.9
NM	-25.2	4.2	44.9	46.4
ND	48.3	49.8	56.8	59.9
NV	28.1	33.9	52.8	55.8
SD	23.8	25.6	37.1	33.7
UT	7.4	21.4	50.3	47.2
WA	63.5	69.1	65.5	70.5
WY	45.8	55.9	55.0	59.6
OR	84.7	87.2	85.5	87.6

Sulfate performance at IMPROVE sites (green indicates better performance):

- WAQS Met slightly better performance in January
- EPA Met has better performance than WAQS Met in July

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Summary Meteorological Sensitivity

- Comparison among simulations show in general similar spatial patterns for ozone, sulfate nitrate, PM2.5 but there are differences
- Both simulations have positive biases for Ozone due to overstated ozone BCs
  - WAQS tends to have higher ozone concentrations in July, likely due to overstated convective precipitation in EPA 12-km WRF simulations
  - Overstated 2014 GEOS-Chem ozone BCs confound the ozone comparison
- Both simulations have negative biases for PM2.5. WAQS tends to have better performance than EPA
  - Sulfate is a mixed picture. EPA slightly better than WAQS met. Is that for right reasons?
    - Difficult to interpret with 2014 GEOS-Chem overstated SO2/SO4 BCs (eruptions)
  - Nitrate is slightly better with EPA than WAQS met, especially in summer. Is that for right reason?
- Meteorology sensitivity: Inconclusive, no obvious 'winner'
- Selected WAQS 12-km WRF 12WUS2 domain for final 2014 annual Shake-Out CAMx & CMAQ simulations
  - EPA overstated convective precipitation a concern

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Biogenic Sensitivity

MEGAN vs. BEIS within the WAQS 12-km 12US2 Domain

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CAMx Configuration: Biogenic Emissions Sensitivity

- Biogenic Sensitivity Simulation: Only biogenic emissions are different; all other aspects are kept consistent or identical

	BEIS	MEGAN
Modeling Domain	12WUS2	
Boundary Conditions	36US1	
Biogenic Emissions	BEIS	MEGAN
Fire/Anthro Emissions	2014 NEI	
Advection Solver	PPM	
Chemistry Solver	EBI	
Plume-in-Grid	GREASD	

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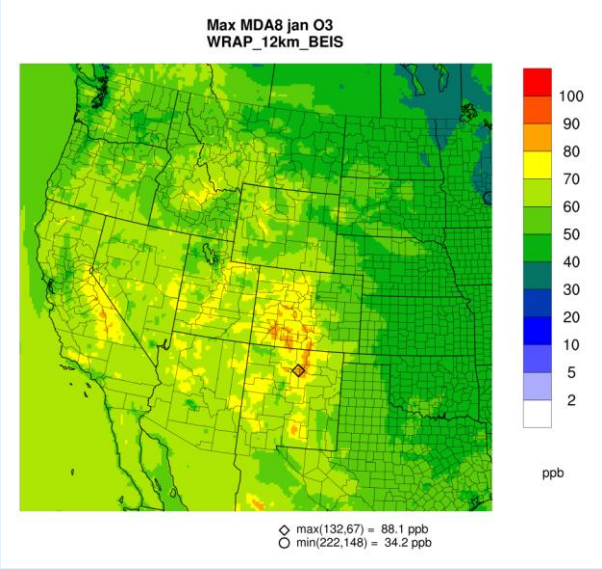
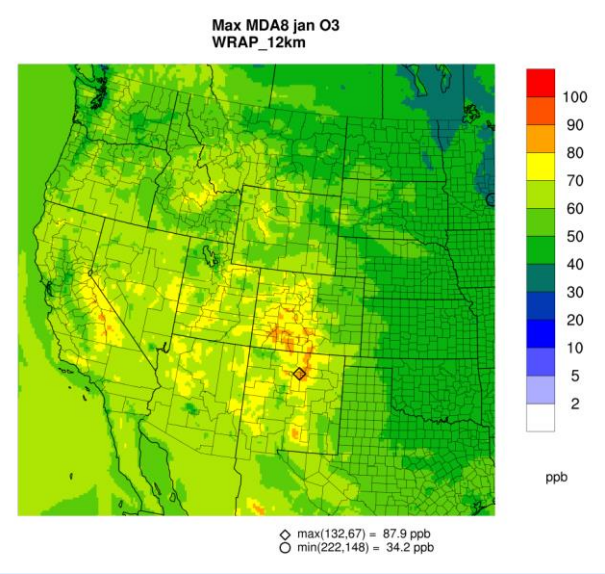
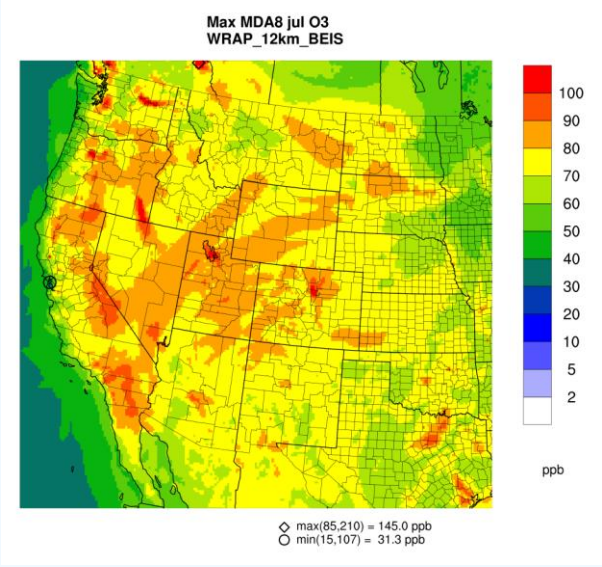
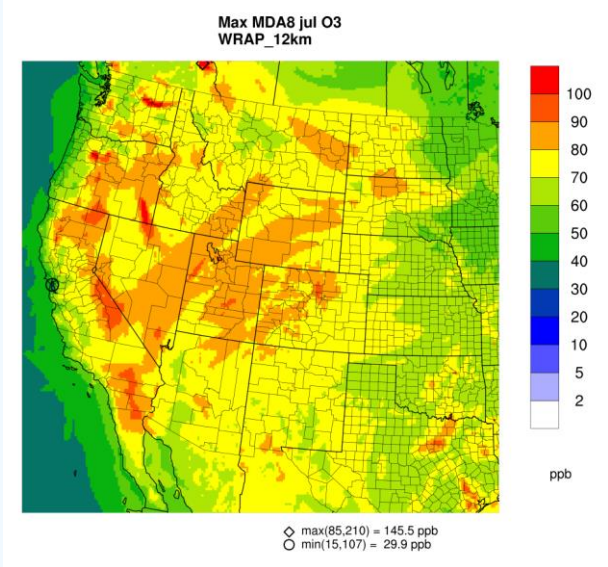
Biogenic Sensitivity: Surface Ozone

- Maximum daily 8-hr average ozone concentrations
- Similar spatial distributions

	BEIS	MEGAN
Jan		
July		

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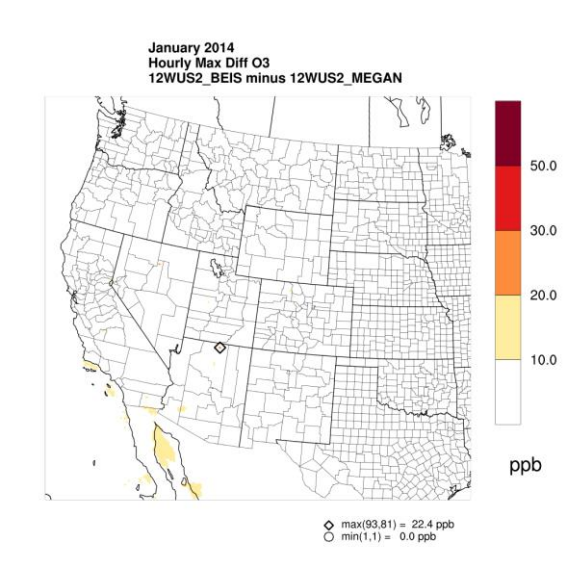
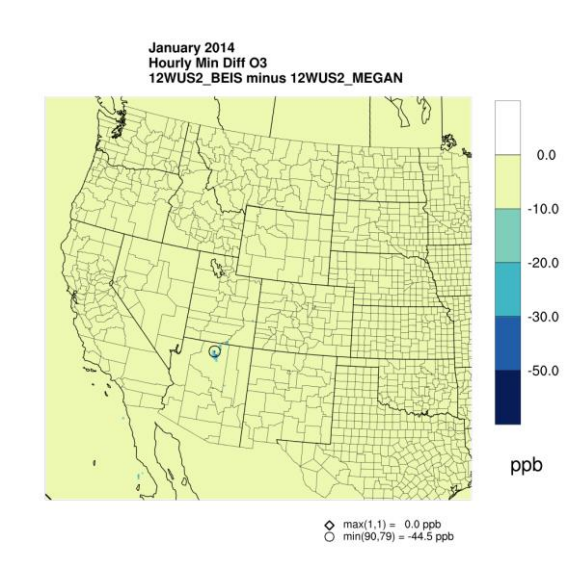
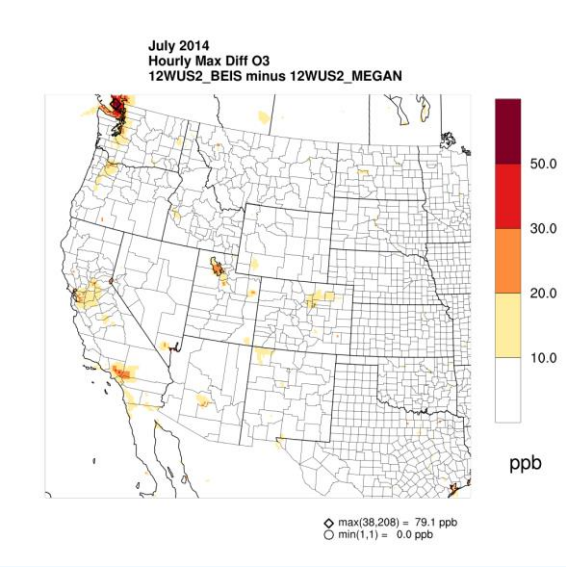
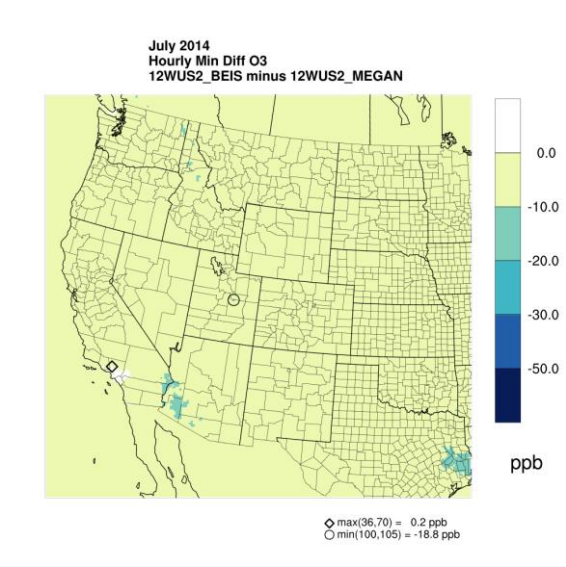
Biogenic Sensitivity: Surface Ozone Differences

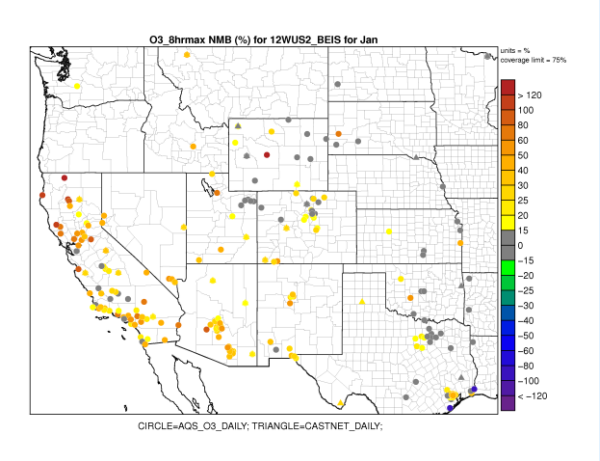
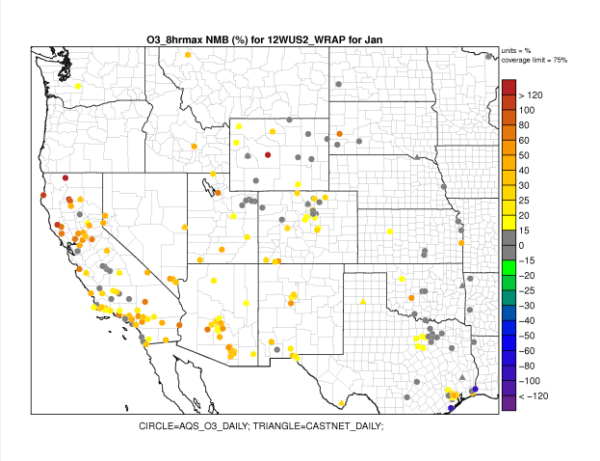
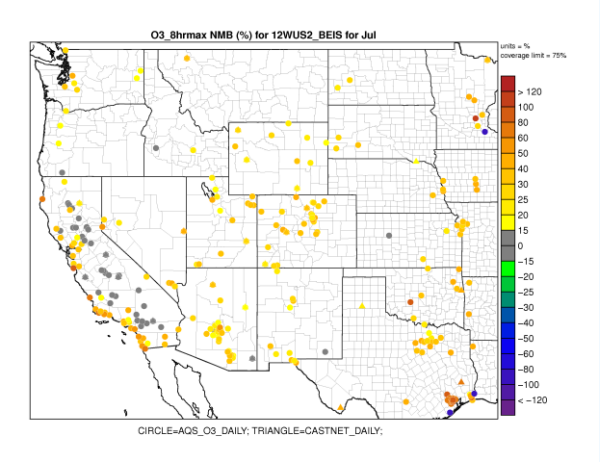
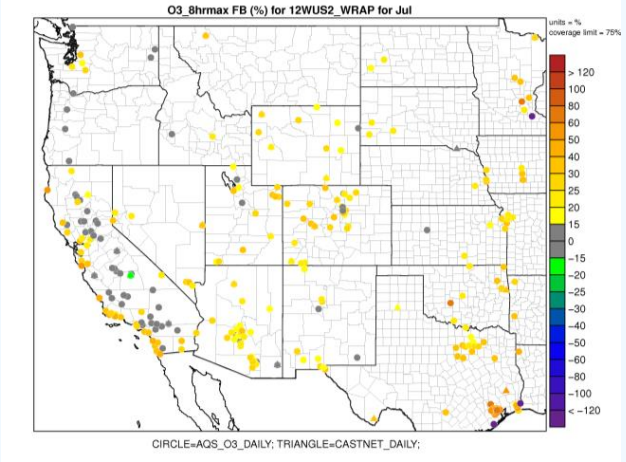
- Maximum differences in hourly concentrations
- First Column indicates when BEIS is higher than MEGAN
- Second column indicates when MEGAN is higher than BEIS
- For both January and July the ozone differences between sensitivities are small

	MAX Diff	MIN Diff
Jan		
July		

RAMBOLL

Biogenic Sensitivity: Ozone Bias Overlay

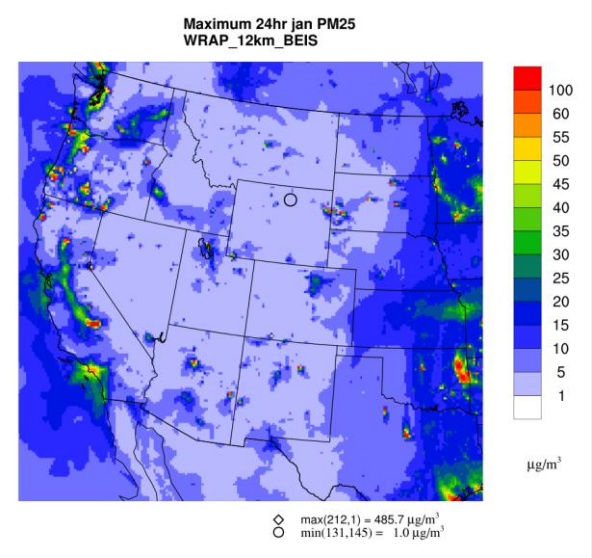
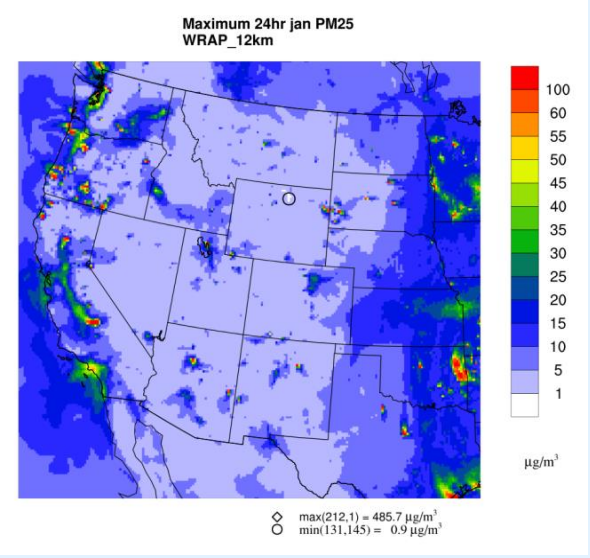
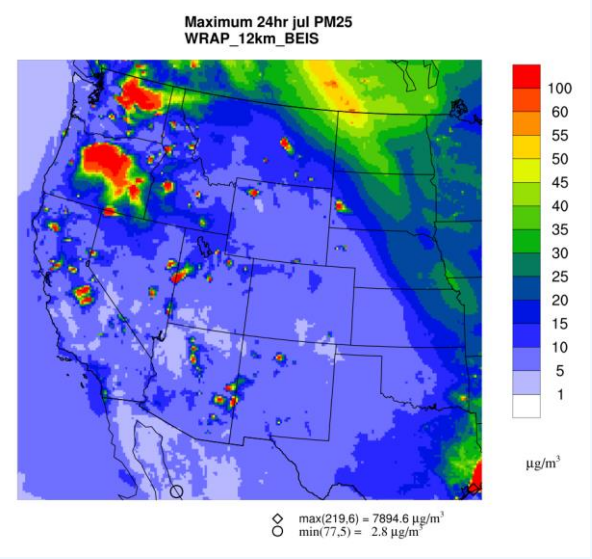
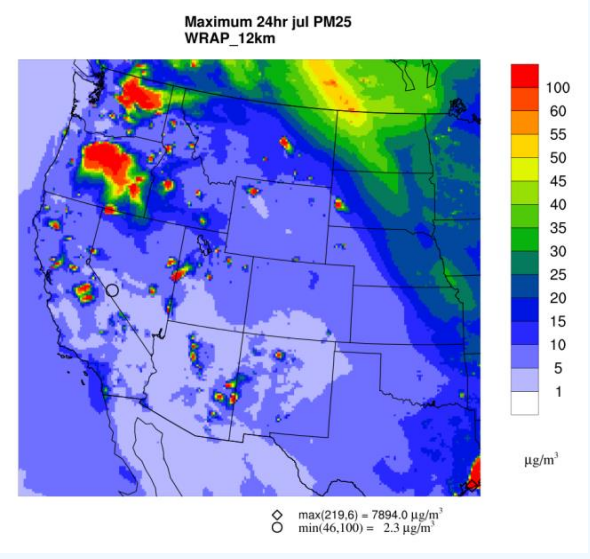
- Both simulations lead to ozone over-predictions in both January and July due to GCBCs
- Overlay Bias patterns very similar on both sensitivities

	BEIS	MEGAN
Jan		
July		

RAMBOLL

Biogenic Sensitivity: Surface PM2.5 Maximum

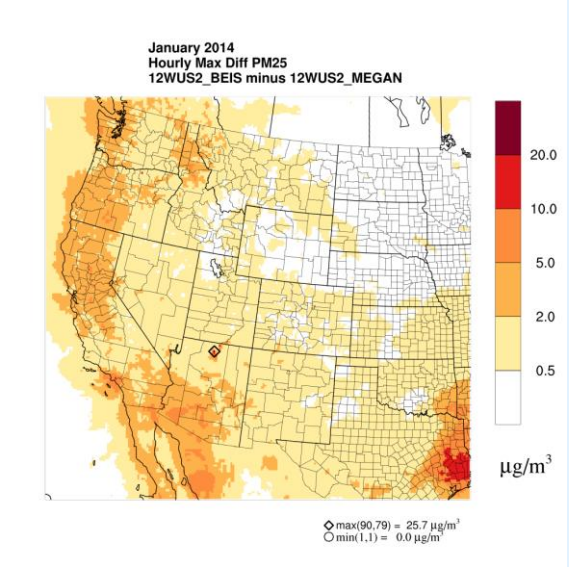
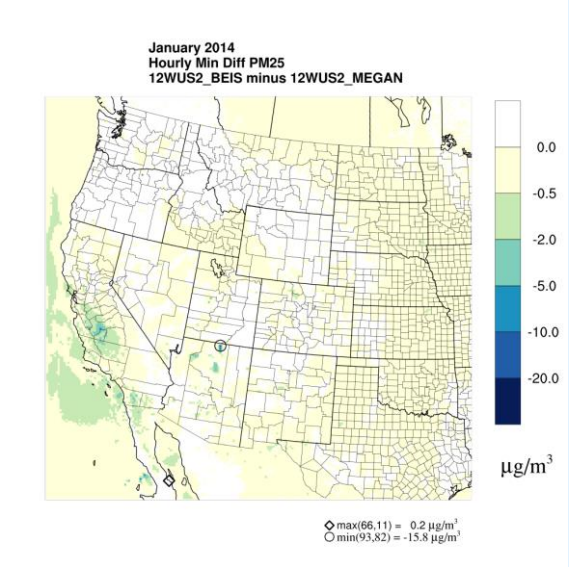
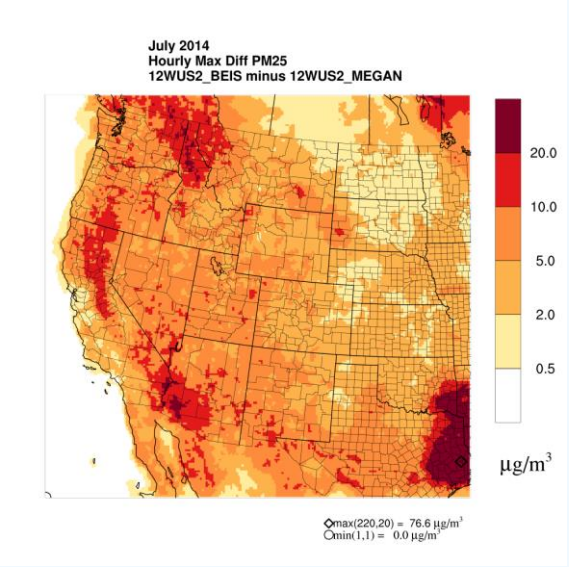
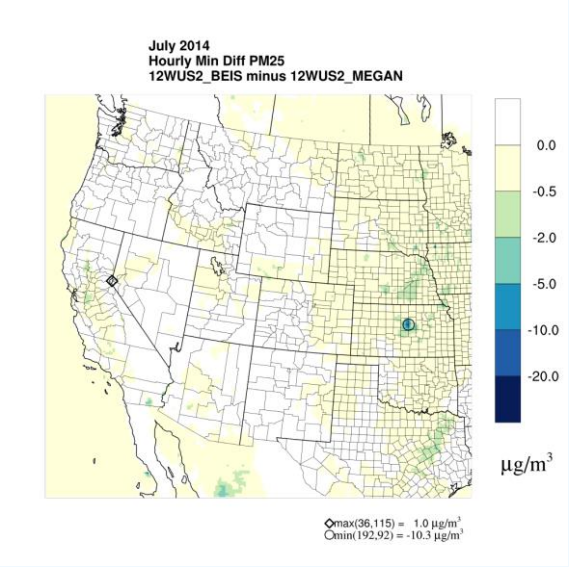
- Maximum of daily PM2.5 24-h average concentrations
- Similar spatial distributions

	BEIS	MEGAN
Jan		
July		

RAMBOLL

Biogenic Sensitivity: Surface PM2.5 Differences

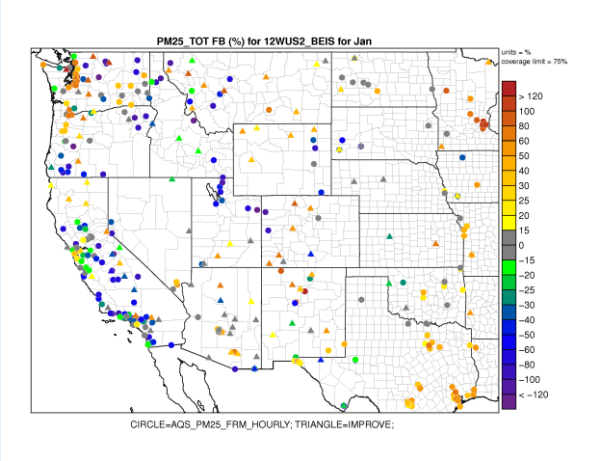
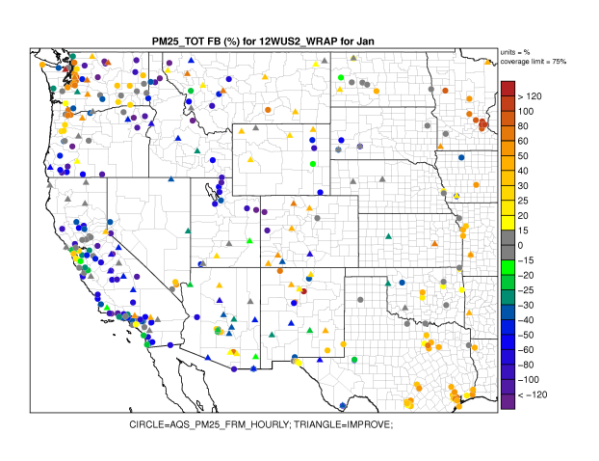
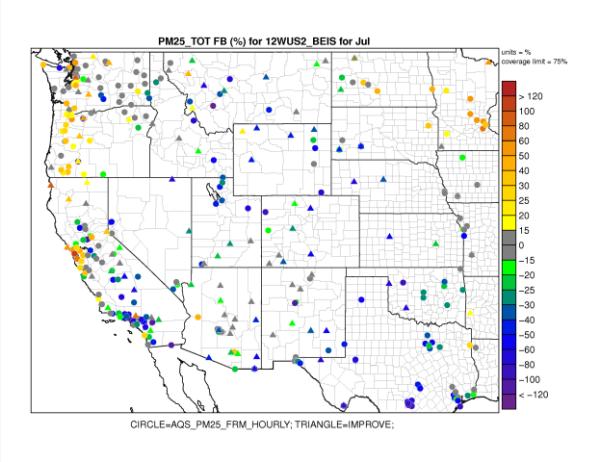
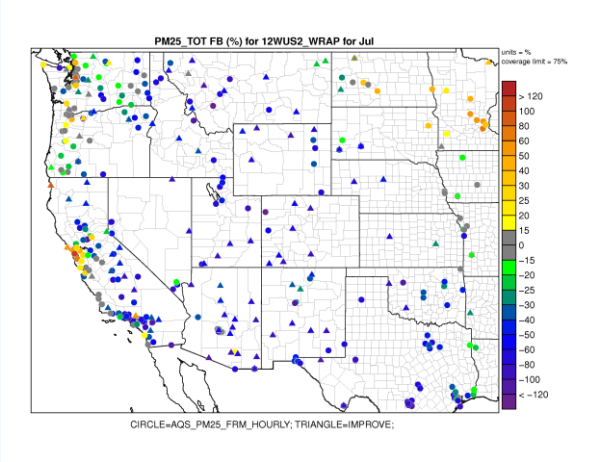
- Maximum differences in hourly concentrations
- BEIS sensitivity leads to consistently higher PM2.5 concentrations.

	MAX Diff	MIN Diff
Jan		
July		

RAMBOLL

Biogenic Sensitivity: PM2.5 Bias Overlay

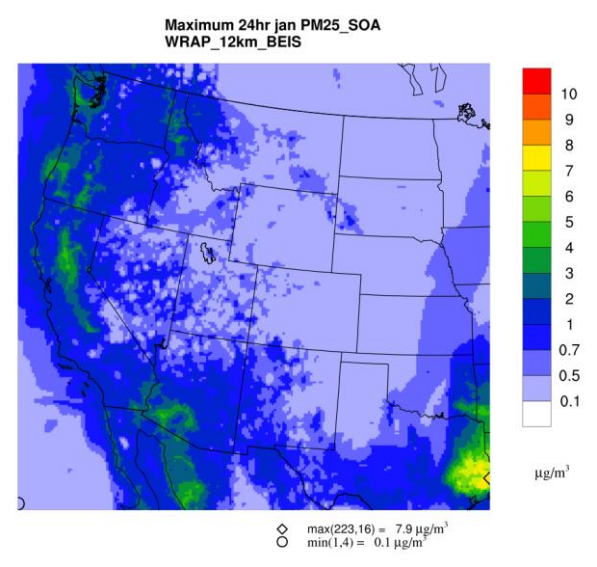
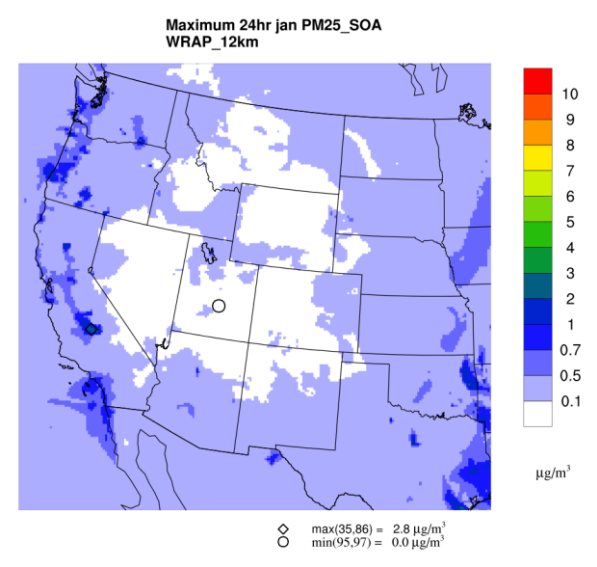
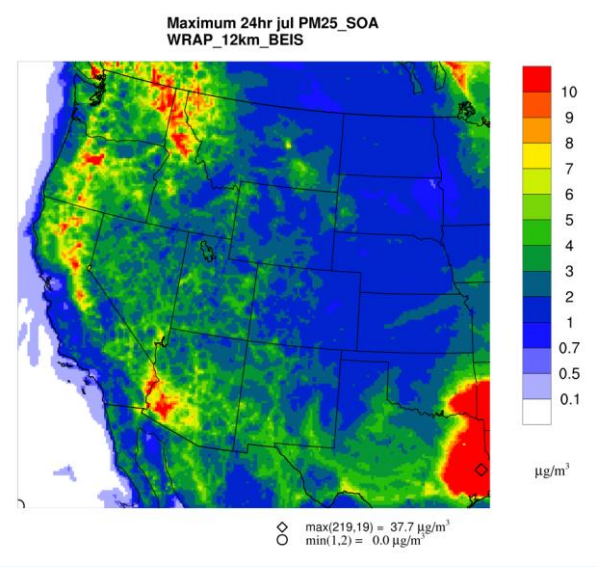
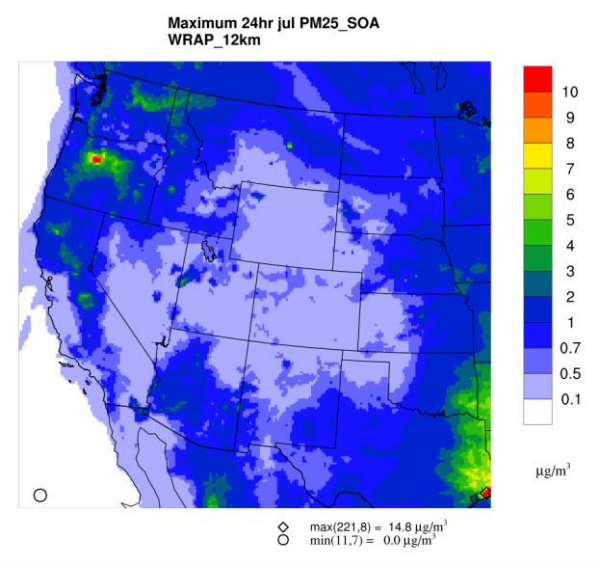
- Both simulations tend to underpredict total PM2.5 similarly in January
- In July BEIS PM2.5 concentrations show slightly better performance and even some over-predictions in Oregon

	BEIS	MEGAN
Jan		
July		

RAMBOLL

Biogenic Sensitivity: Surface SOA

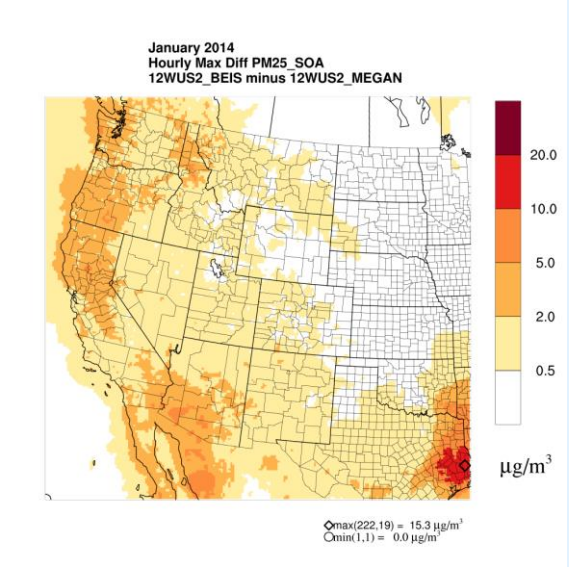
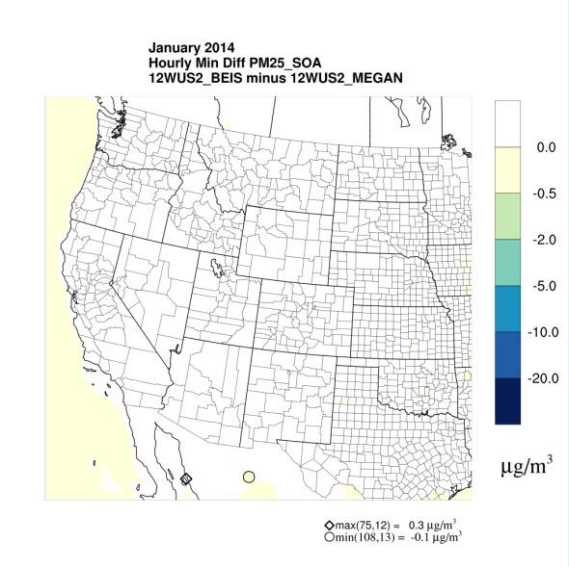
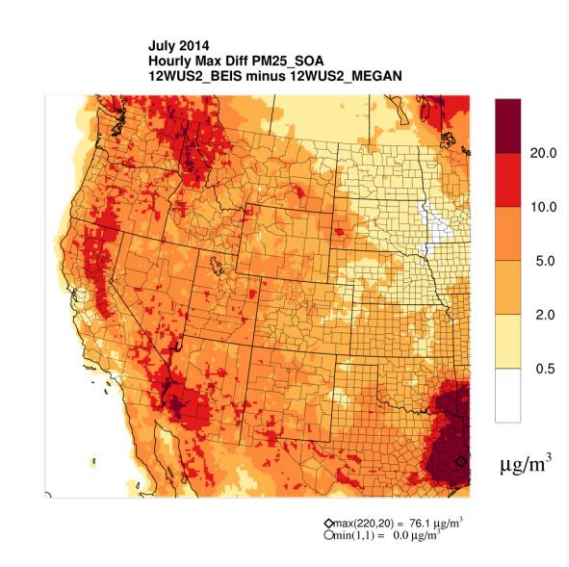
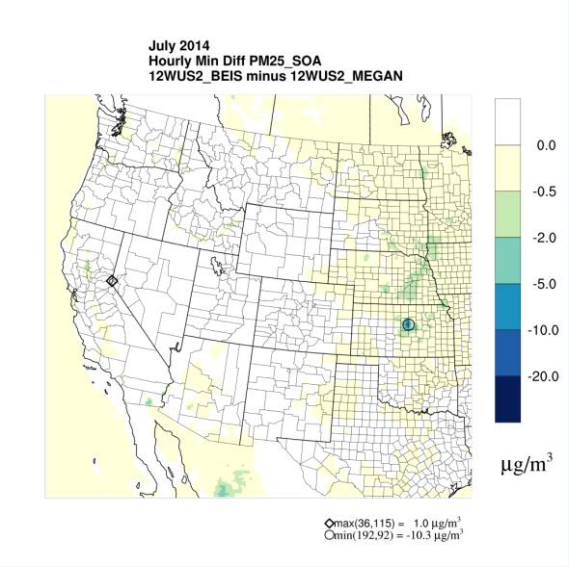
- Maximum of daily (24-h) average concentrations
- BEIS produces higher SOA relative to MEGAN. Particularly in the summer
- Main differences in PM2.5 are likely due to the increased SOA

	BEIS	MEGAN
Jan		
July		

RAMBOLL

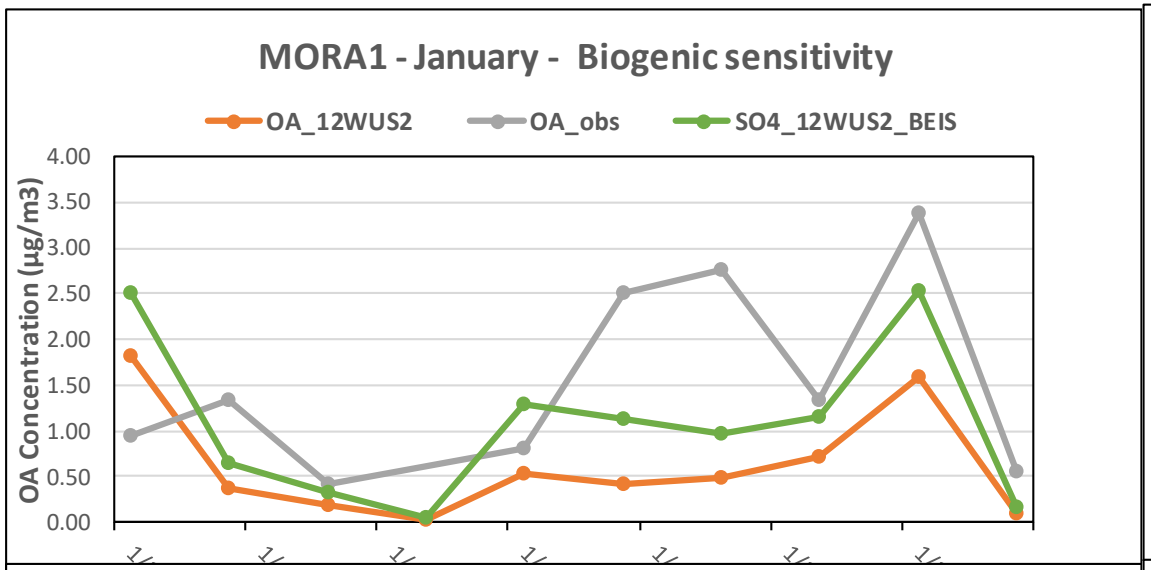
Biogenic Sensitivity: Surface SOA Differences

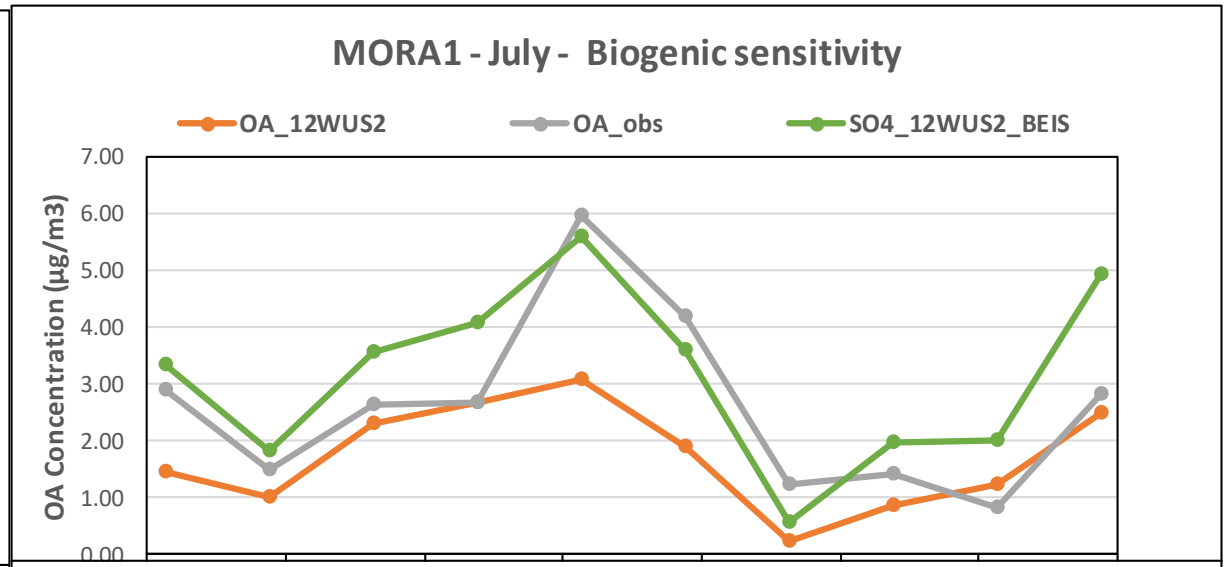
- Differences in hourly concentrations
- Noticeable increase in SOA for July using BEIS

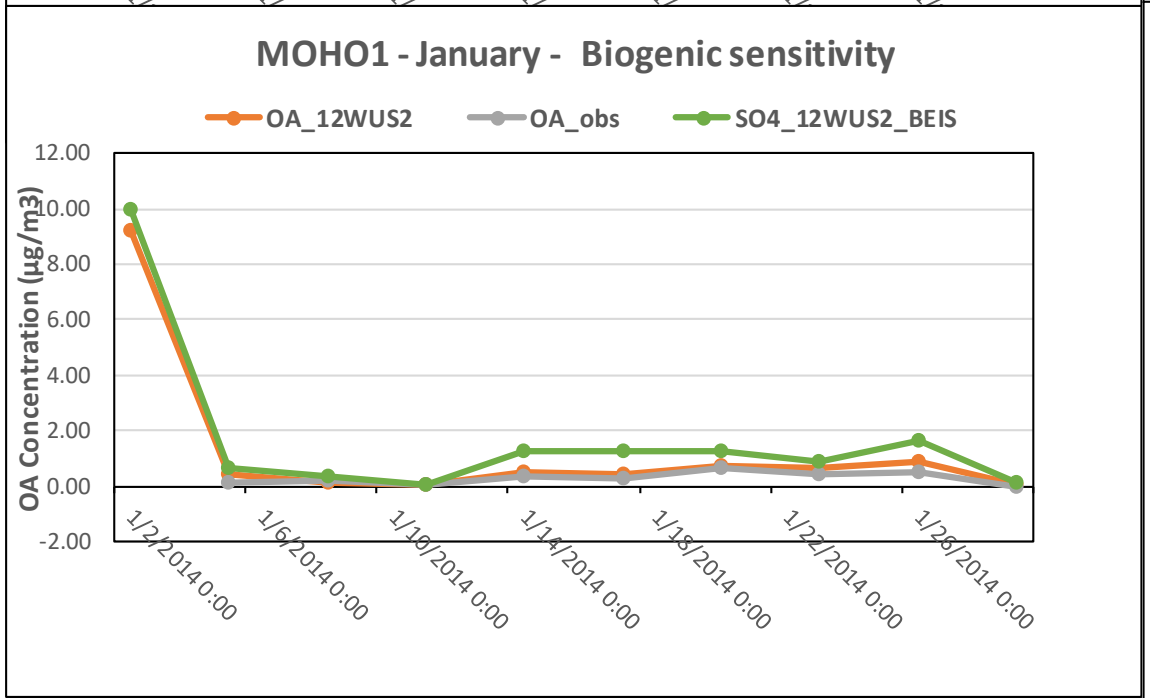
	MAX Diff	MIN Diff
Jan		
July		

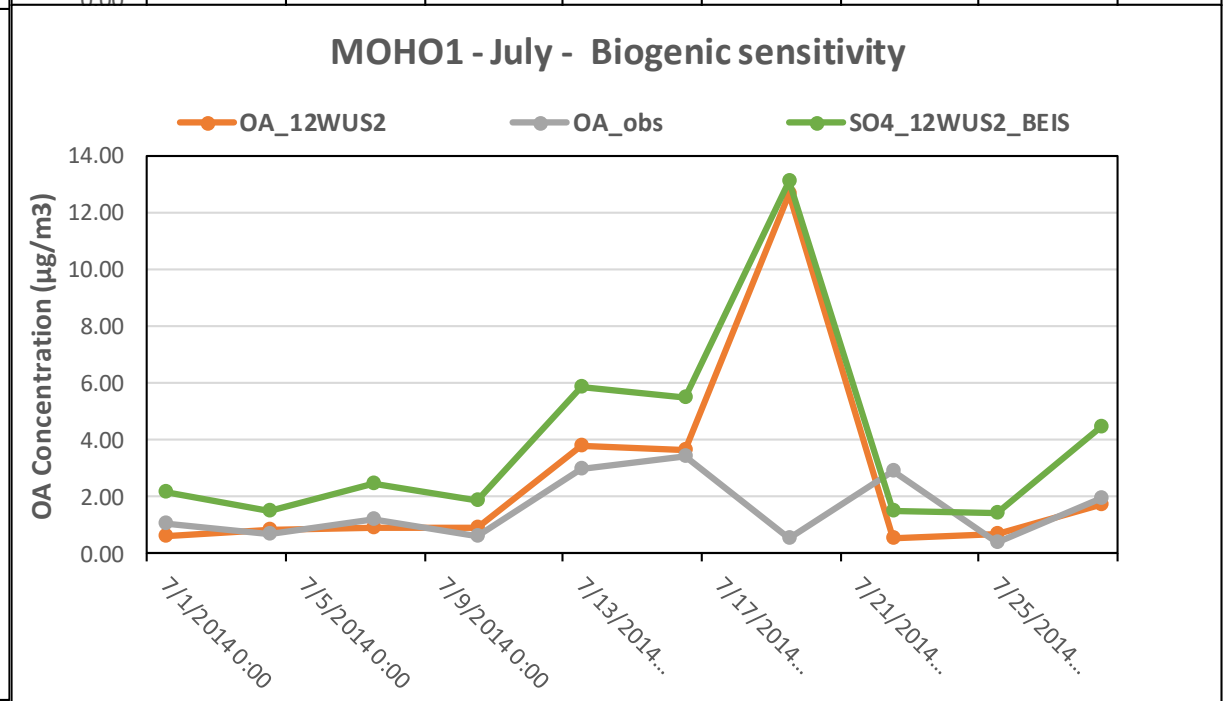
RAMBOLL

BIOGENIC MEGAN VS. BEIS – MT RAINIER WA & MT HOOD OR

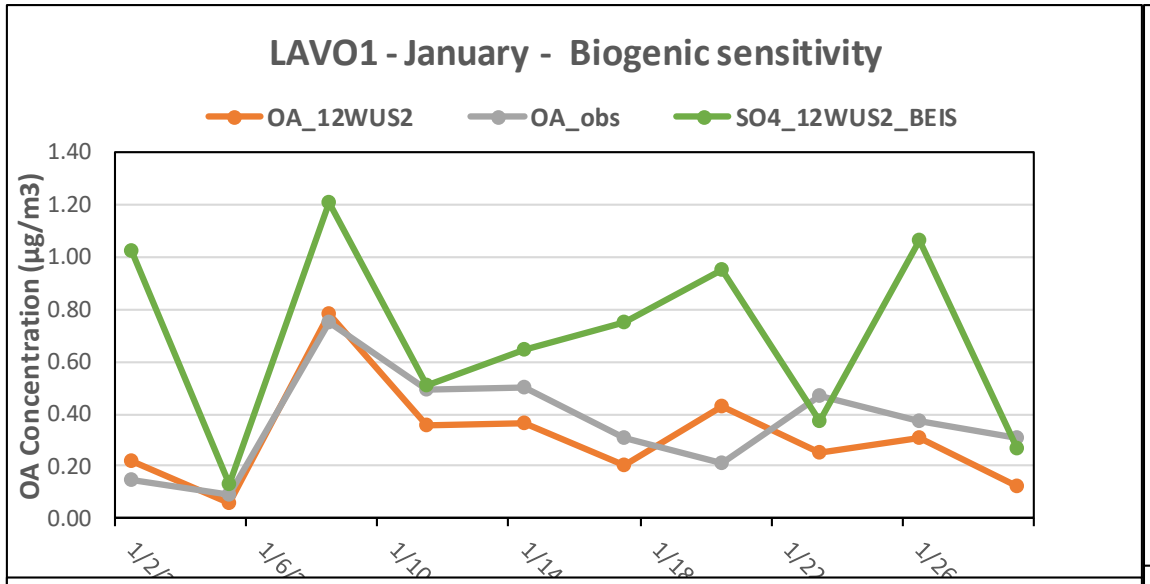


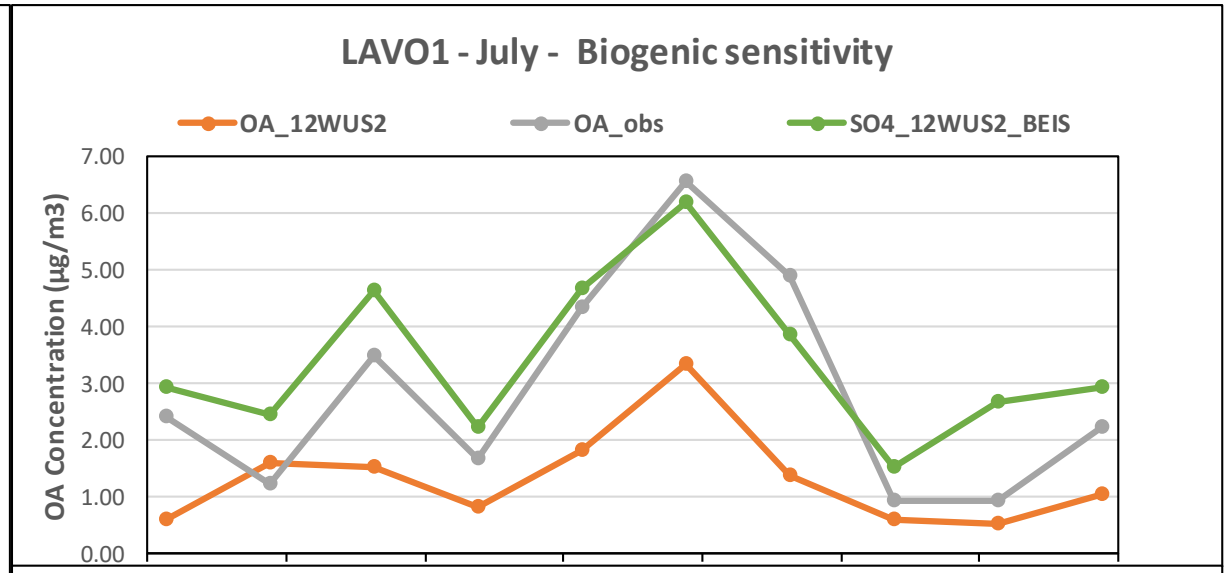


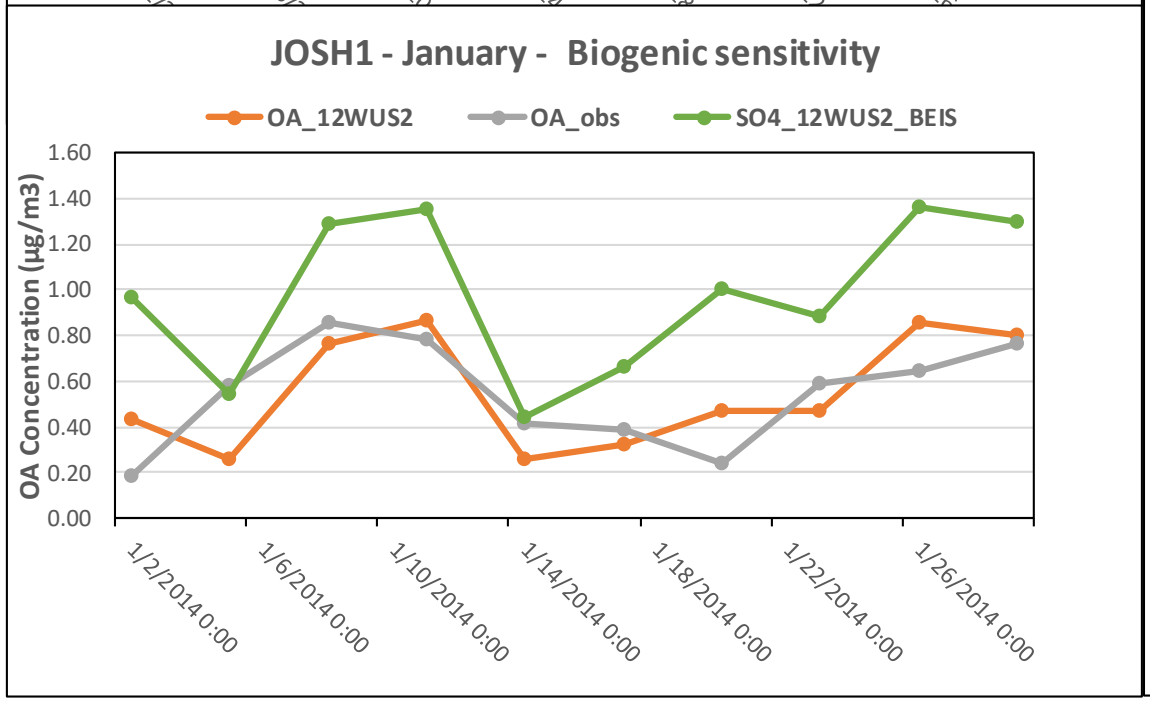


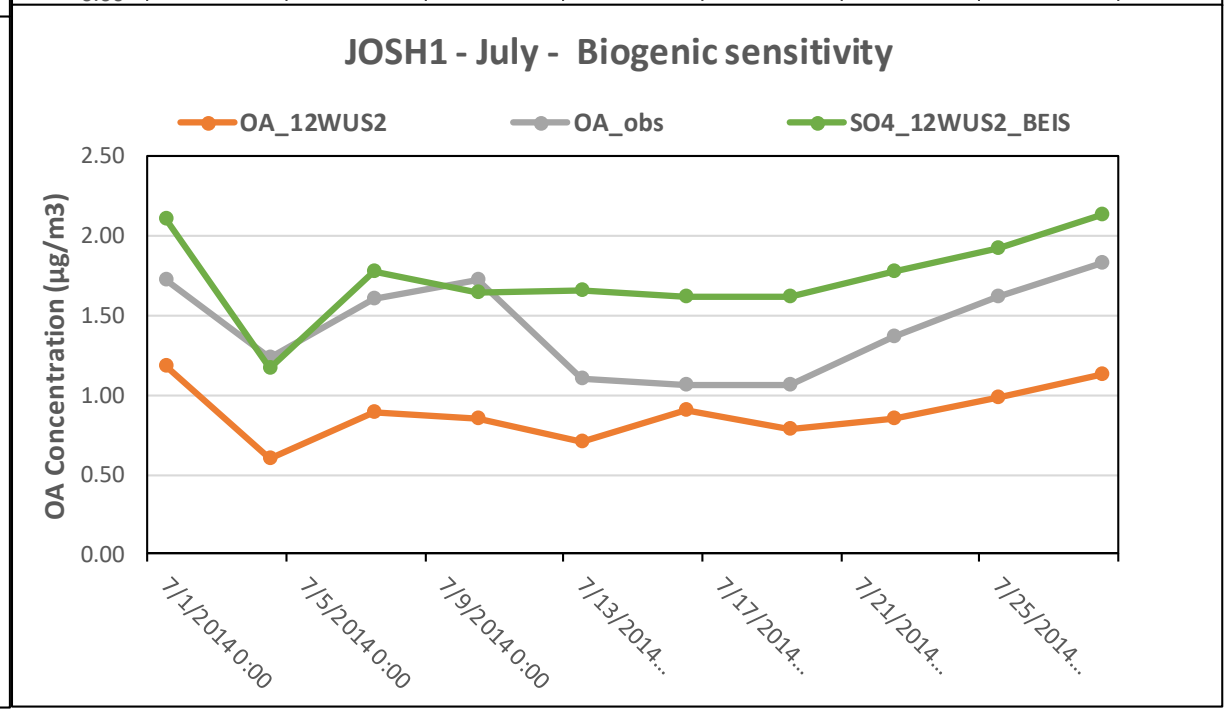


BIOGENIC MEGAN VS. BEIS – LASSEN CA & JOSHUA TREE CA

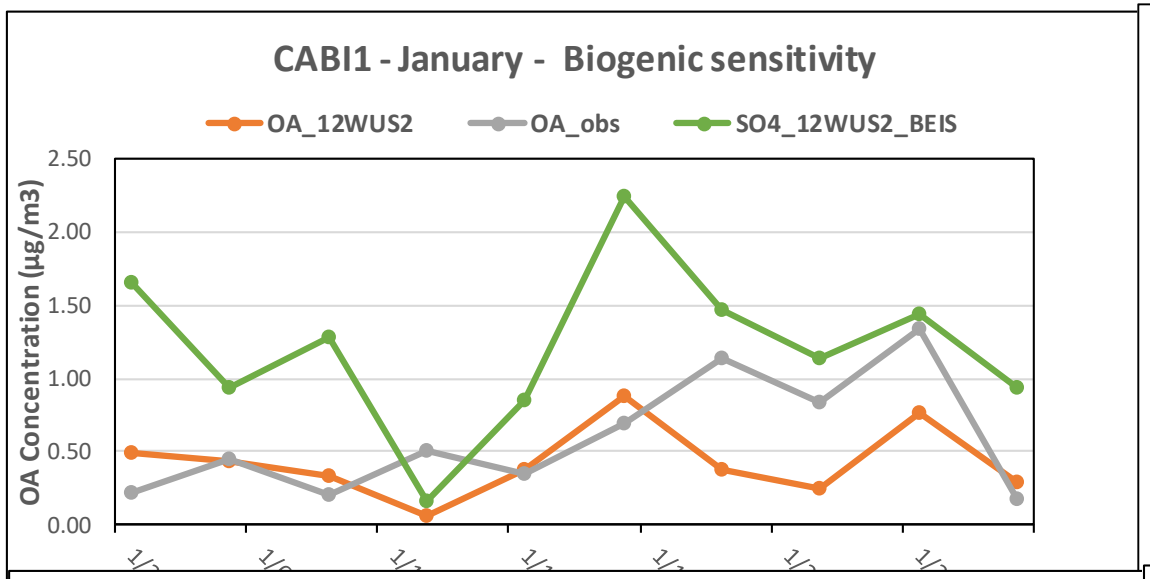


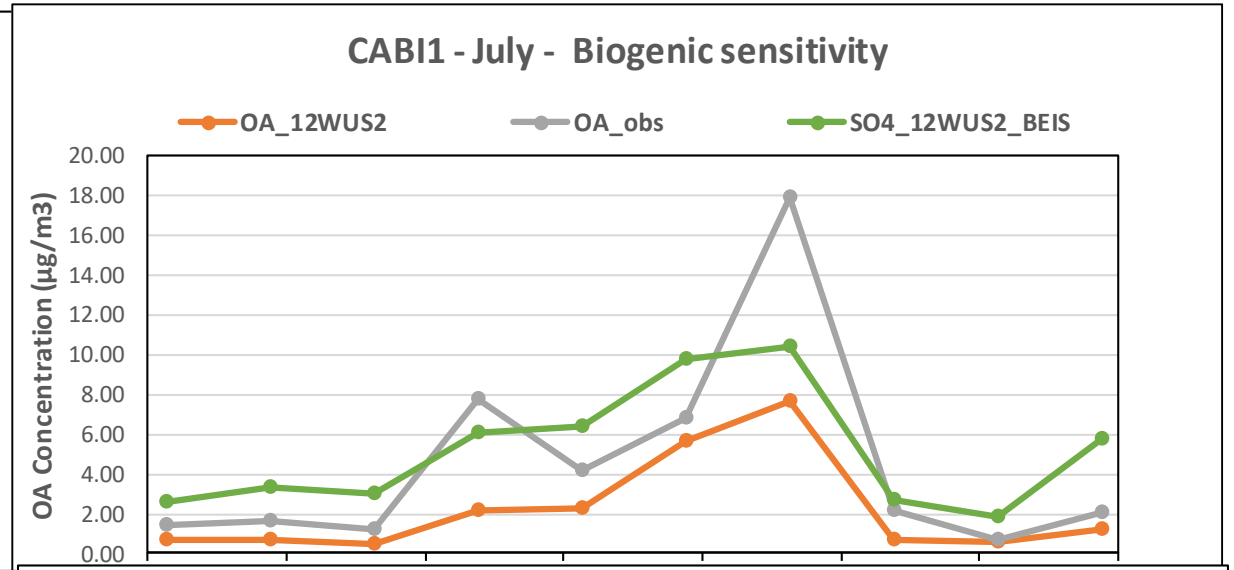


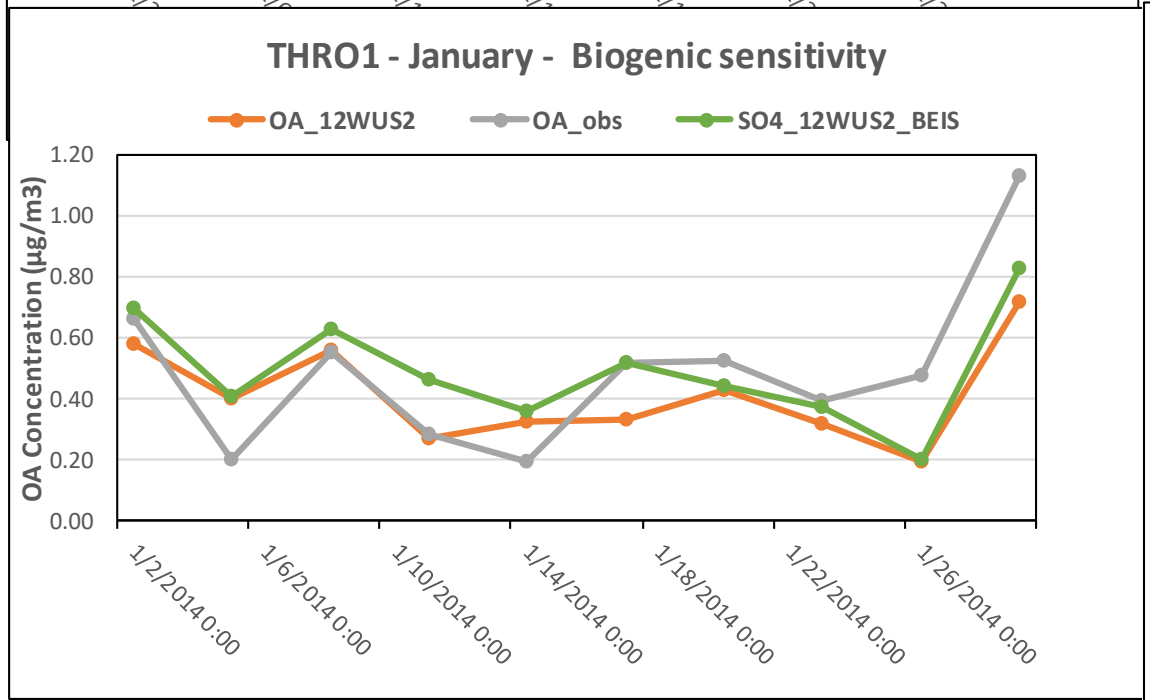


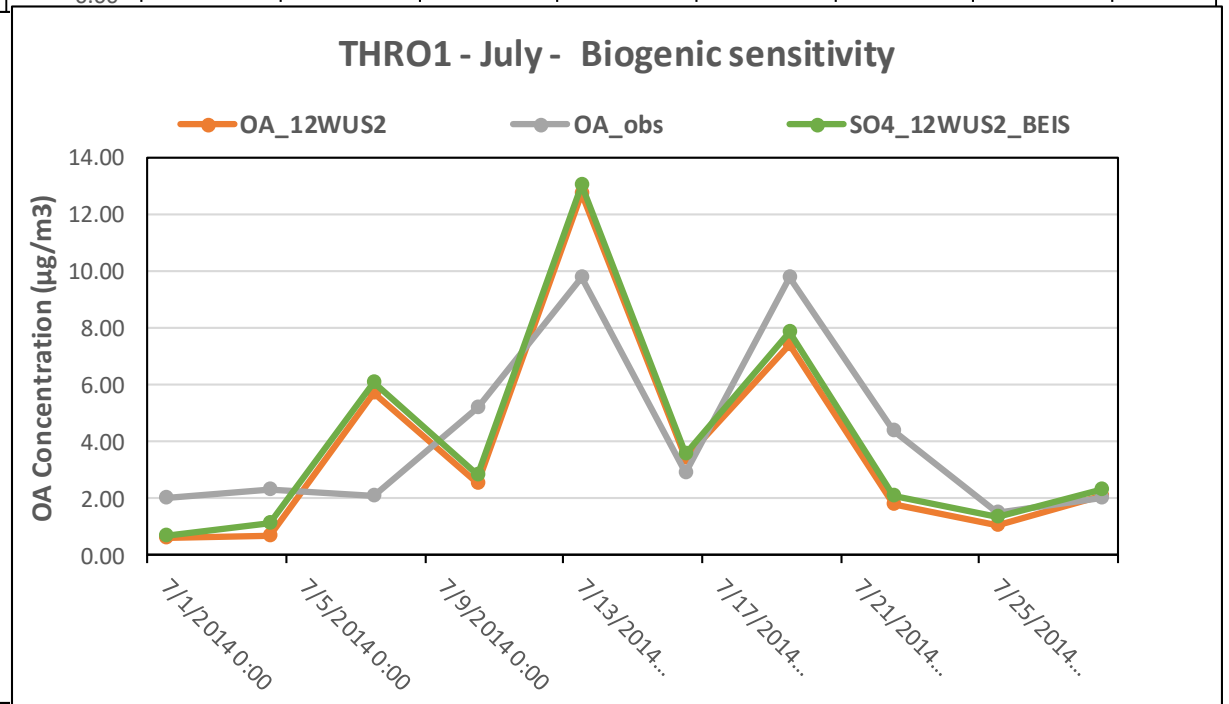


BIOGENIC MEGAN VS. BEIS – CABINET MTN ID & TEDDY ROOS ND

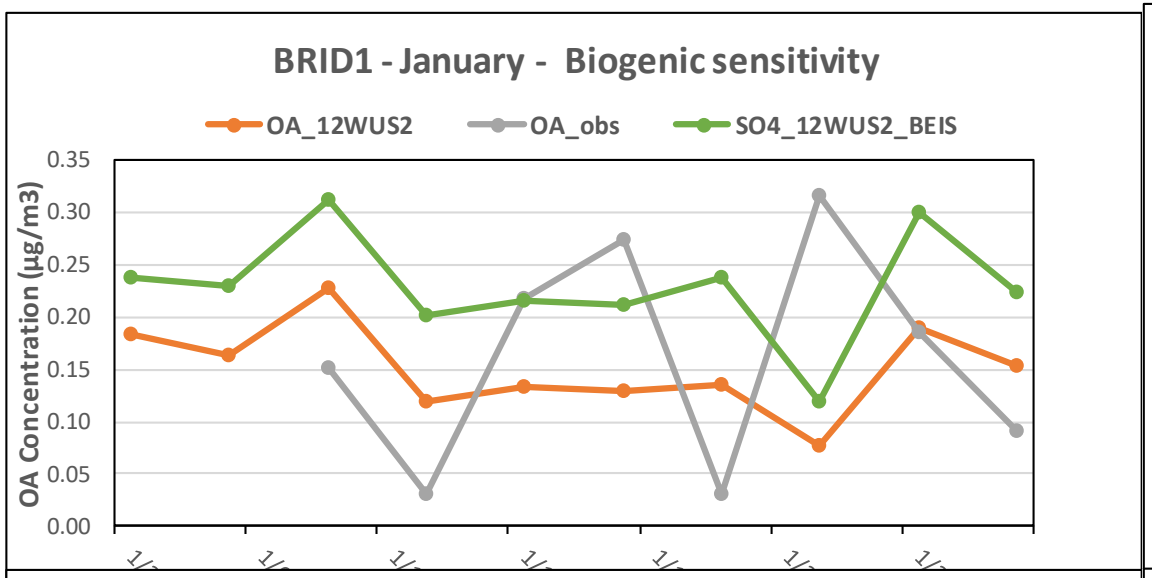


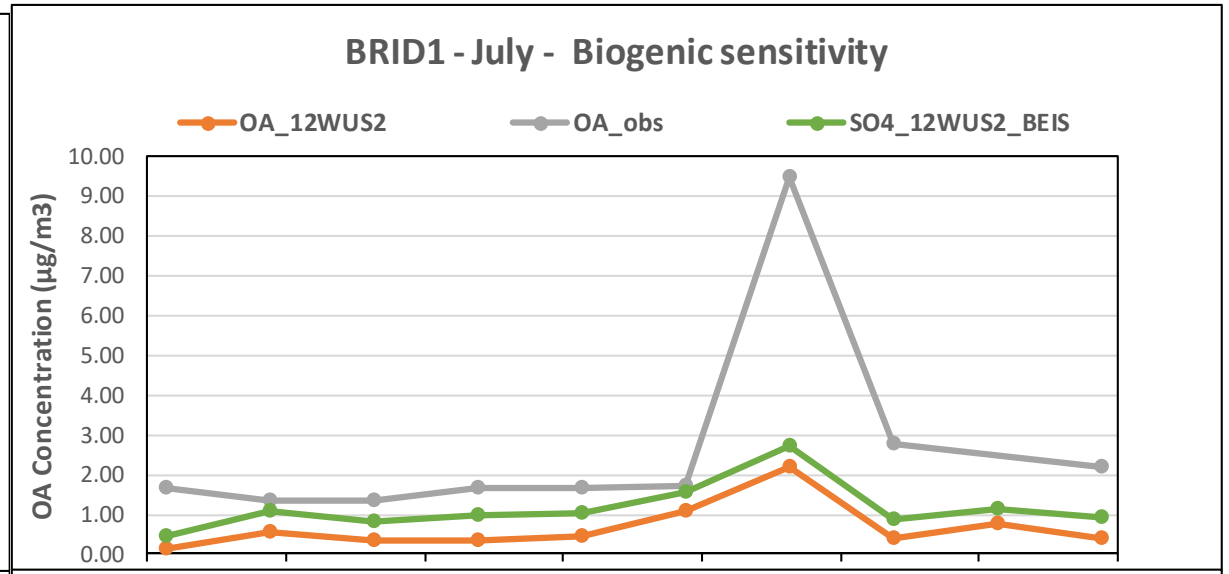


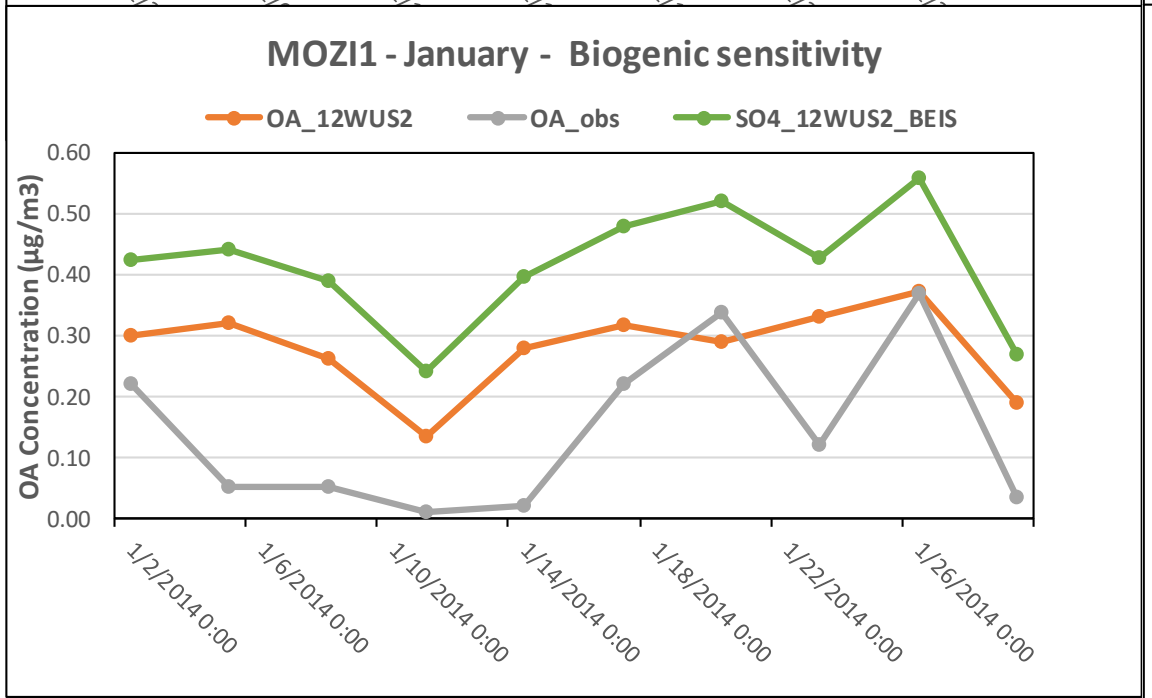


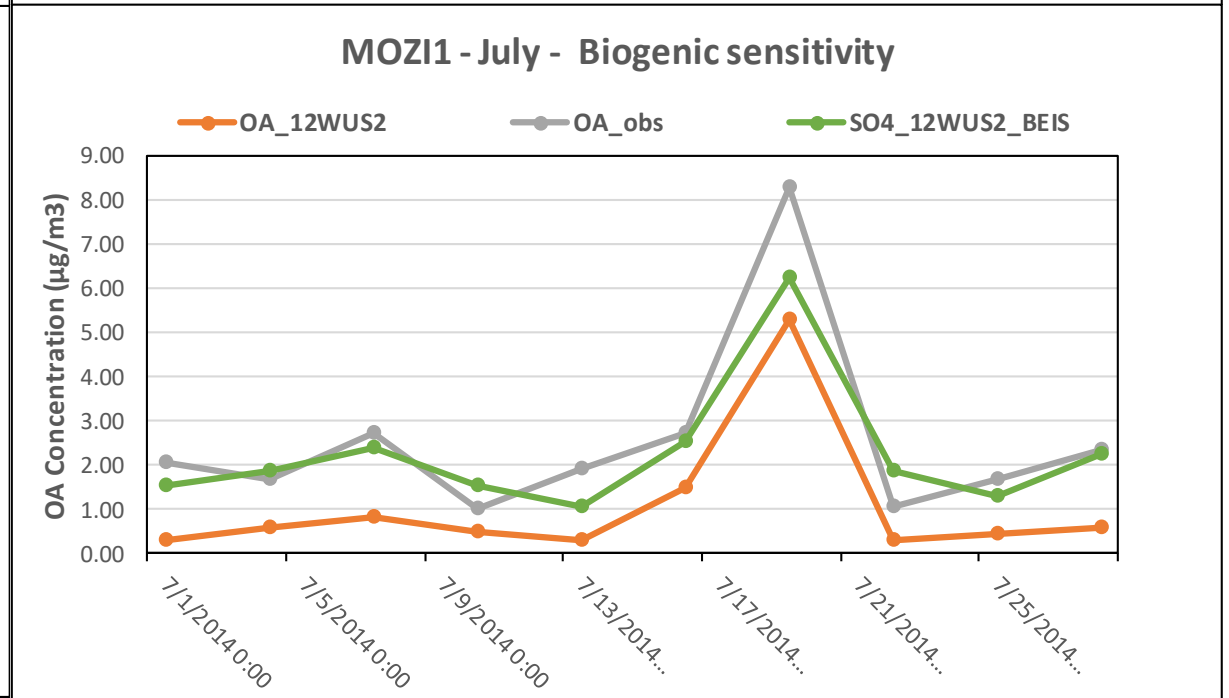


BIOGENIC MEGAN VS. BEIS – BRIDGER WY & MT ZIRKEL CO

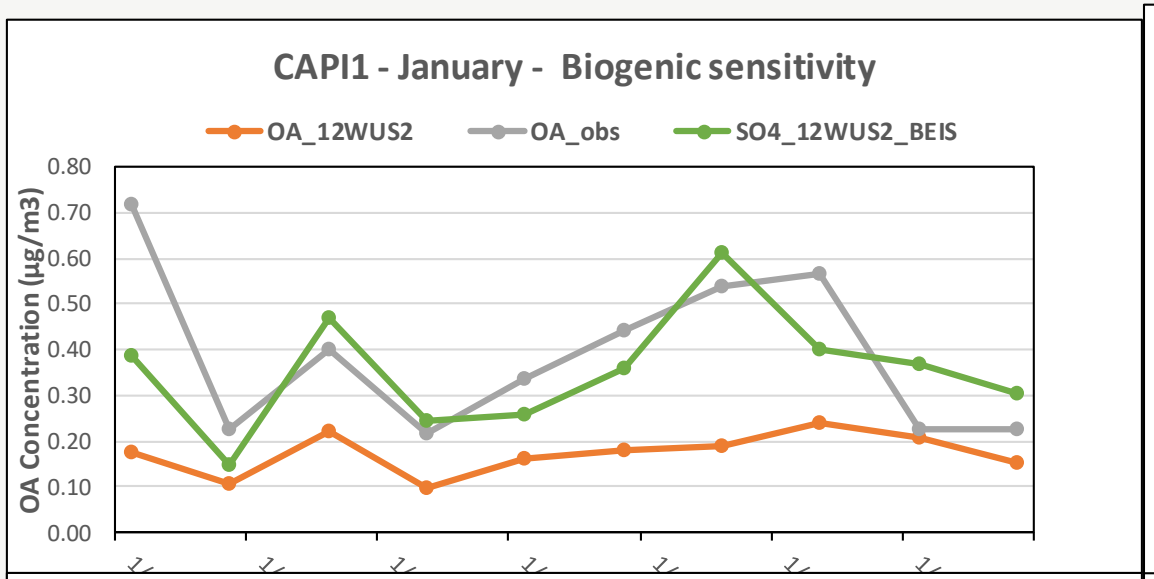


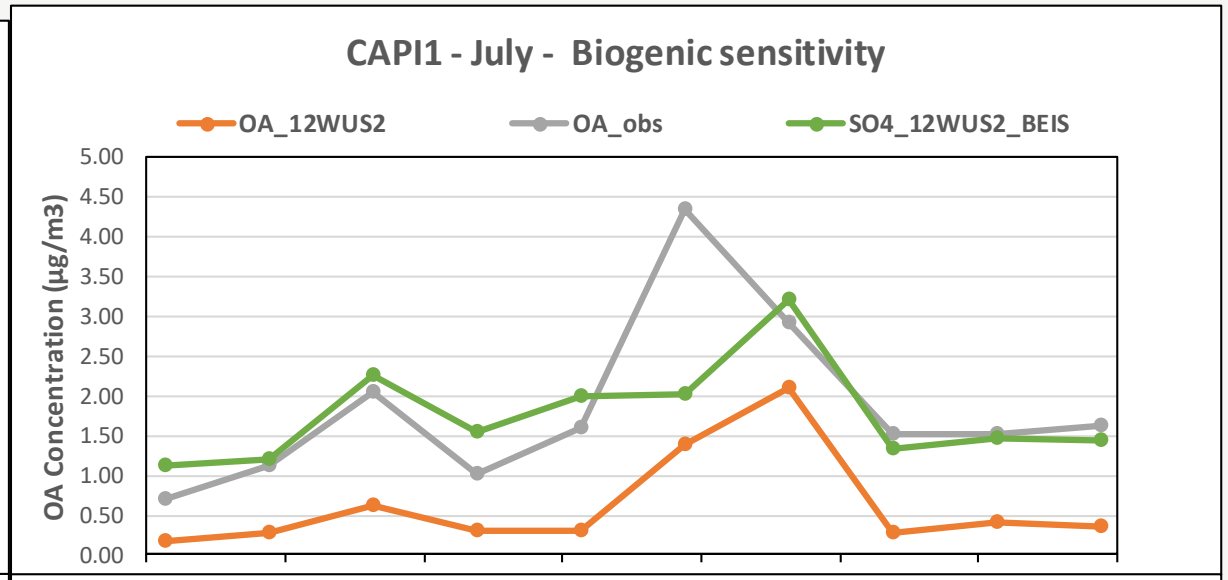


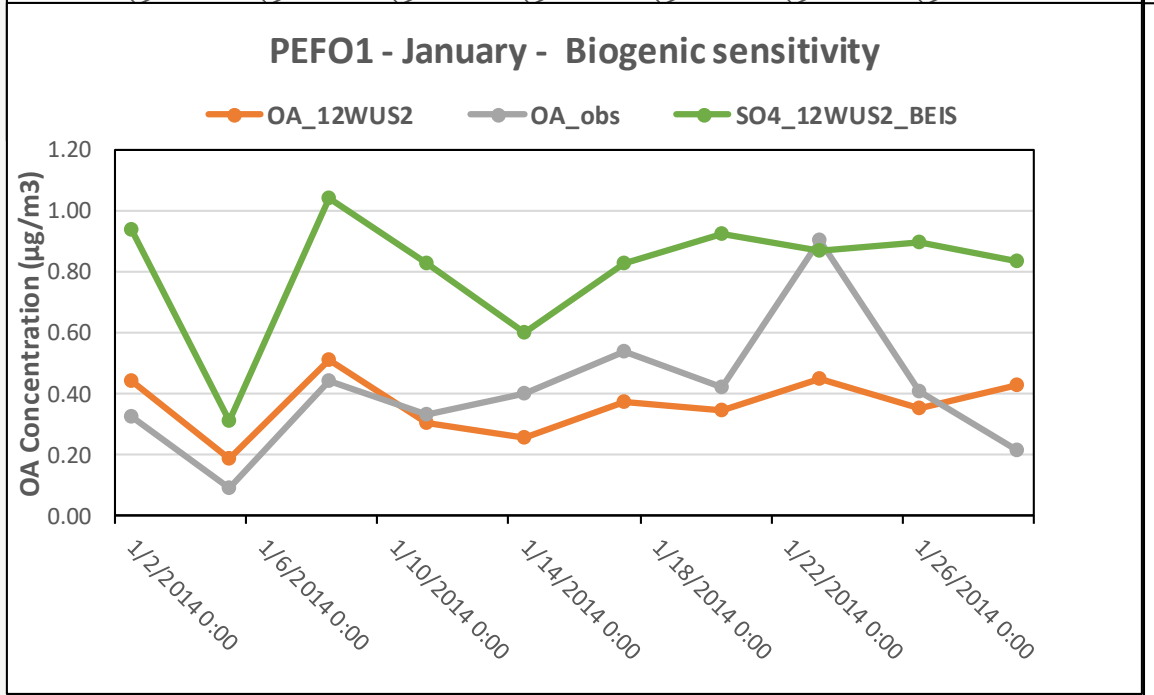


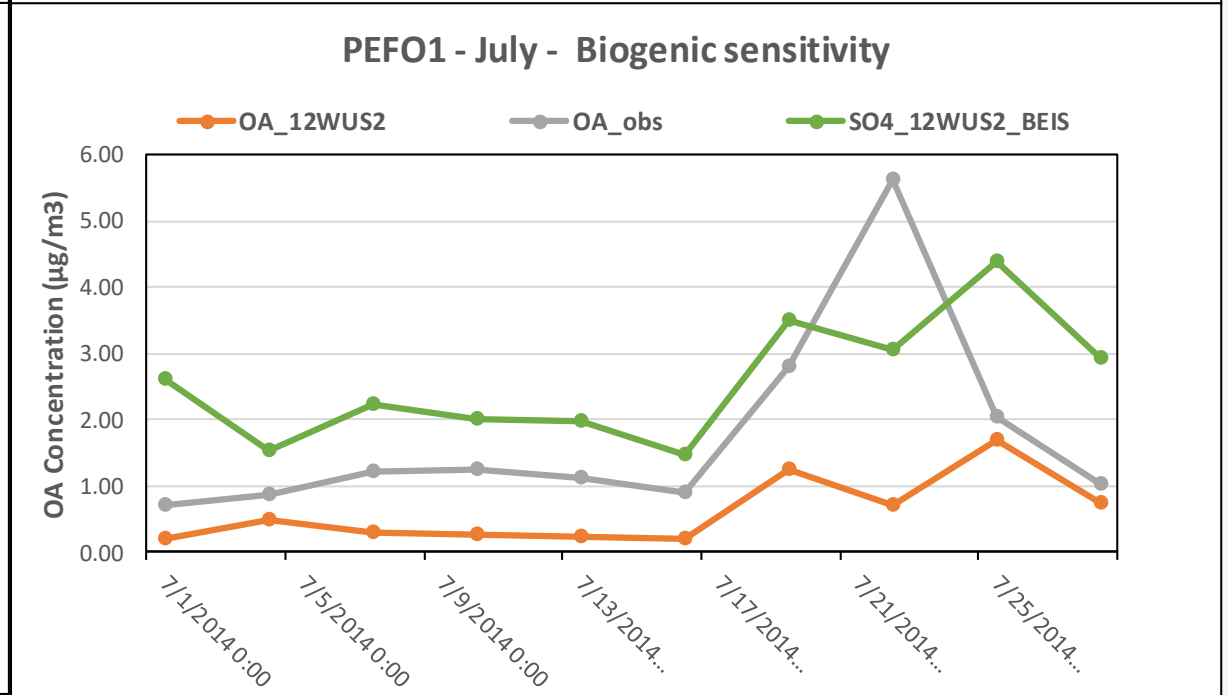


Biogenic MEGAN vs. BEIS – Capitol Reed UT & Petrified Forest AZ

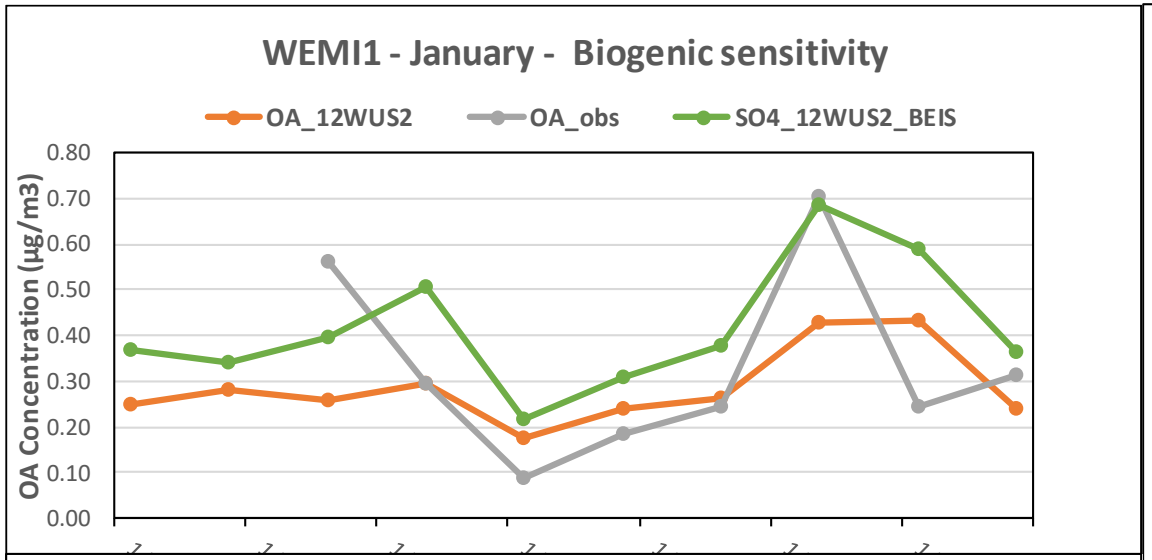


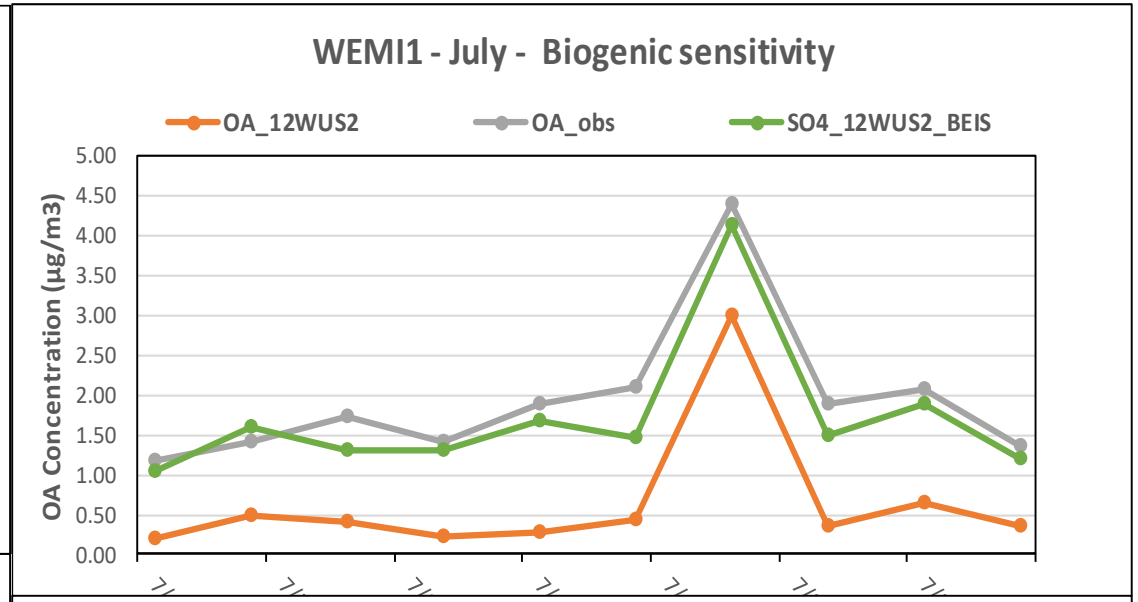


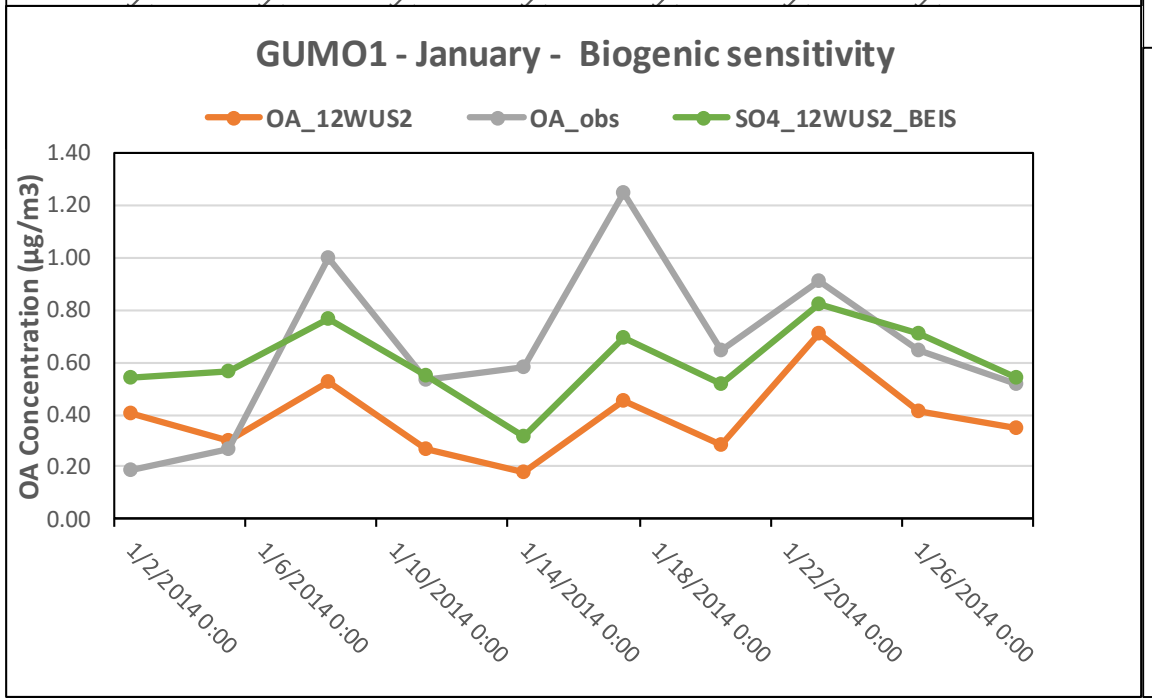


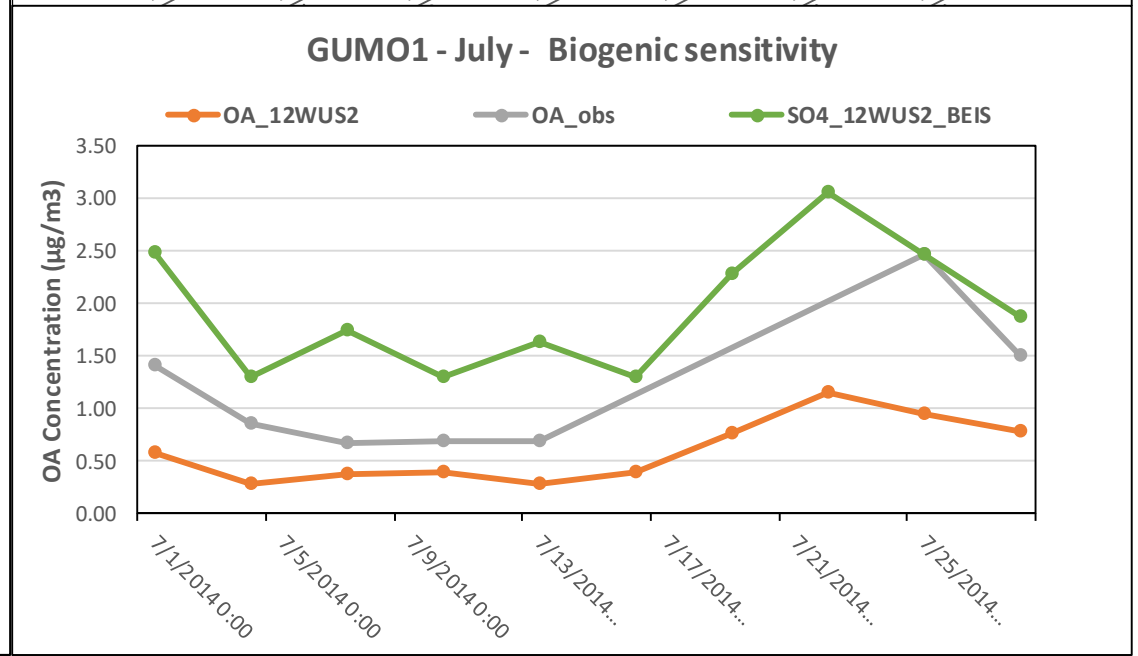


BIOGENIC MEGAN VS. BEIS – WEMINUCHE CO & GUADALUPE NM/TX









Biogenic Sensitivity MEGAN vs. BEIS: Summary

- Ozone differences very small between MEGAN and BEIS
- Essentially no effect on SO4, NO3, EC and Crustal
- $PM_{2.5}$ concentrations with BEIS are higher than MEGAN in July due almost exclusively to increased SOA
- Increase in SOA leads to better OA and PM2.5 performance with BEIS in July at many sites
- OA performance for selected sites indicate better performance using BEIS.
  - Only in OR and WA, which are affected by fires, this leads to overpredictions
- Recommend using BEIS biogenic emissions for final 2014 Shake-Out annual runs based on better OA model performance at most sites
  - Need to examine more closely and revisit this issue in 2014v2
  - Justification for higher (4x to 5x) TERP and SESQ emissions in BEIS compared to MEGAN3 needs to be examined more carefully
    - Some locations with much higher BEIS emissions questionable (e.g., dessert southwest)

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Final Configuration Annual Shakeout

Final CAMx and CMAQ 2014 Annual 36/12-km Shake-Out Runs

- WAQS 12-km 12WUS2 WRF Meteorology
- 12-km 12US2 BEIS Biogenic Emissions
- Revised 2014 GEOS-Chem Jun/Jul BCs

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Final Model Configuration for 2014 Annual Shake-Out Runs

- CAMx and CMAQ 2014 annual 36-km and 12-km simulations
- 2014 GEOS-Chem Boundary Conditions (GCBC)
  - Use updated GCBCs for Jun/Jul without volcano eruptions
- 12-km WRF Meteorology – WAQS 12WUS2 vs. EPA 12US2
  - Difficult to select based on MPE due to GCBC ozone and Jun/Jul SO4/SO2 Overestimation
  - Select WAQS 12WUS2 WRF meteorology based on better precipitation MPE and less wet deposition in summer
- Emissions – MEGAN vs. BEIS biogenic emissions in 12-km domains
  - Select BEIS based on improved OA performance at most, but not all, sites

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Annual 2014 Shake-Out Simulations Configuration

	CAMx	CMAQ
Version	v.6.50	v.5.2.1
Meteorology	WAQS	
Horizontal Domain	12WUS2	
BCON	No eruptions GEOS-Chem for June and July	
Biogenic Emissions	BEIS	
Windblown Dust	Offline-CAMx windblown dust	
Lighting Emissions	Offline-CAMx LNOx pre-processor	In-line
Sea Salt Emissions	Offline-CAMx oceanic pre-processor. Includes DMS as SO2	In-line (no DMS)
Chemical Mechanism	CB6r4 with SOAP + ISORROPIA	CB6r3 with AE6 + ISORROPIA (CB6r3_AE6_AQ)

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