Western Regional Modeling and Analysis Platform

2014v2 Model Performance Evaluation

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WRAP RTOWG Webinar

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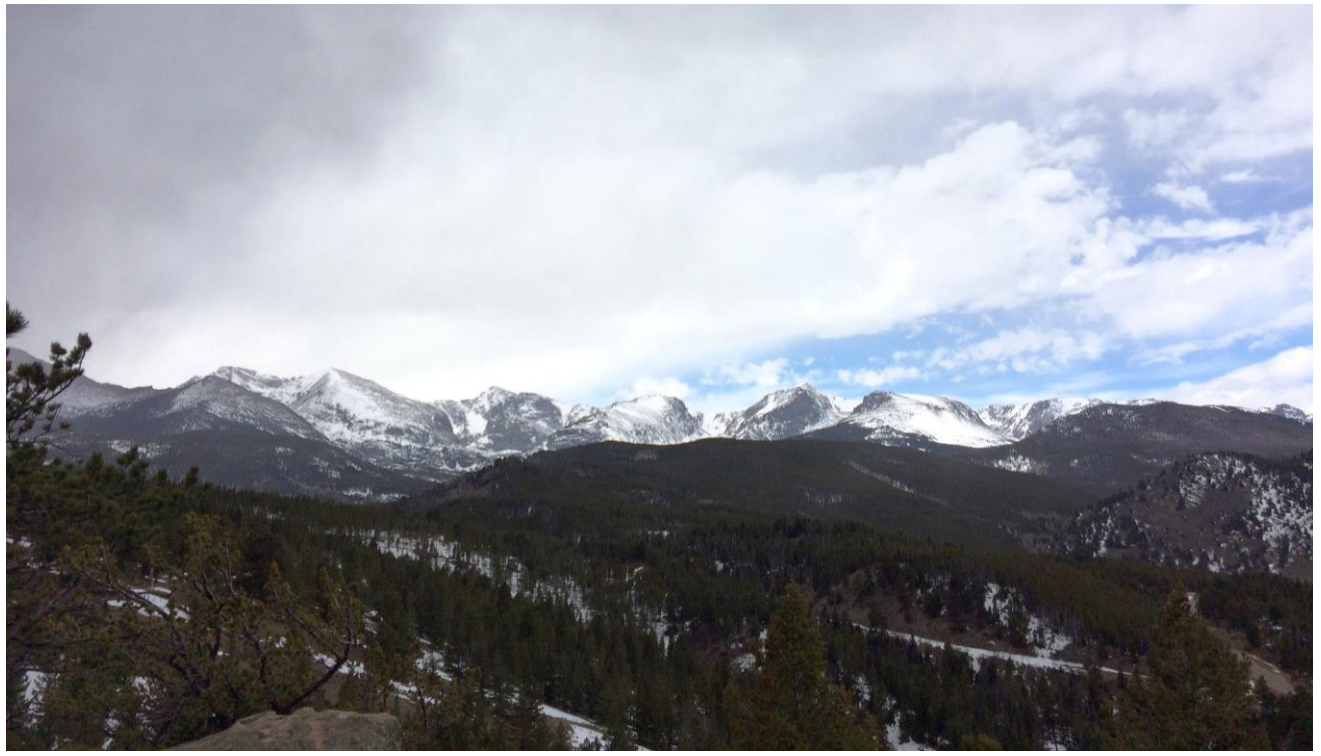

RAMBOLL

WRAP 2014v1 Shake-Out Model Performance Evaluation (MPE)

- CAMx & CMAQ 2014v1 36/12-km Modeling Platform and MPE
  - **http://views.cira.colostate.edu/iwdw/docs/waqs_2014v1_shakeout_study.aspx**
- Several MPE issues were identified in 2014v1 MPE:
  - EPA's 2014 GEOS-Chem simulation overestimated ozone year-round
    - Conducted revised 2014 GEOS-Chem simulation that corrected problem
  - Coastal SO4 overestimation in CAMx
    - Conducted sensitivity tests (e.g., DMS chemistry) but was unable to correct issue
  - NO3 underestimation in western U.S.
    - Tested and adopted ammonia bi-directional dry deposition module
  - BEIS vs MEGAN biogenic emissions
    - Evaluated new MEGAN v3.1 that performed better than previous version of MEGAN, but retained BEIS for 12WUS2 domain due to mostly better PM2.5 OA performance

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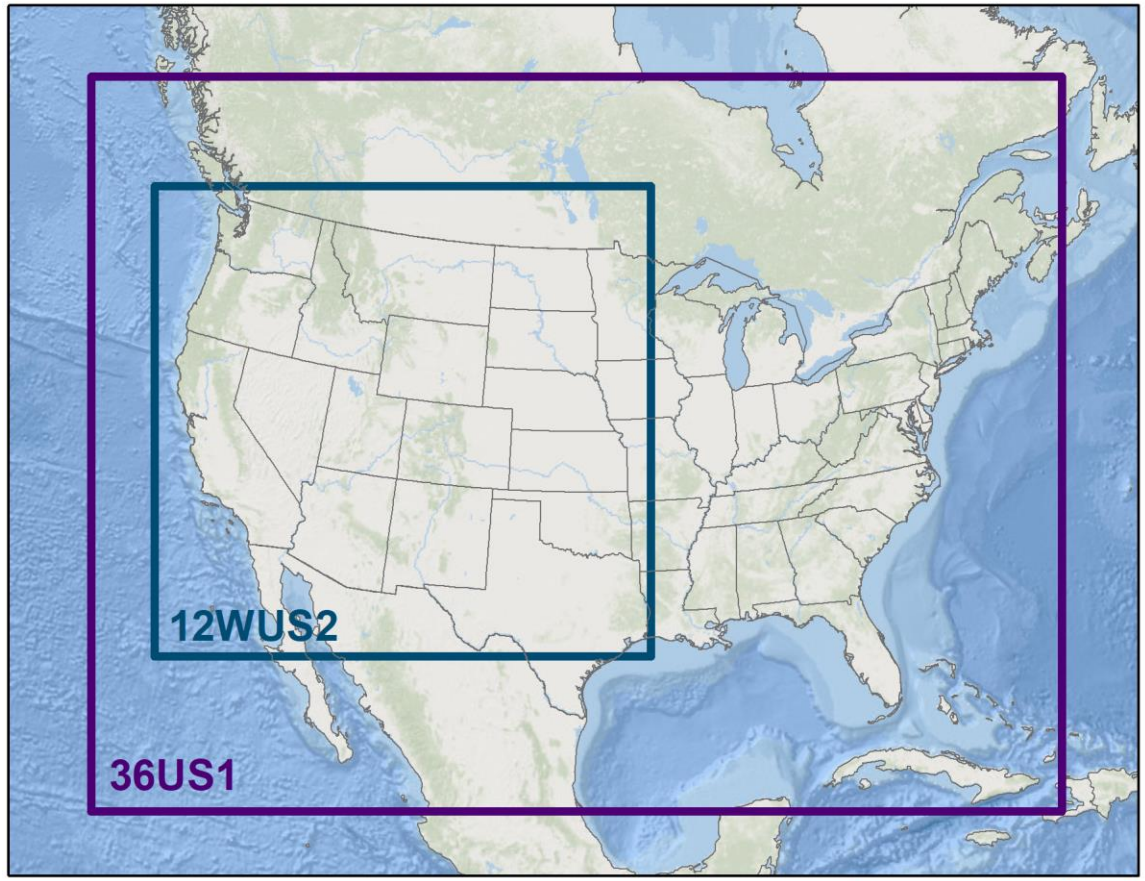
2014v1 vs. 2014v2 Final Model Configuration (Major Changes in **Red**)

Option	CAMx		CMAQ (Postponed)	
	2014v1	2014v2	2014v1	2014v2
Model	CAMx v6.5	**CAMx v7.0**	CMAQ v5.2.1	**CMAQ V5.3**
Nesting	One-Way	**Two-Way**	One-Way	One-Way
# Levels	25	25	25	**35**
BCs	EPA GC	**WRAP GC**	EPA GC	**WRAP GC**
Anthro.	2014v1	**2014v2**	2014v1	**2014v2**
Biogenic 12WUS2	BEIS	BEIS	BEIS	BEIS
Fires	Bluesky	**WRAP**	Bluesky	Bluesky
NH3 BiDi	No	**Yes**	No	No
Elements	No	**Yes**	Yes	Yes
SOAALK	No	**Yes**	Yes	Yes

CAMx 2014v2 Base Case / Model Performance Evaluation (MPE)

- CAMx v7.0 & 2014 Annual Period
- 36US1/12WUS2 Two-Way Grid Nesting
- Evaluate CAMx performance generally using same procedures as in EPA's Sep 19, 2019 national regional haze modeling that used CAMx v7.0 and 2016beta' platform
- CMAQ 2014v2 modeling on hold:
  - New CMAQ v5.3 (Aug 2019) & MCIP v5
  - Needs complete re-processing of WRF met data
  - No longer supports layer collapsing, so run times ~ 2x CAMx
  - Doesn't support two-way nesting
  - Reported issues with source apportionment
  - New version of model needs more tests
    - CMAQ v5.3.1 released Dec 2019 w/ bug fixes



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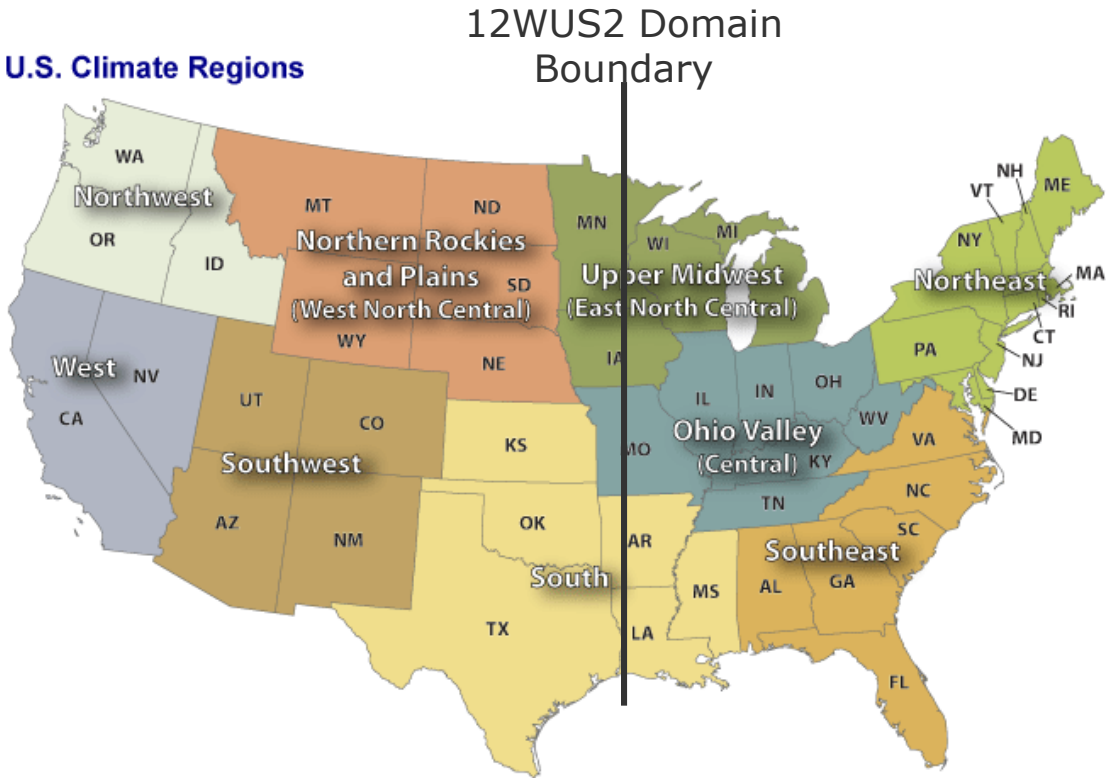
CAMX 2014v2 MPE for 12WUS2 Domain and 7 Climate Regions



- Climate Regions used by EPA to Evaluate CAMx 2016 beta’
- For CAMx 2014v2 evaluation have whole climate regions:
  - West
  - Northwest
  - Southwest
  - NRockiesPlains
- And partial climate regions:
  - South

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Primary Model Performance Statistical Metrics used by EPA

- Mean Bias (**MB**) average difference between Predictions and Observations (ug/m3)

$$MB\ (\mu g\ m^{-3}) = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

- Normalized Mean Bias (**NMB**) avg difference between Pred and Obs normalized by avg Obs

$$NMB\ (\%) = \frac{\sum_1^n (P - O)}{\sum_1^n (O)} * 100$$

Compare with EPA 2016beta' MPE and use Performance Goals and Criteria to help put CAMx 2014v2 MPE in context (Emery et al., 2016, JAWMA)

- Mean Error (**ME**) avg absolute differences between Pred and Obs (ug/m3)

$$ME\ (\mu g\ m^{-3}) = \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i|$$

- Normalized Mean Error (**NME**) avg absolute difference between Pred and Obs normalized by avg Obs

$$NME\ (\%) = \frac{\sum_1^n |P - O|}{\sum_1^n (O)} * 100$$

- Person's Correlation Coefficient (**r**)

$$r = \frac{\sum_{i=1}^{n}(P_i - \bar{P})(O_i - \bar{O})}{\sqrt{\sum_{i=1}^{n}(P_i - \bar{P})^2}\sqrt{\sum_{i=1}^{n}(O_i - \bar{O})^2}}$$

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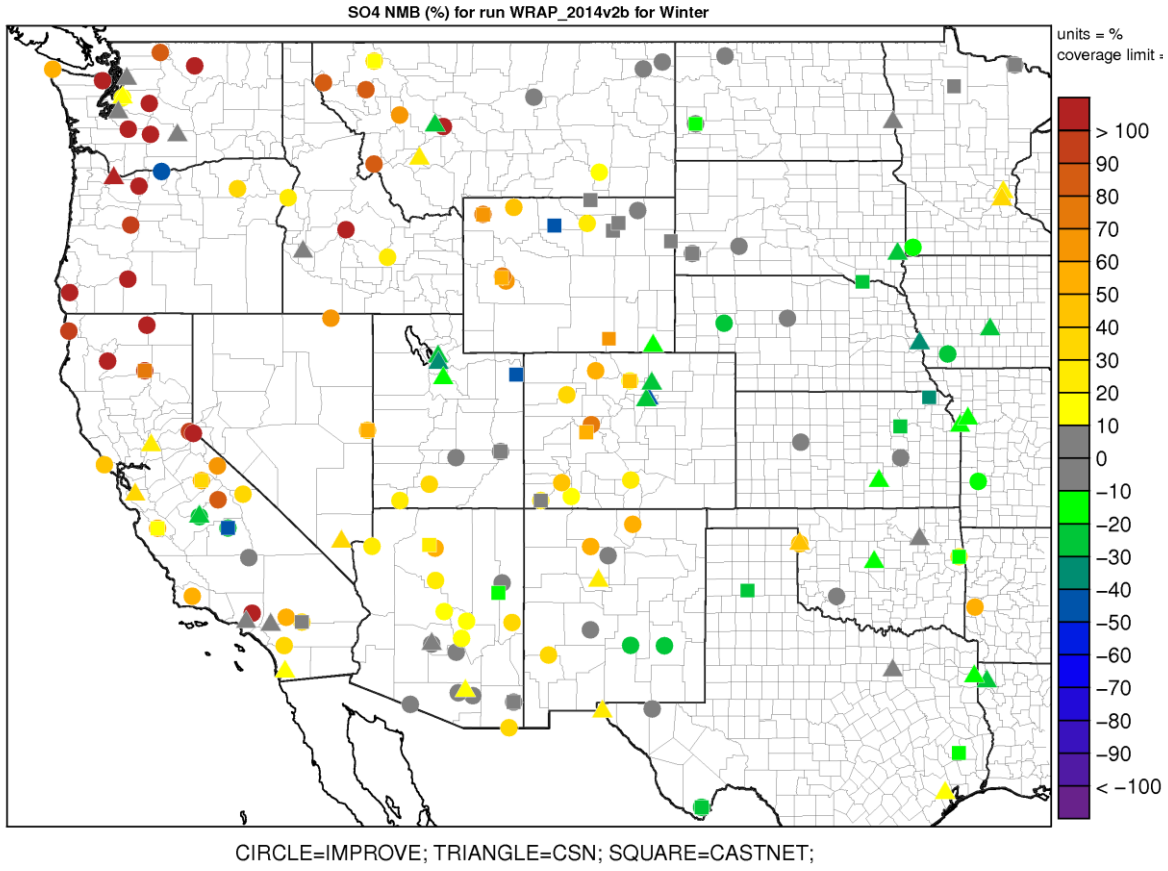
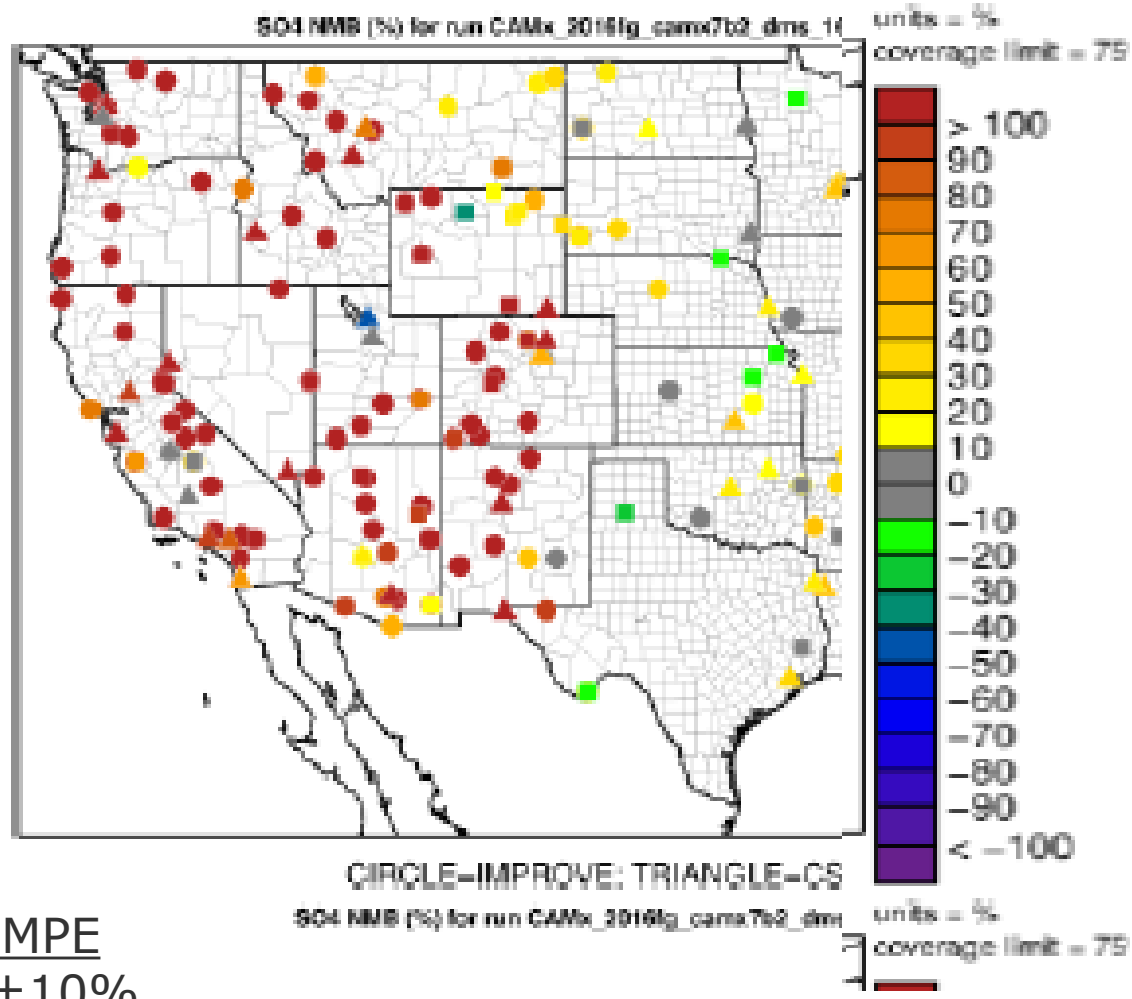
SO4 NMB Winter -- Spatial Maps of MPE Statistics for WUSA

WAQS CAMx 2014v2



EPA CAMx 2016beta'

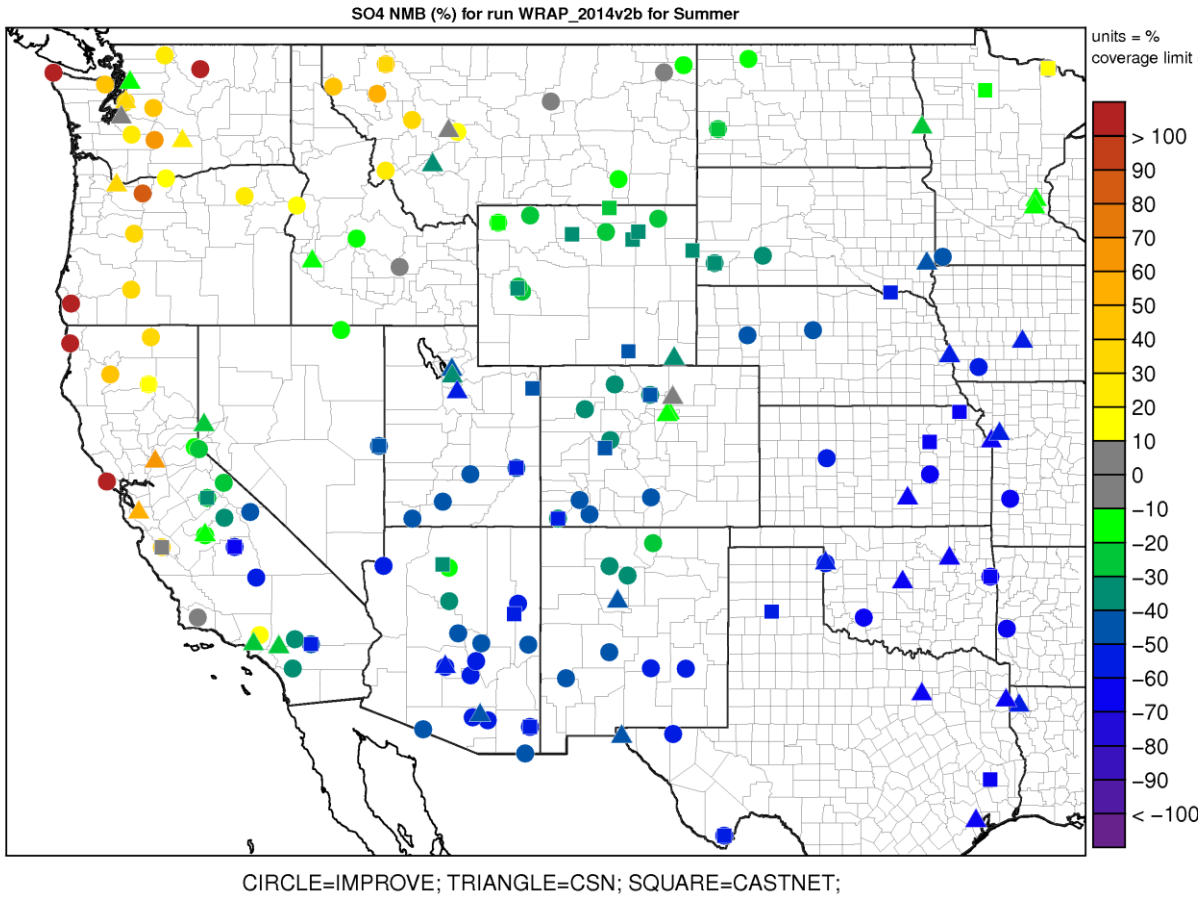


SO4 NMB MPE
Goal ≤±10%
Criteria ≤±30%

RAMBOLL

SO4 NMB Summer -- Spatial Maps of MPE Statistics for WUSA

WAQS CAMx 2014v2



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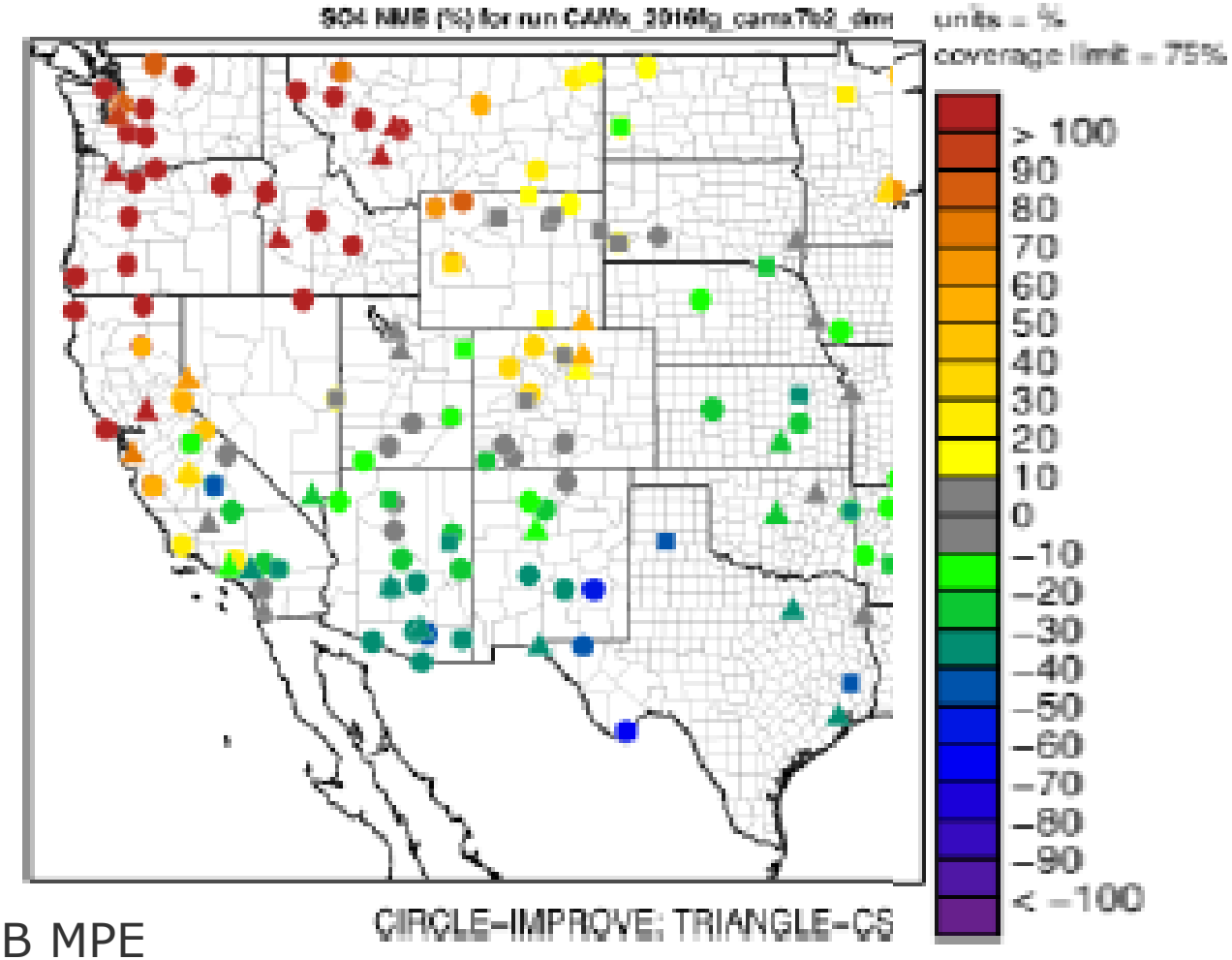

SO4 NMB MPE
Goal ≤±10%
Criteria ≤±30%

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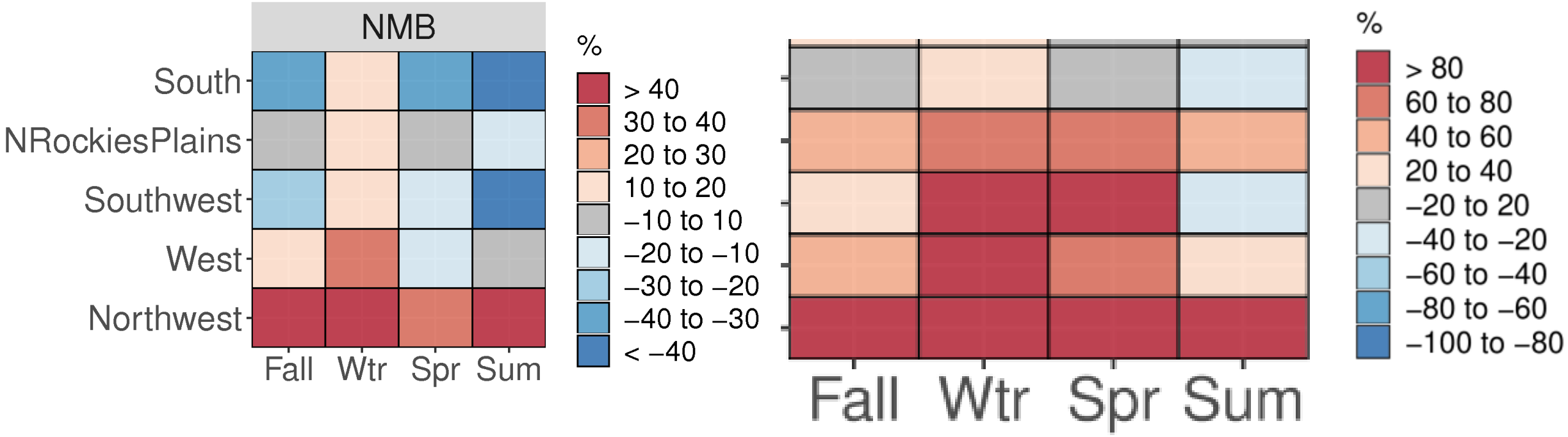
SO4 NMB Kellygrams -- IMPROVE Regional Model Performance

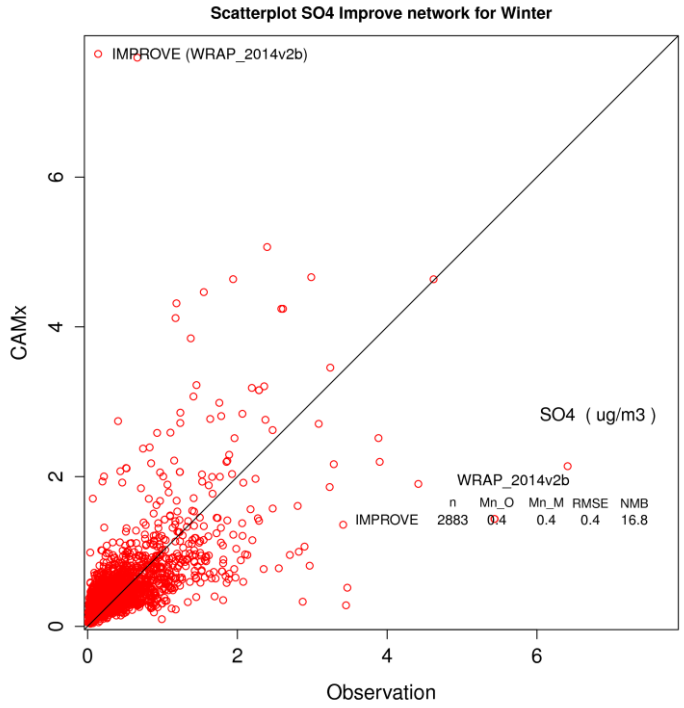
- Note different AMET auto-scale
- Northwest SO4 overestimation both base cases, worse with 2016beta'
- 2014v2 better SO4 MPE West, Southwest and NRockiesPlains
- 2014v2 larger underestimation than 2016beta' in South

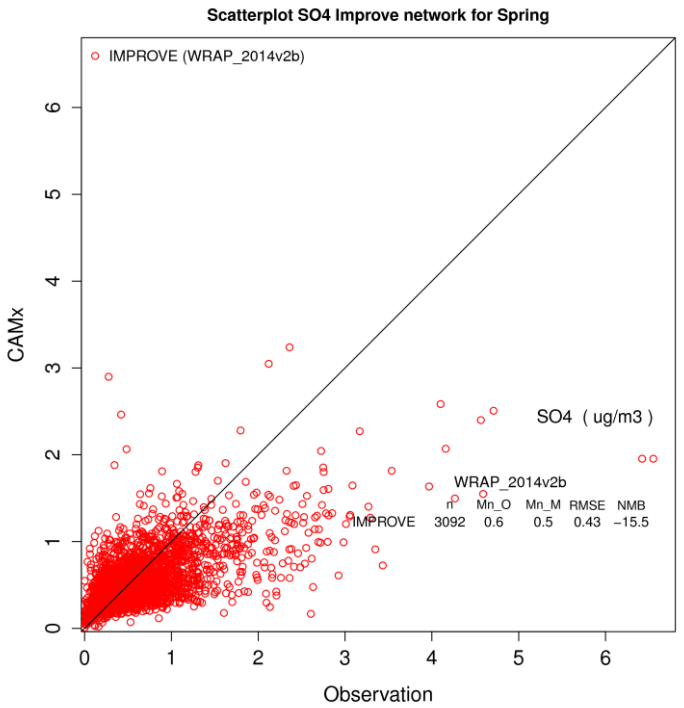


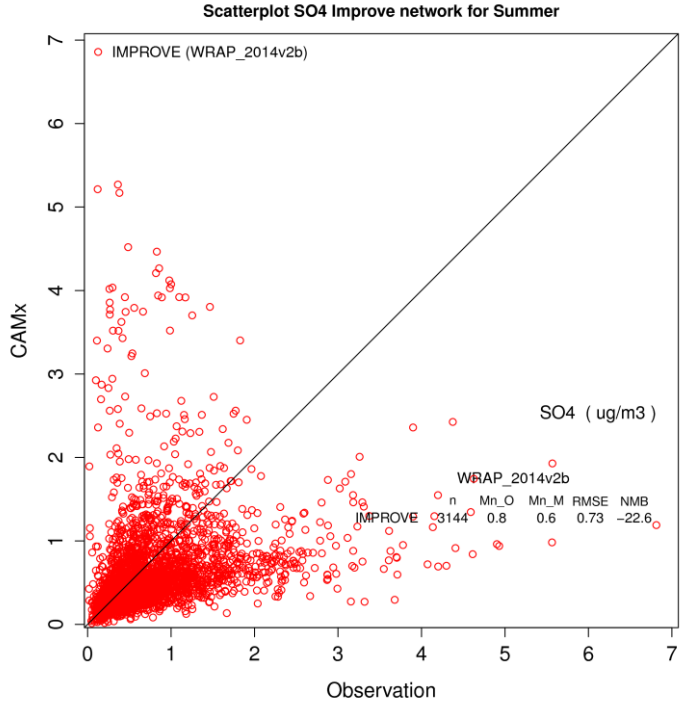
SO4 NMB MPE
Goal ≤±10%
Criteria ≤±30%

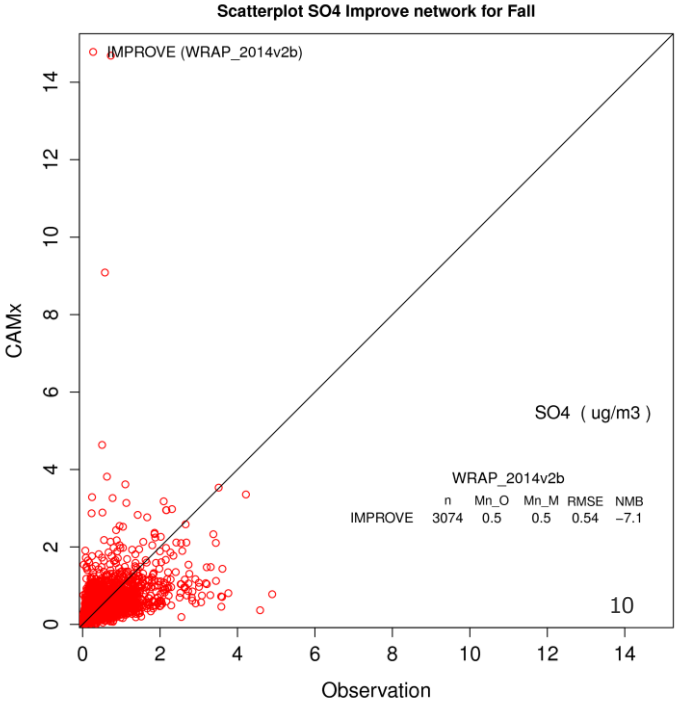
2014v2 SO4 Scatter

- Winter, Spring, Summer, Fall
- NMB = 17%, -16%, -23%, -7%
  - Goal ≤±10%; Criteria ≤±30%
- Coastal SO4 overestimation in summer
- Northwest SO4 overestimation
- SO4 underestimation in South, especially in Spring and Summer

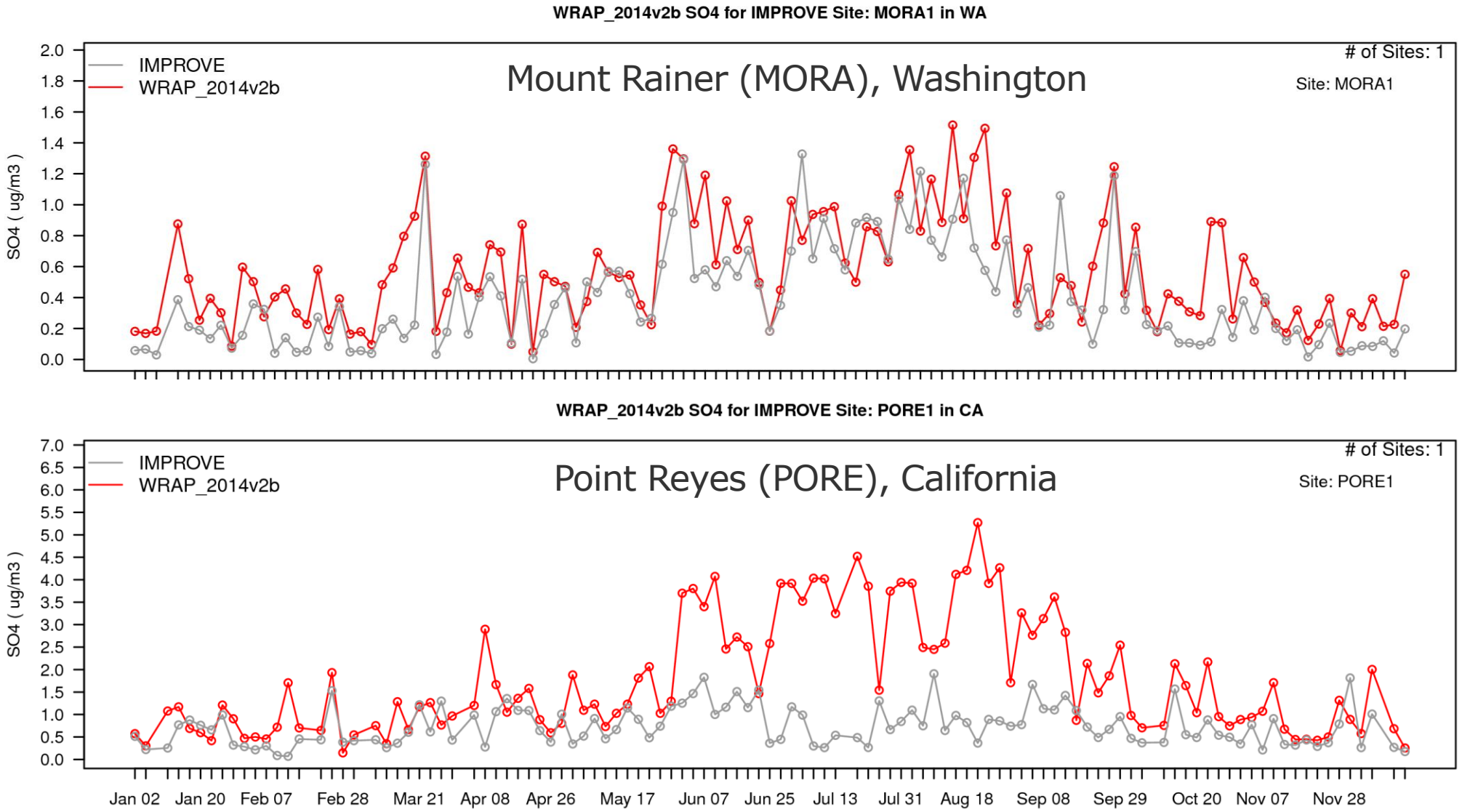




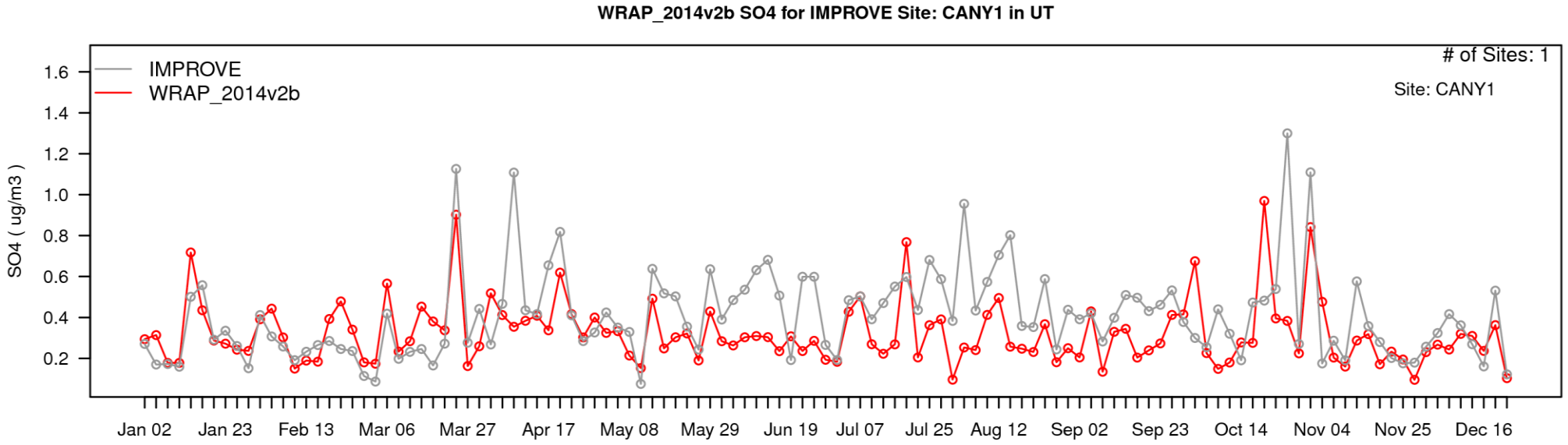


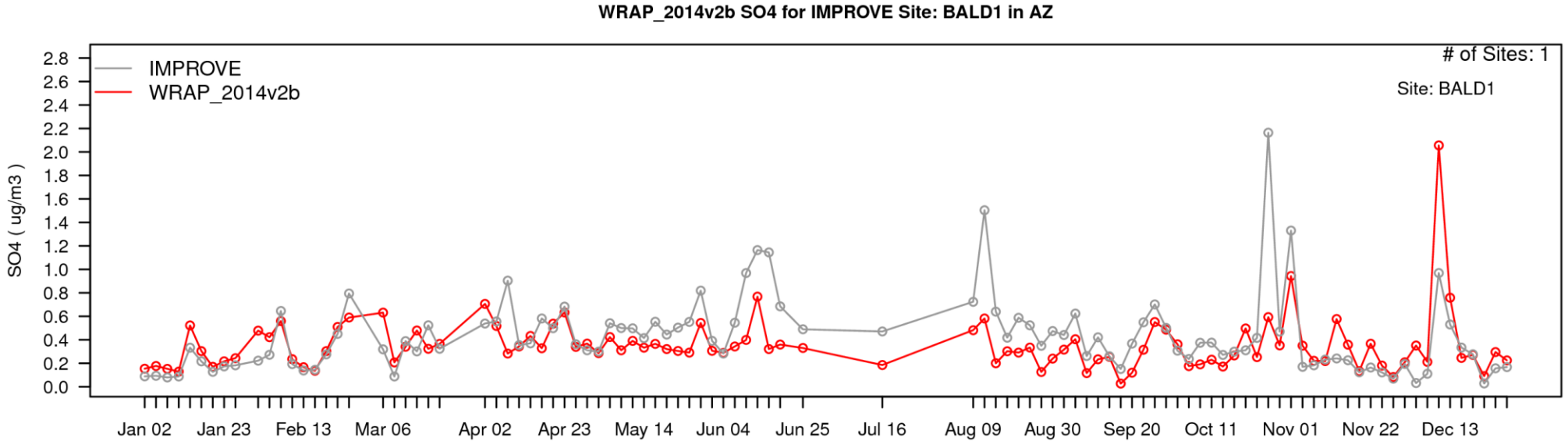


SO4 Time Series – MORA-Northeast & PORE-West

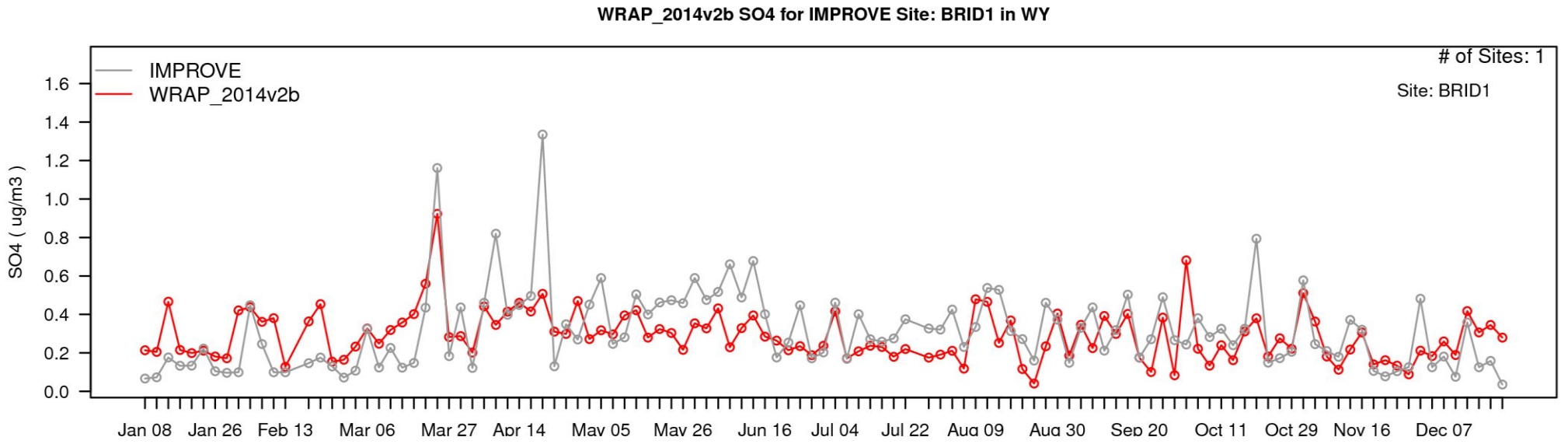


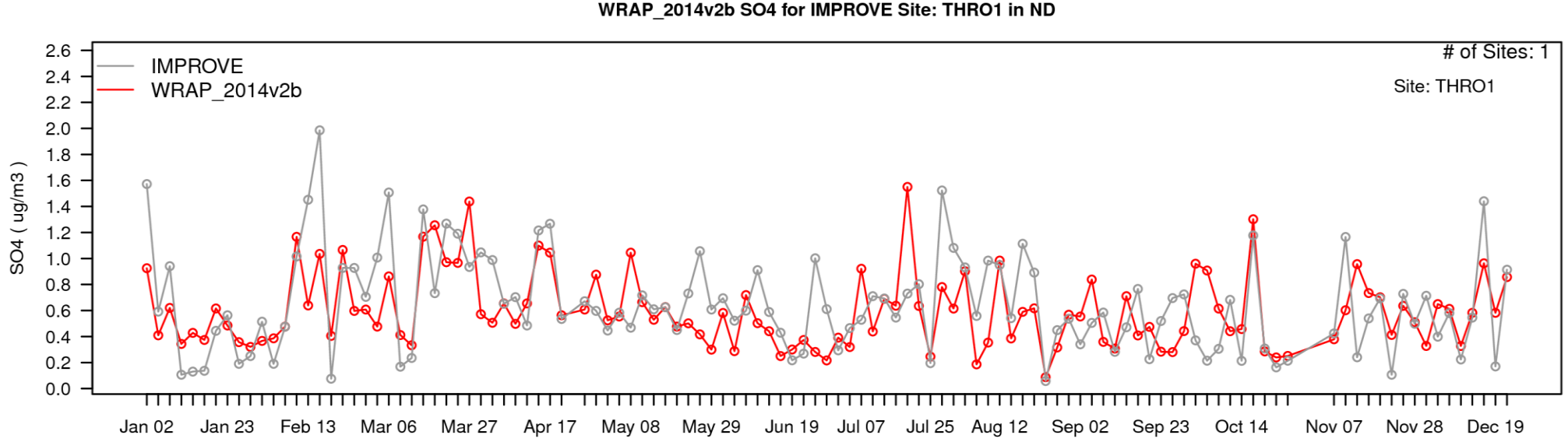
SO4 Time Series – CANY & BALD-Southwest



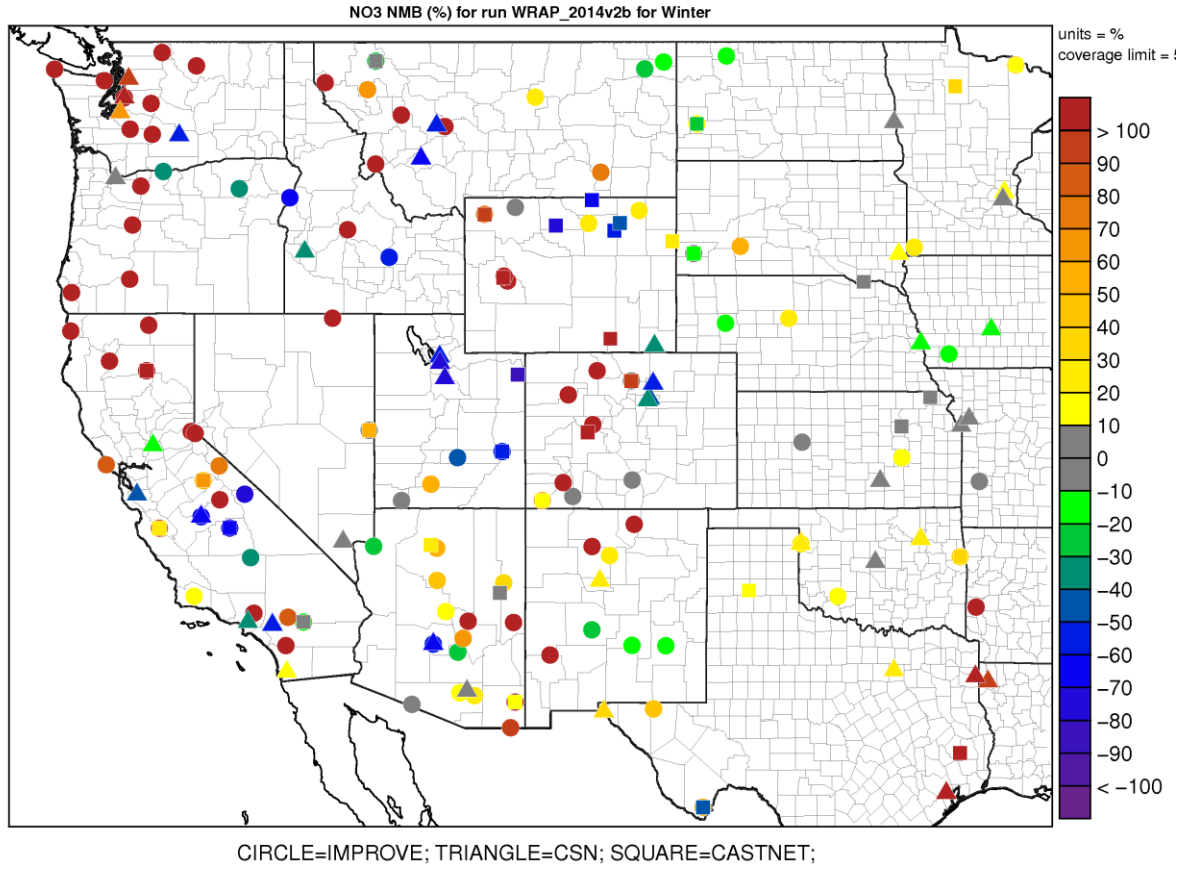


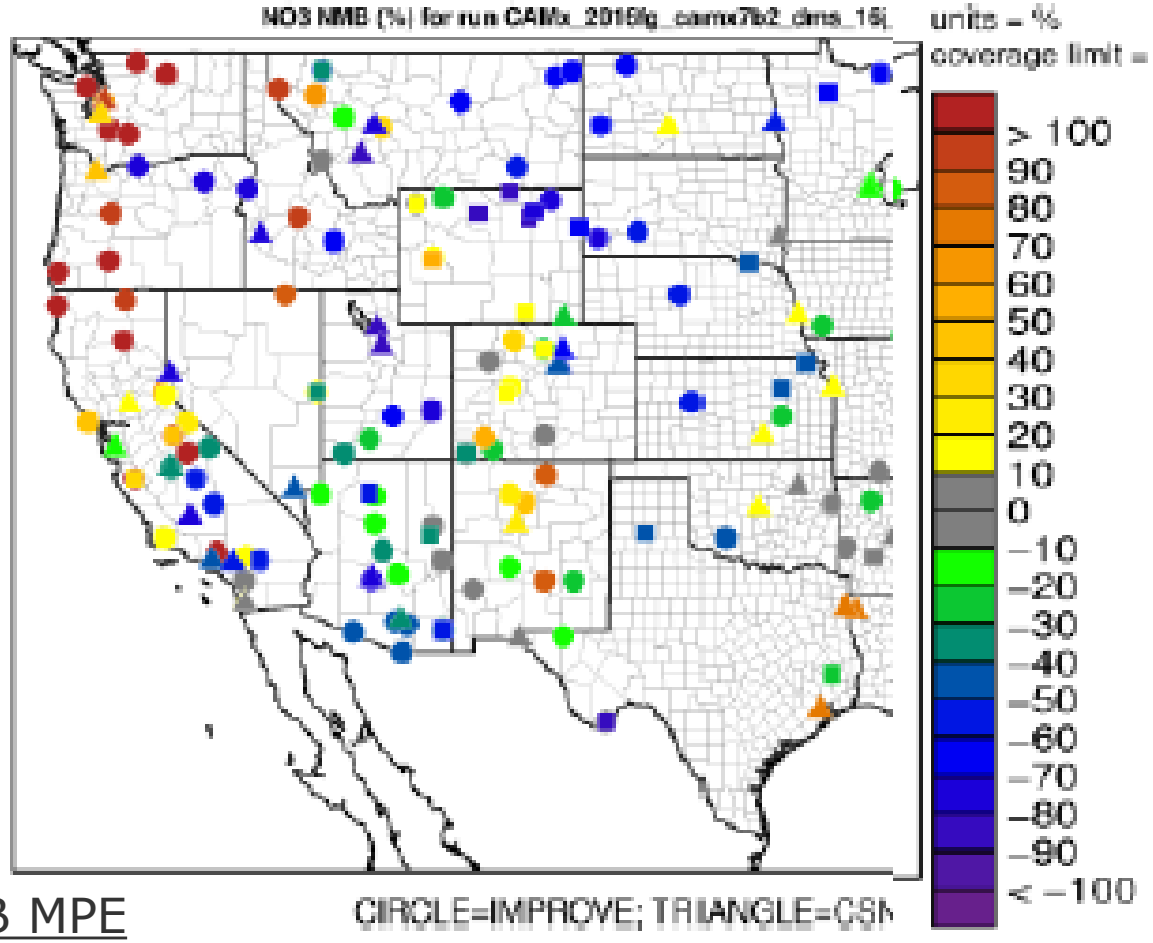
SO4 Time Series – BRID & THRO-NRockiesPlains





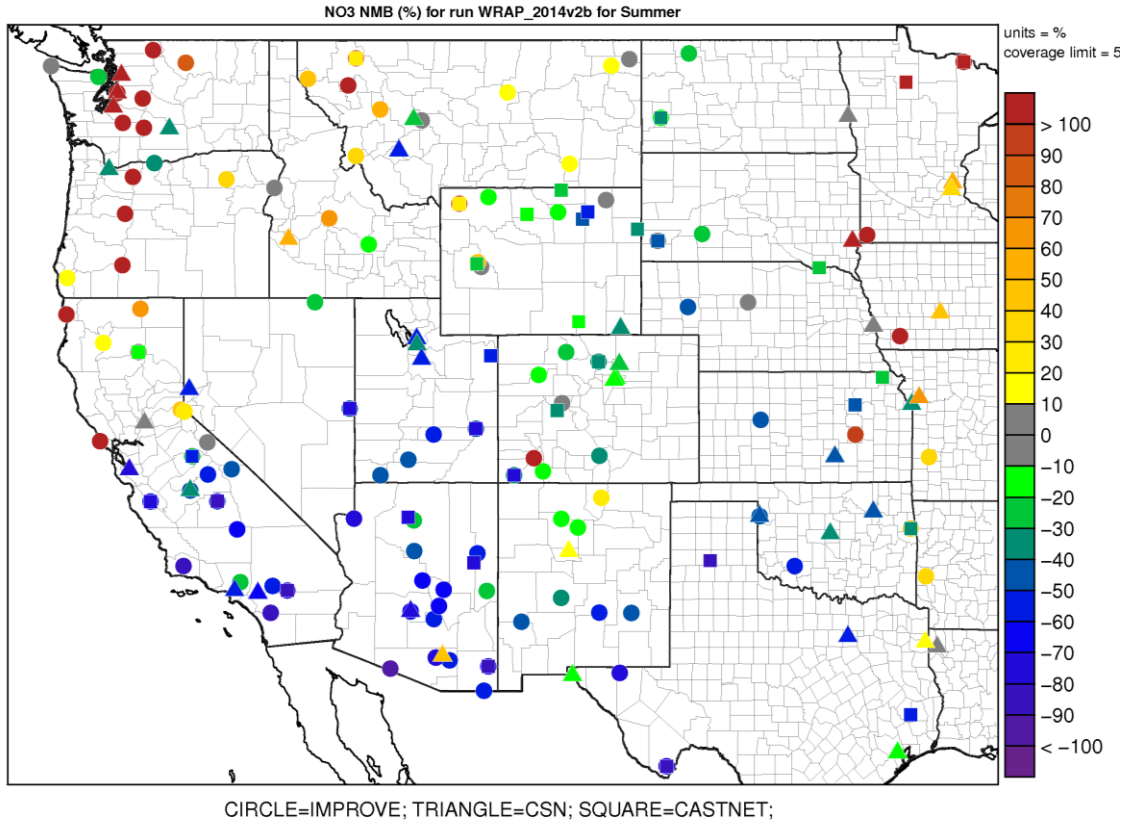
NO3 NMB Winter -- Spatial Maps of MPE Statistics for WUSA

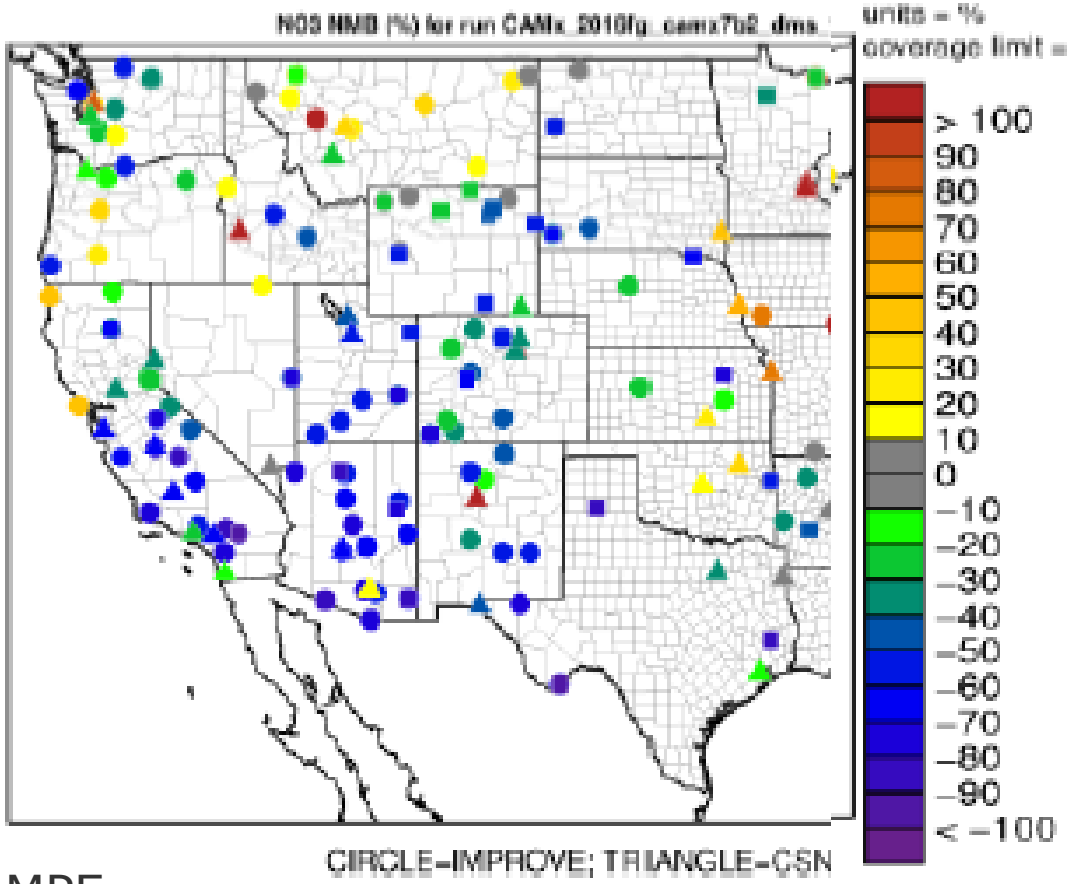




NO3 NMB MPE
Goal ≤±15%
Criteria ≤±65%

NO3 NMB Summer -- Spatial Maps of MPE Statistics for WUSA





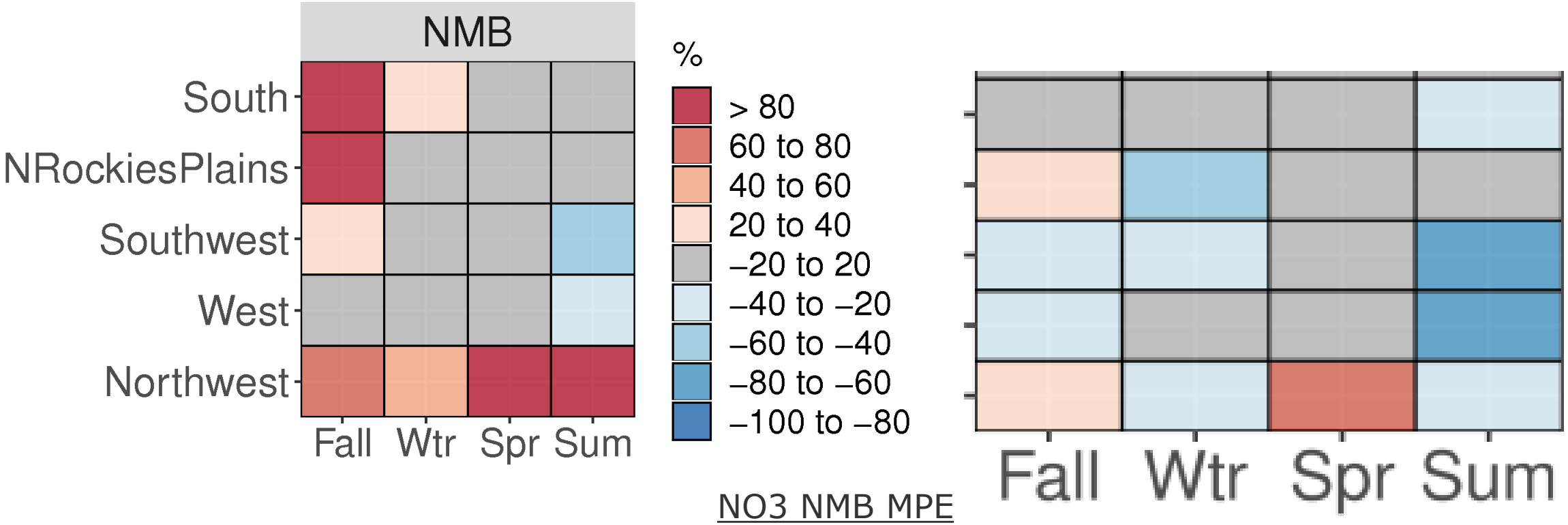
NO3 NMB MPE

Goal ≤±15%

Criteria ≤±65%

NO3 NMB Kellygrams -- IMPROVE Regional Model Performance

- 2014v2 higher NO3 than 2016beta'
  - 2014v2 run with bi-di ammonia and drydep with lower surfaced resistance (RSCALE = 1)
- 2014v2 Northwest All Year and Fall Most Regions NO3 overestimation bias
- 2014v2 better winter NO3 performance



NO3 NMB MPE
Goal ≤±15%
Criteria ≤±65%

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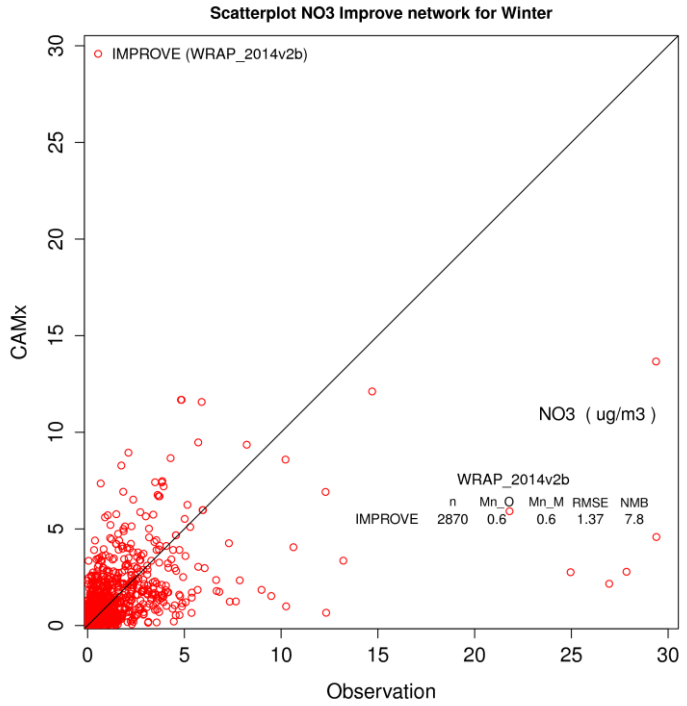
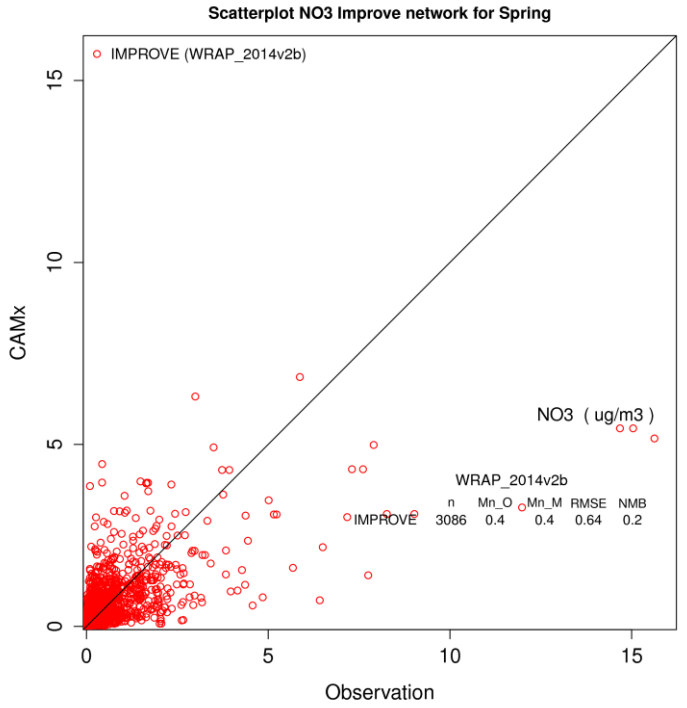
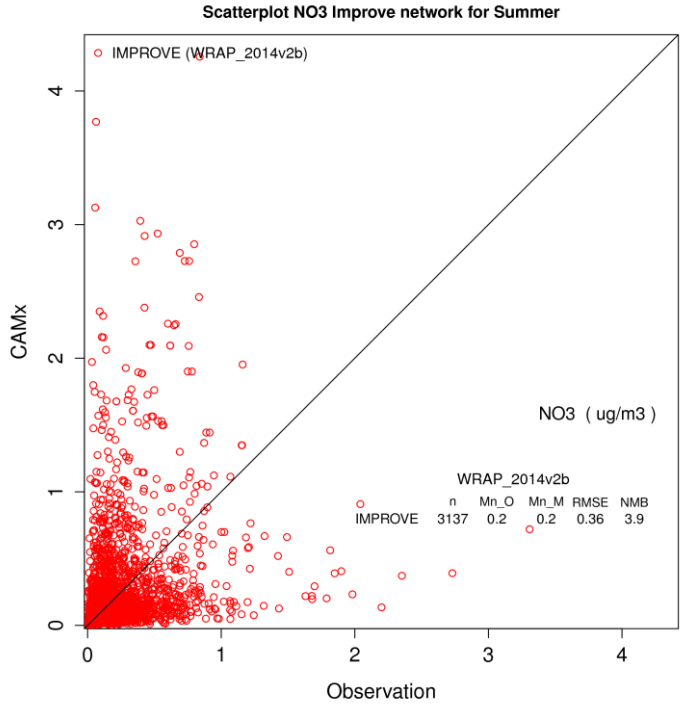
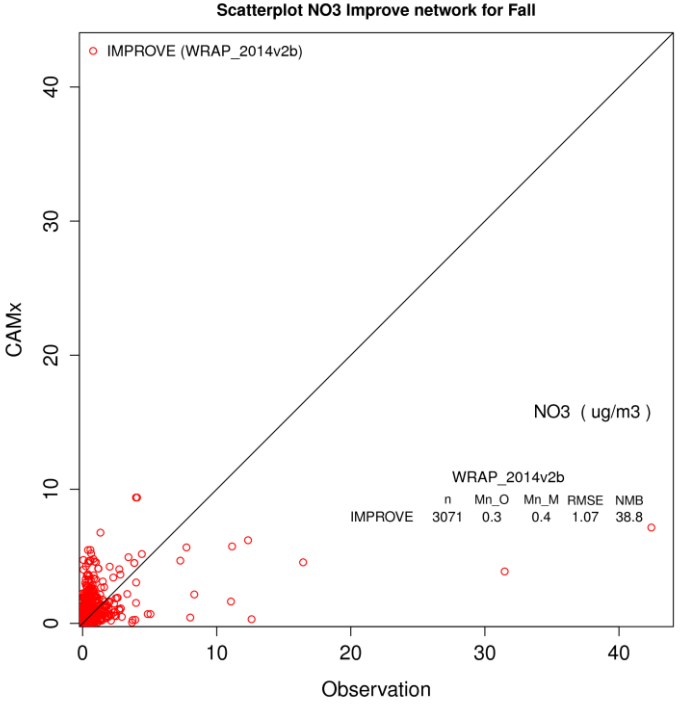
NO3 IMPROVE WUSA

- Winter, Spring, Summer, Fall
- NMB = 8%, 0%, 4%, 39%
  - Goal ≤±15%; Criteria ≤±65%
- Fall and Summer NO3 overestimation

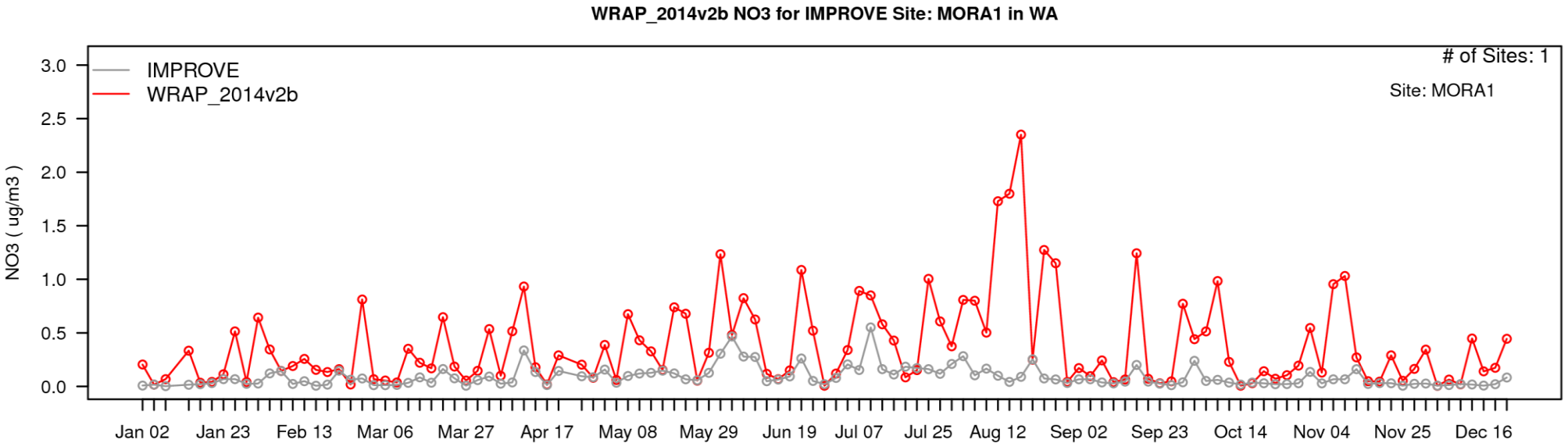


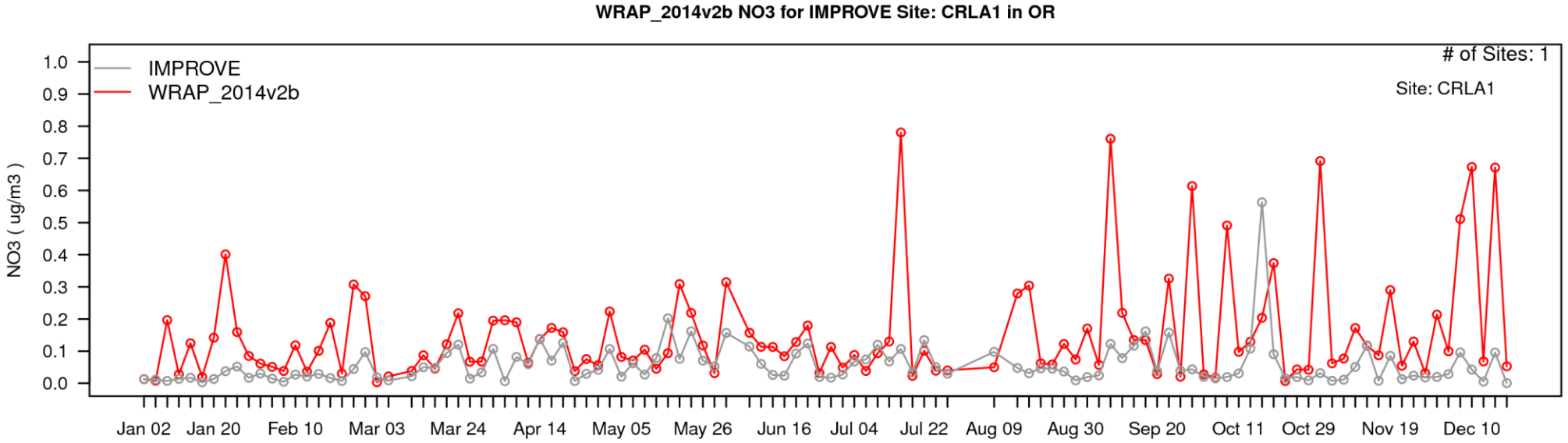




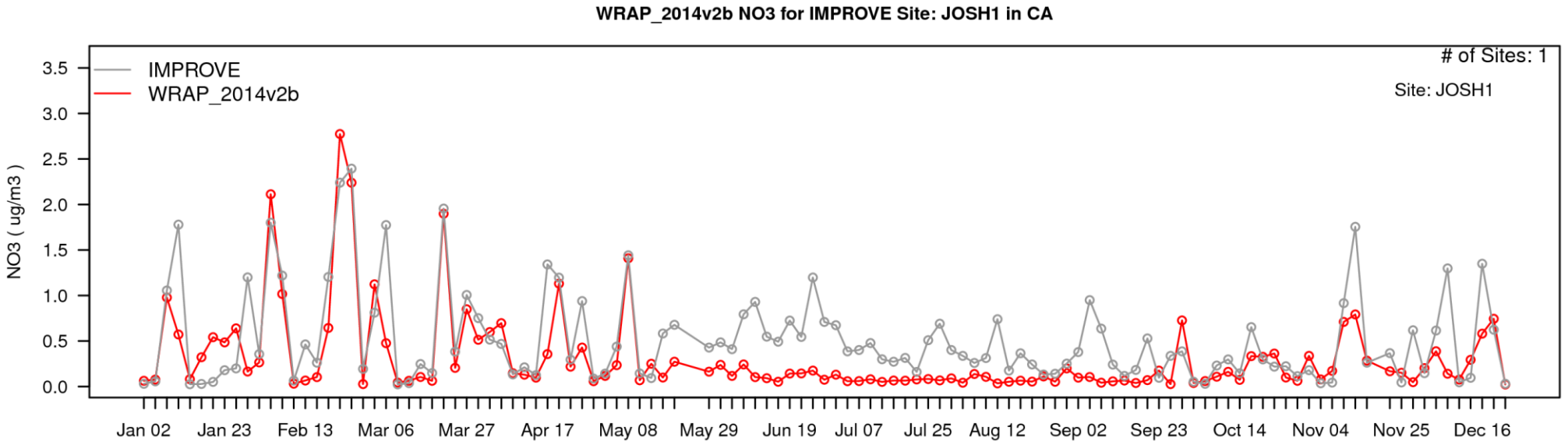


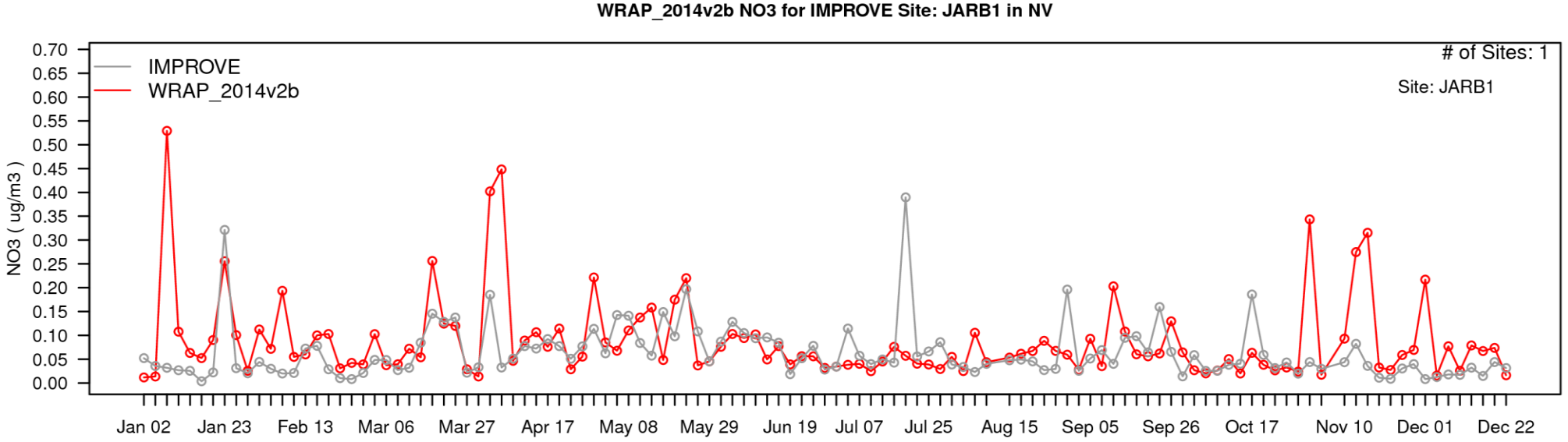
NO3 Time Series – Northwest: MORA & CRLA



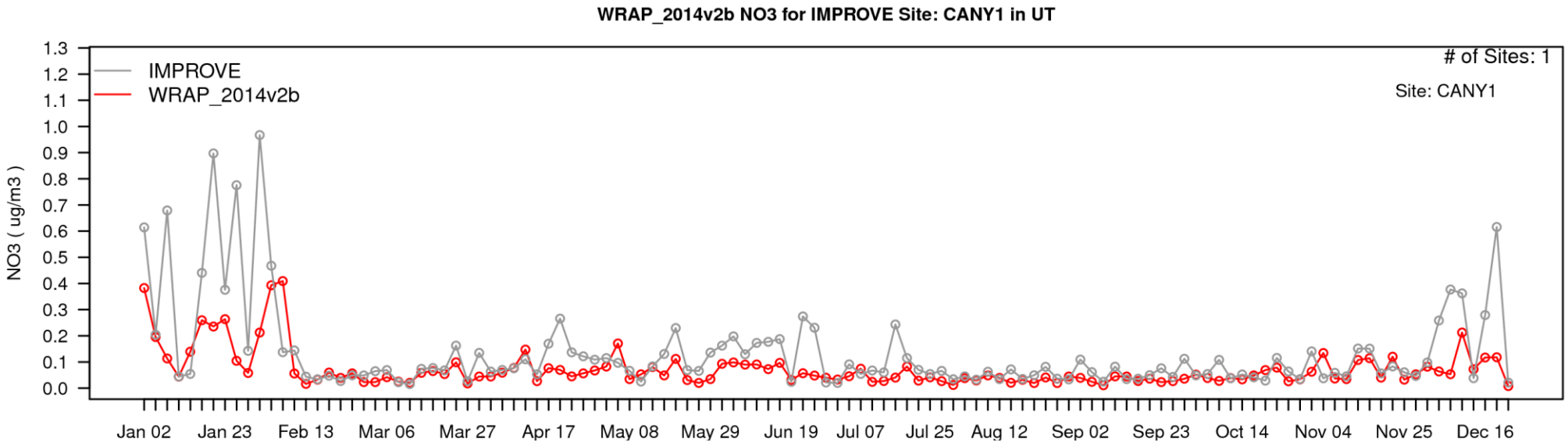


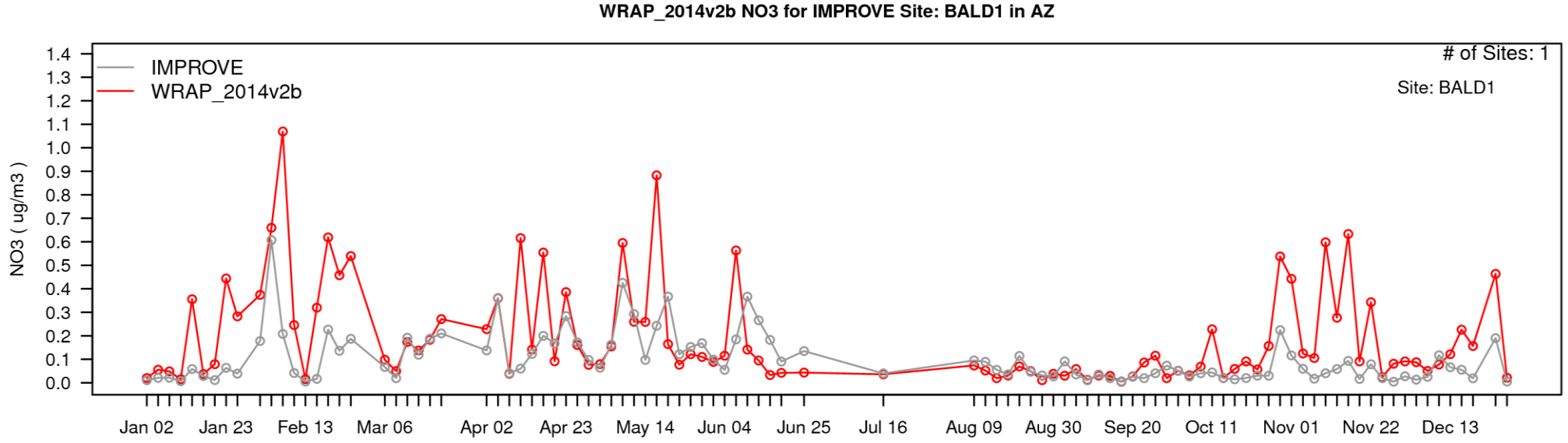
NO3 Time Series – West: JOSH & JARB



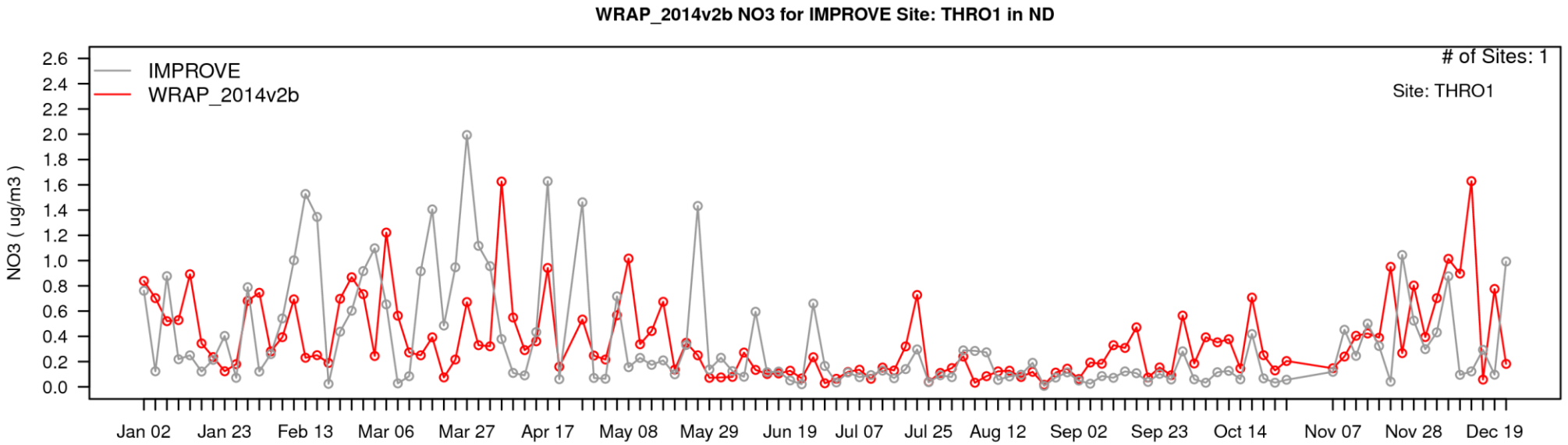


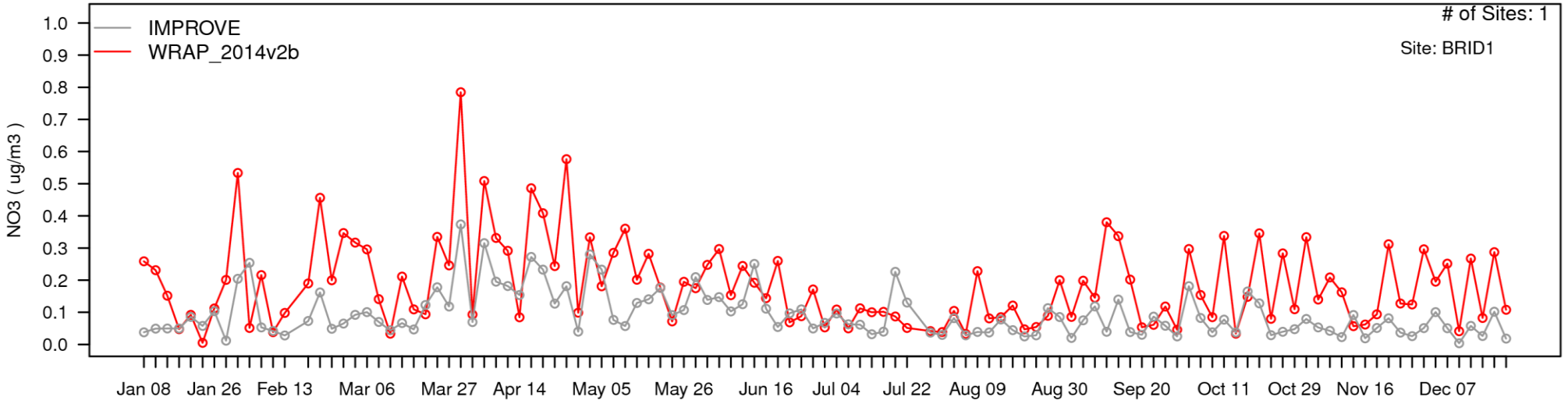
NO3 Time Series – Southwest: CANY & BALD



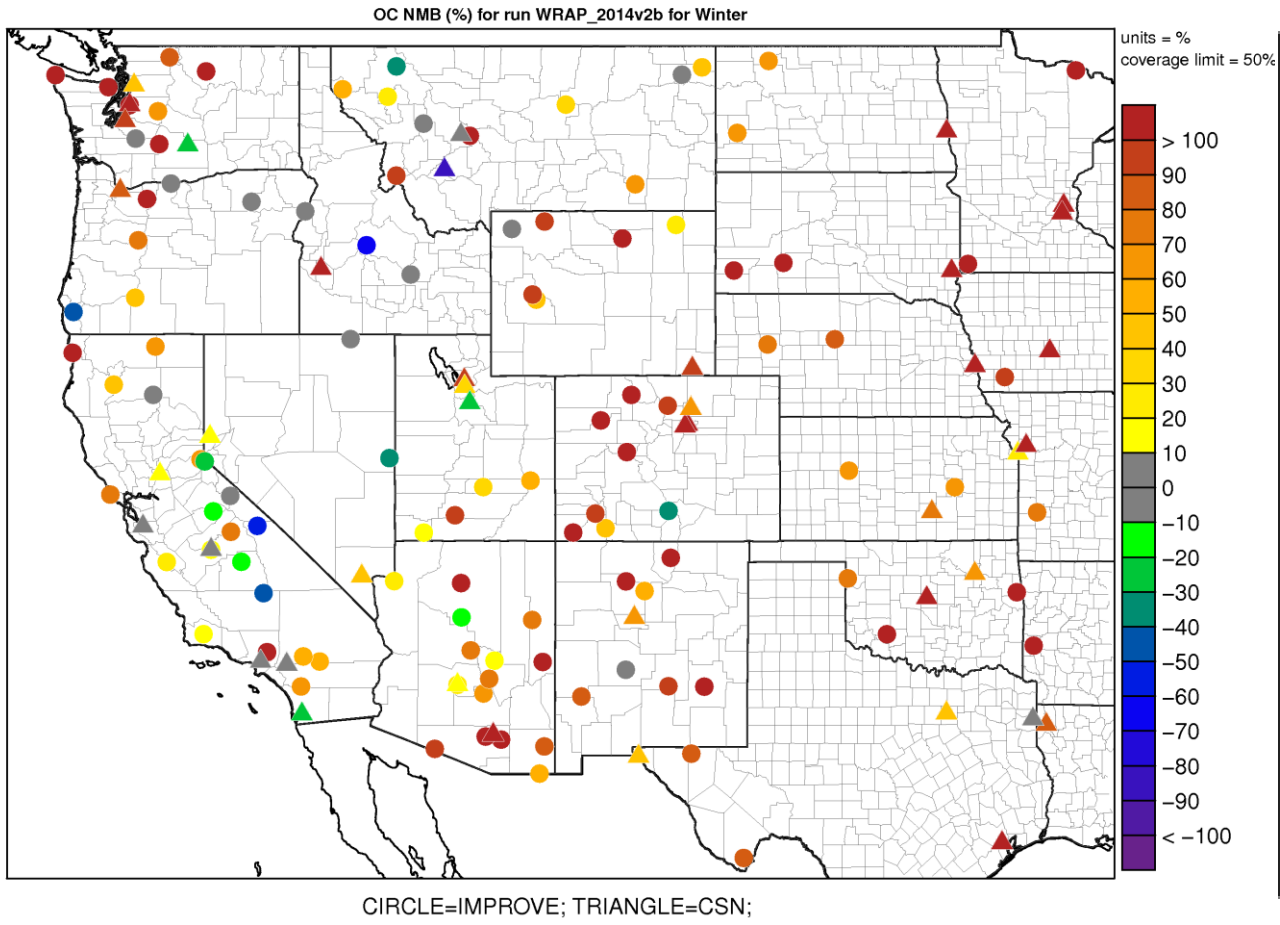


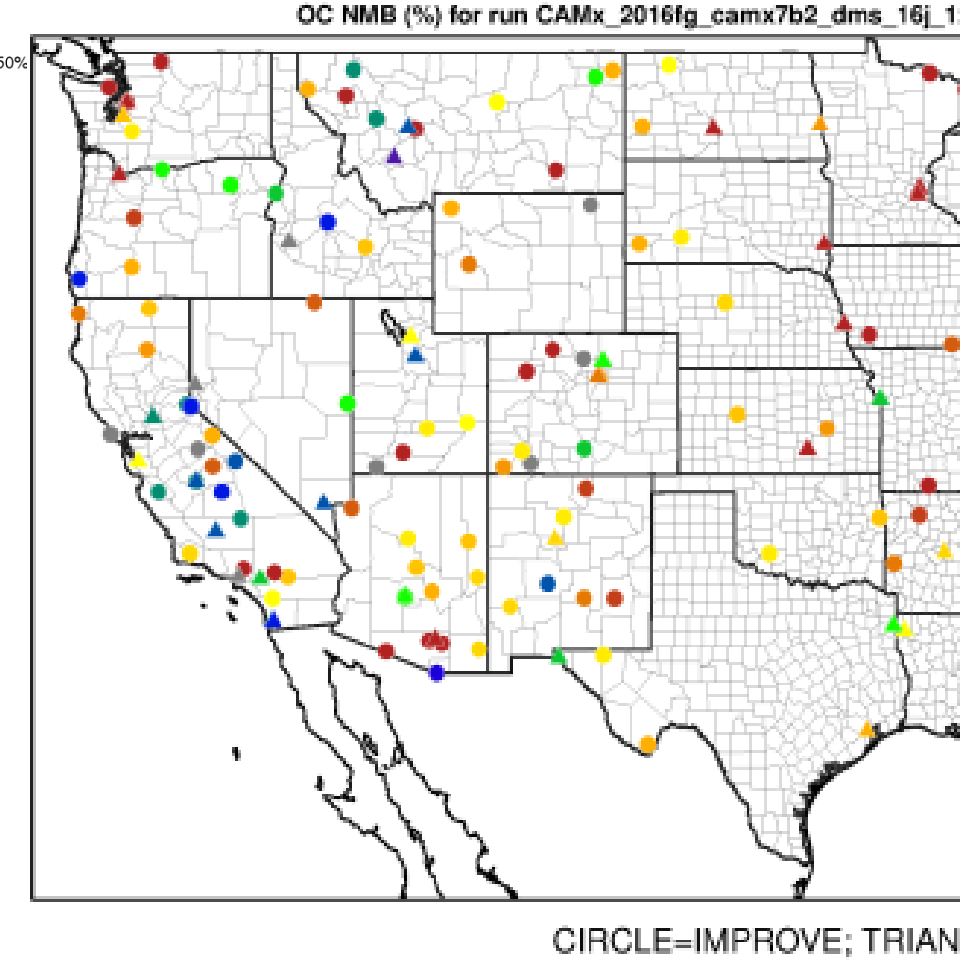
NO3 Time Series – NRockiesPlains: THRO & BRID



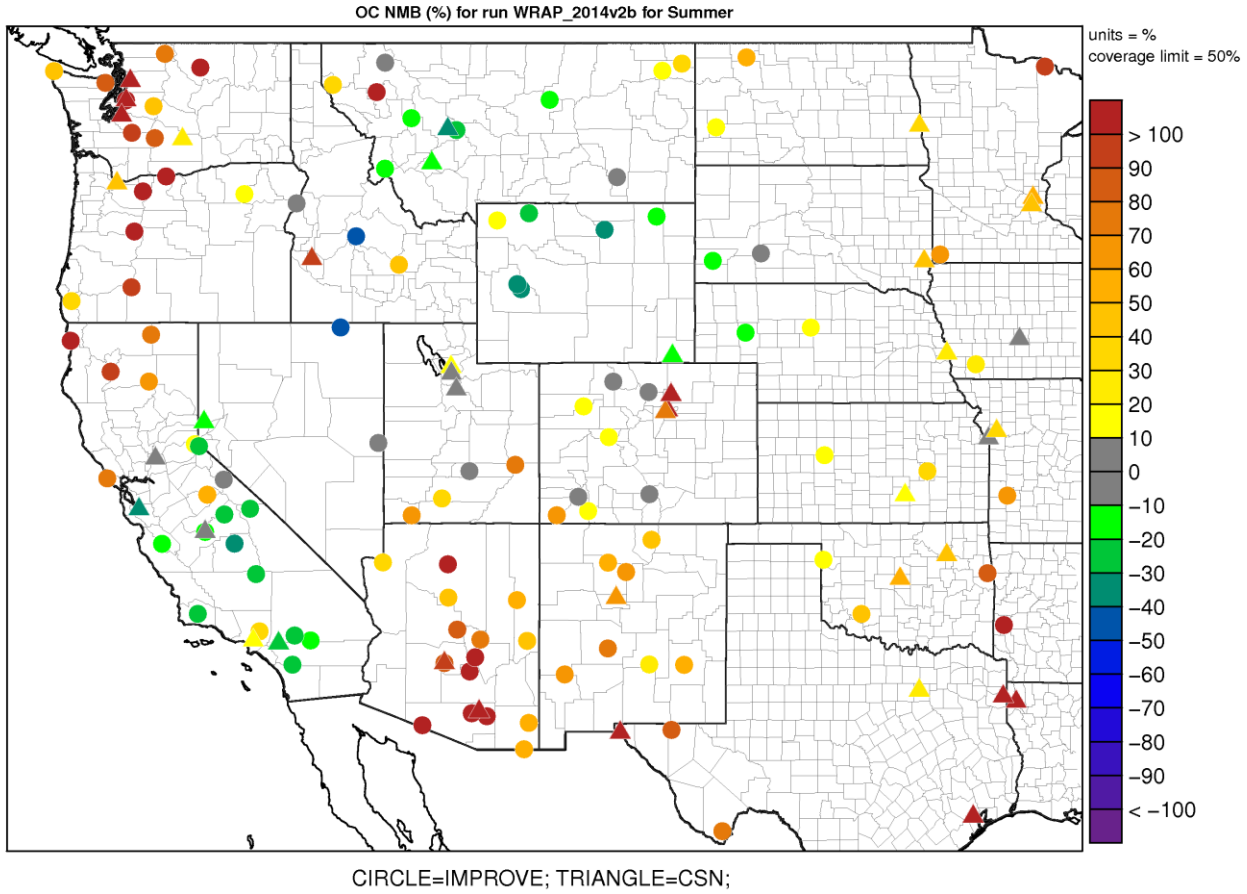


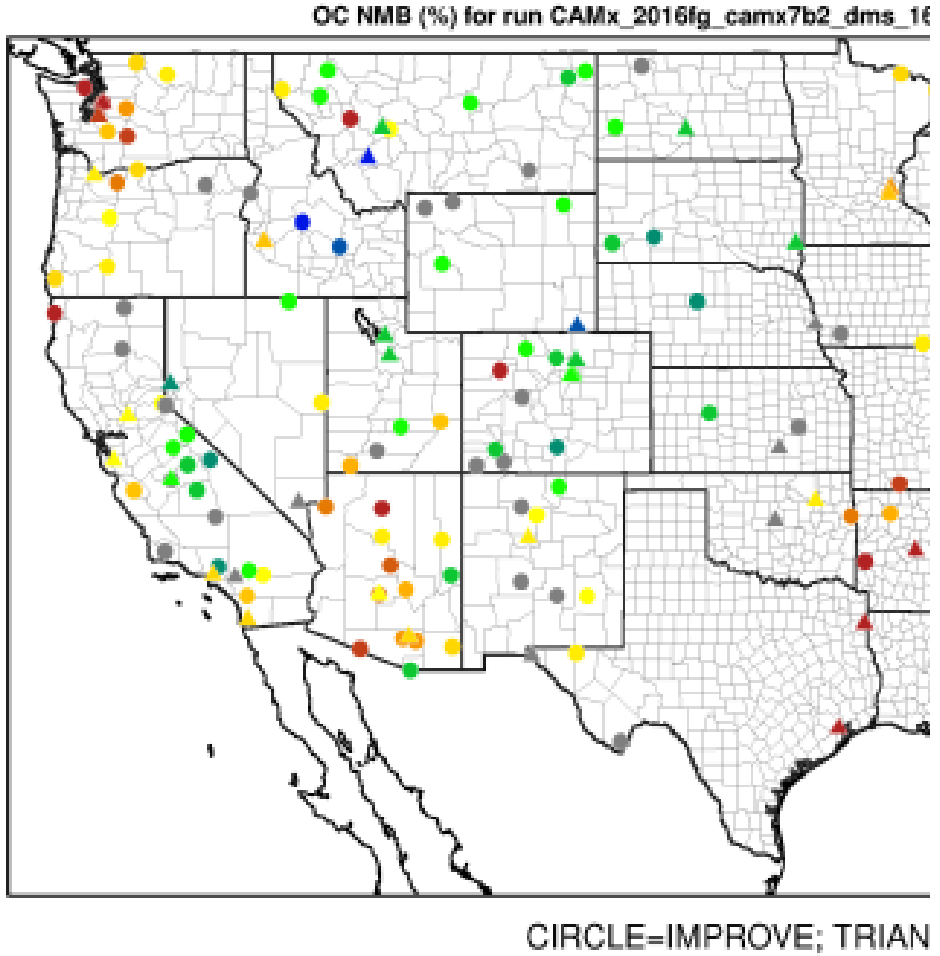
OA NMB Winter -- Spatial Maps of MPE Statistics for WUSA



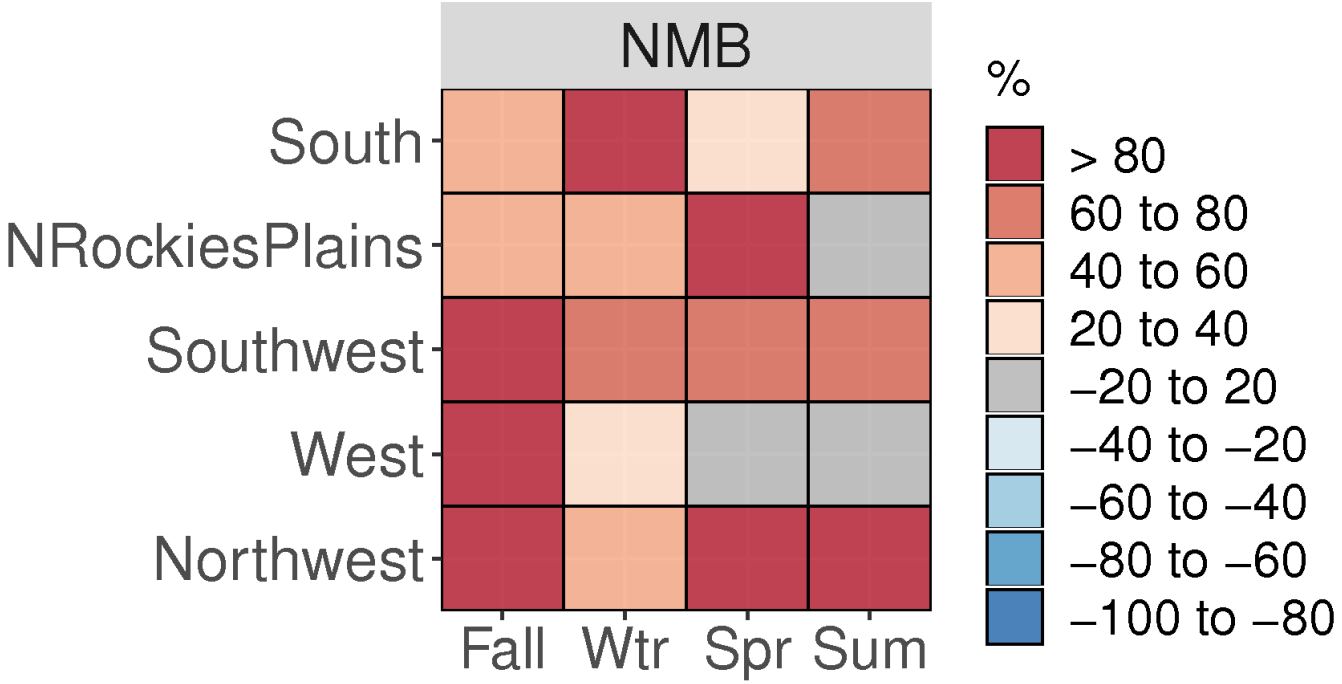


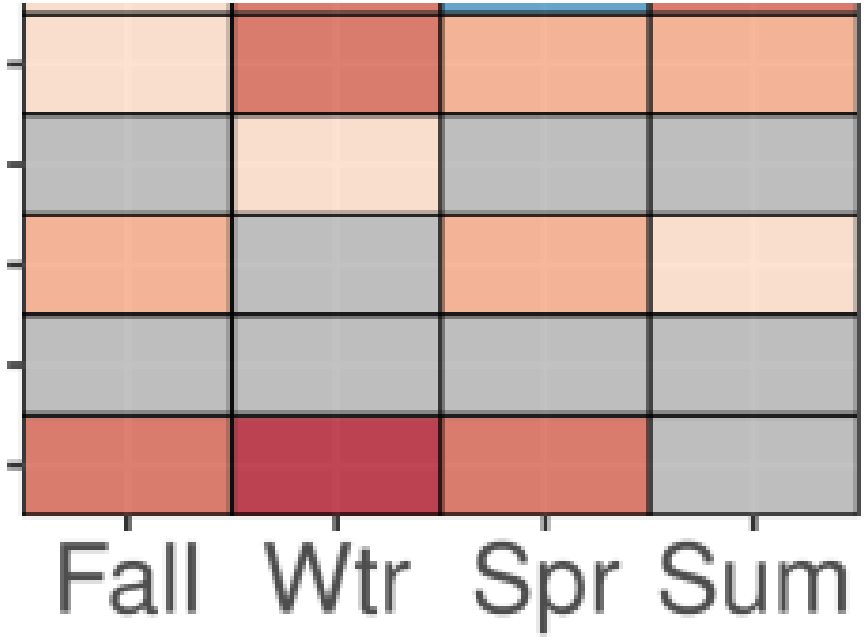
OA NMB Summer -- Spatial Maps of MPE Statistics for WUSA





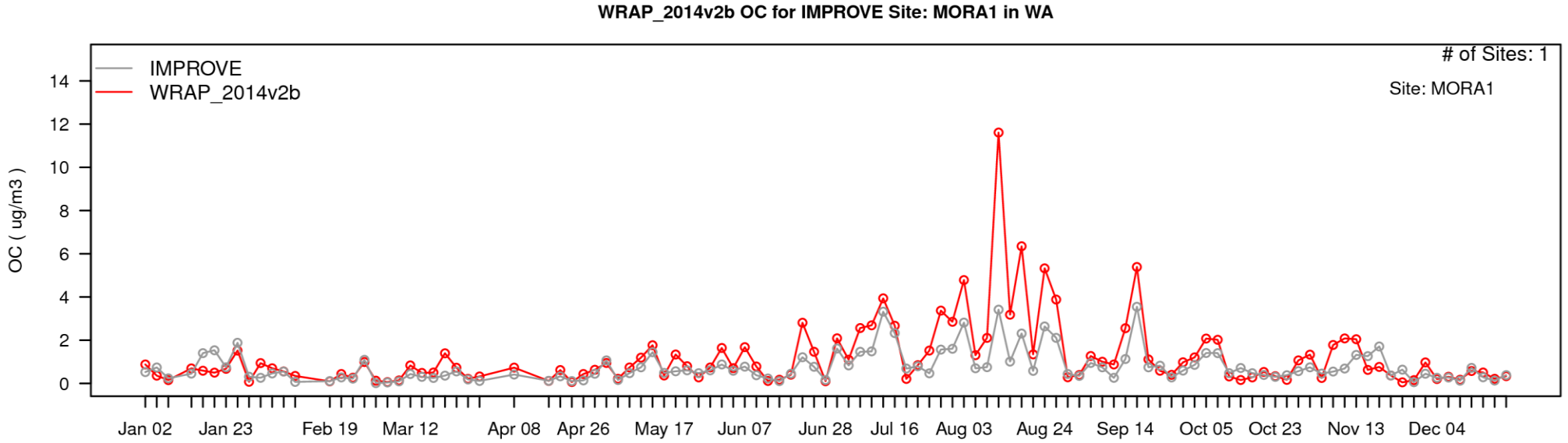
OA NMB Kellygrams -- IMPROVE Regional Model Performance

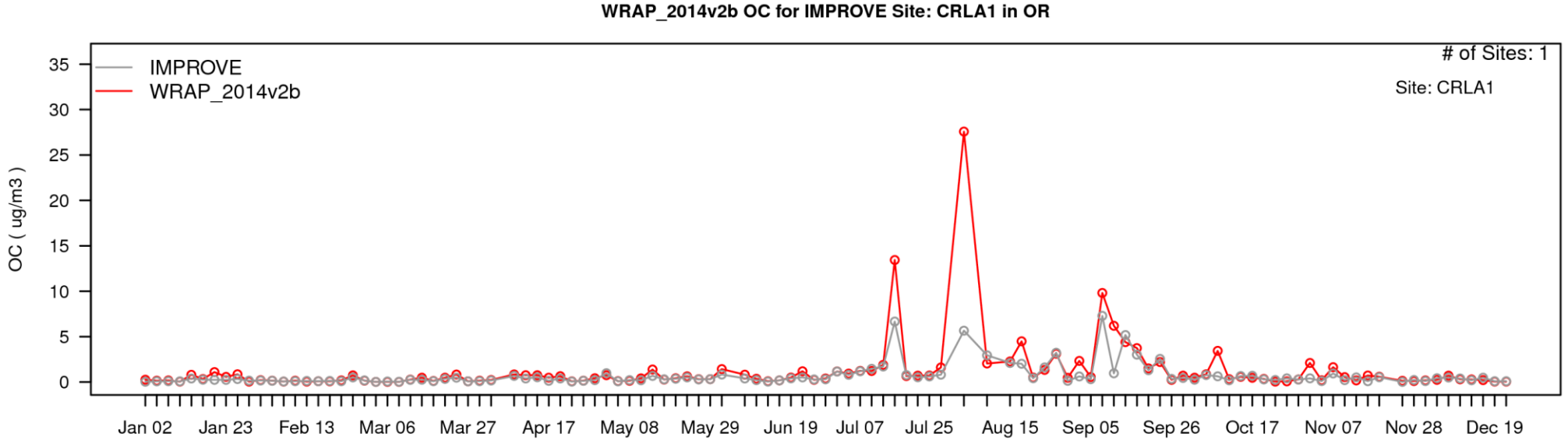




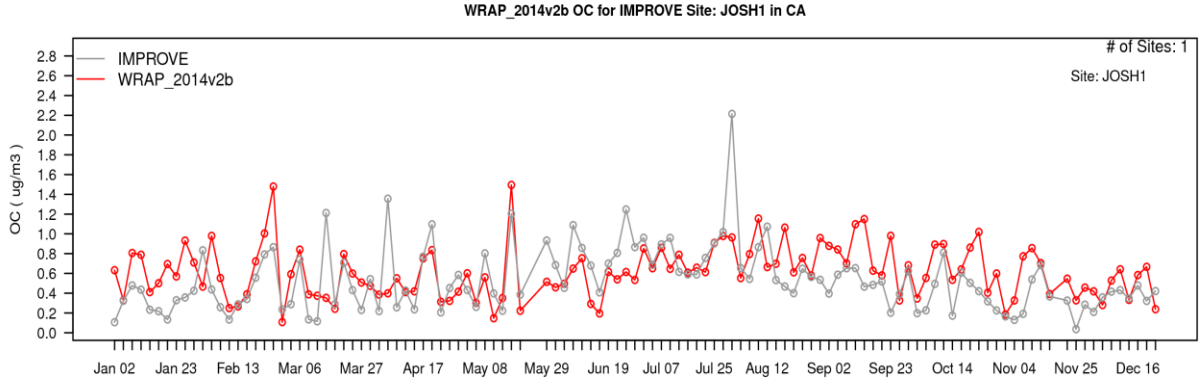
OA NMB MPE
Goal ≤±15%
Criteria ≤±50%

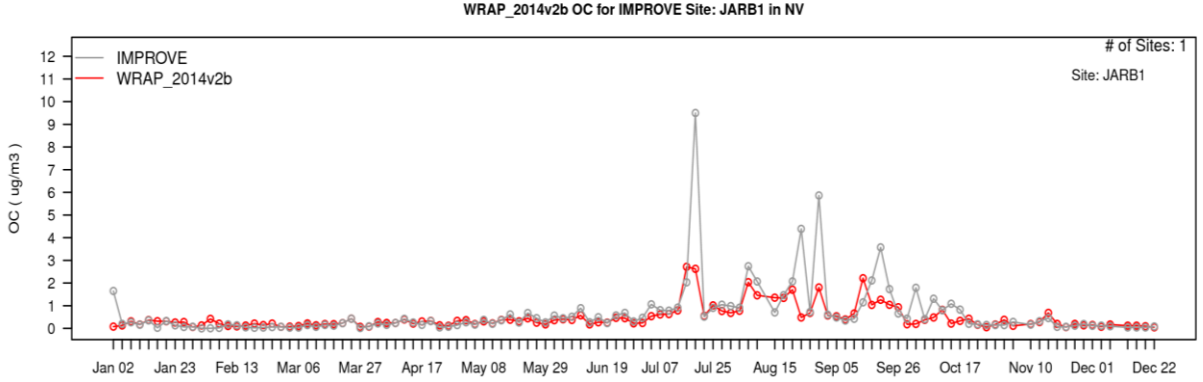
OA Time Series – Northwest: MORA & CRLA

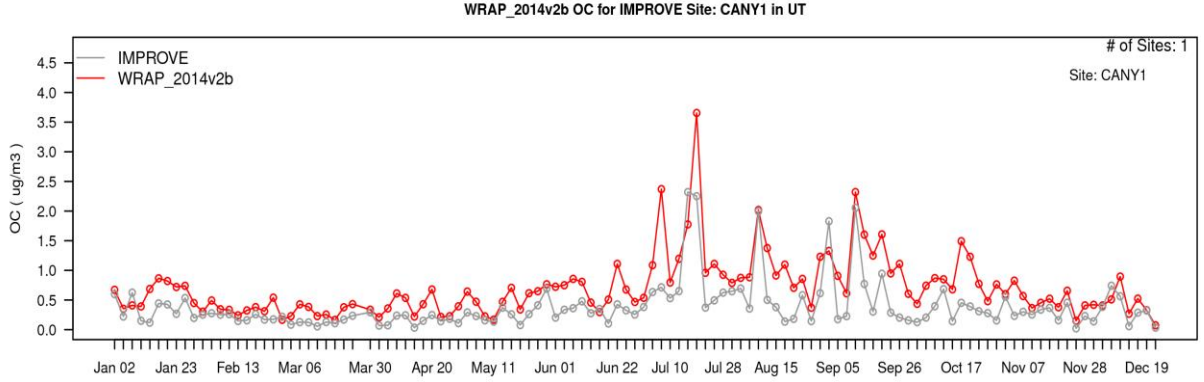


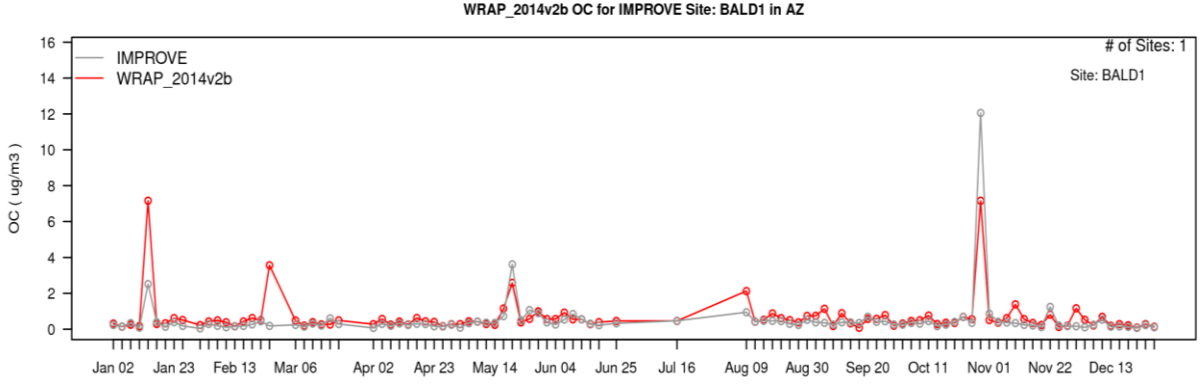


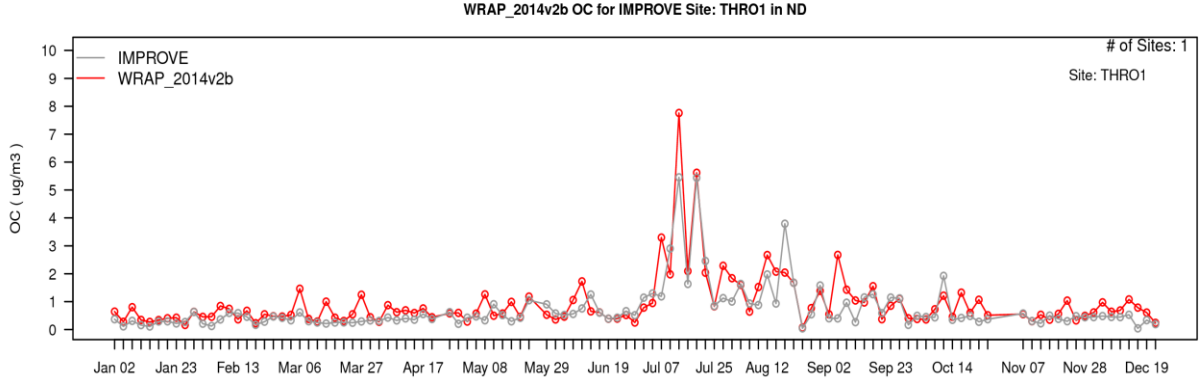
OA Time Series – JOSH&JARB, CANY&BALD, THRO&BRID

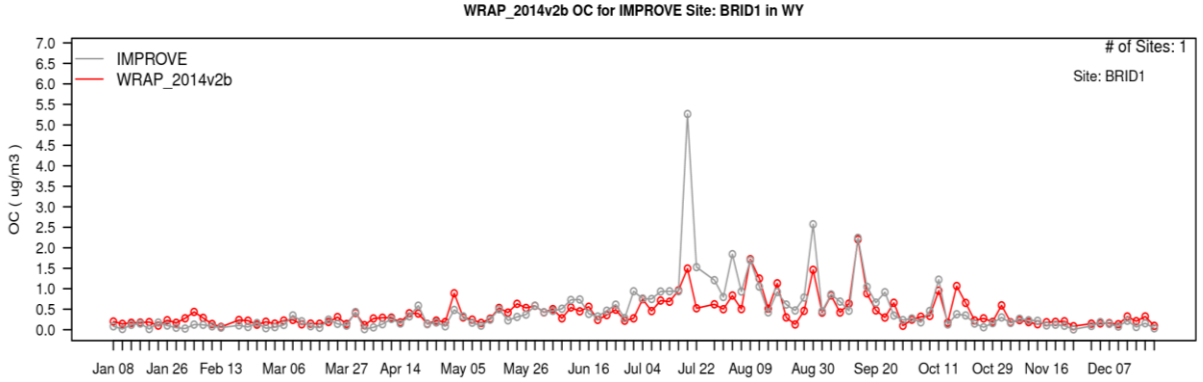




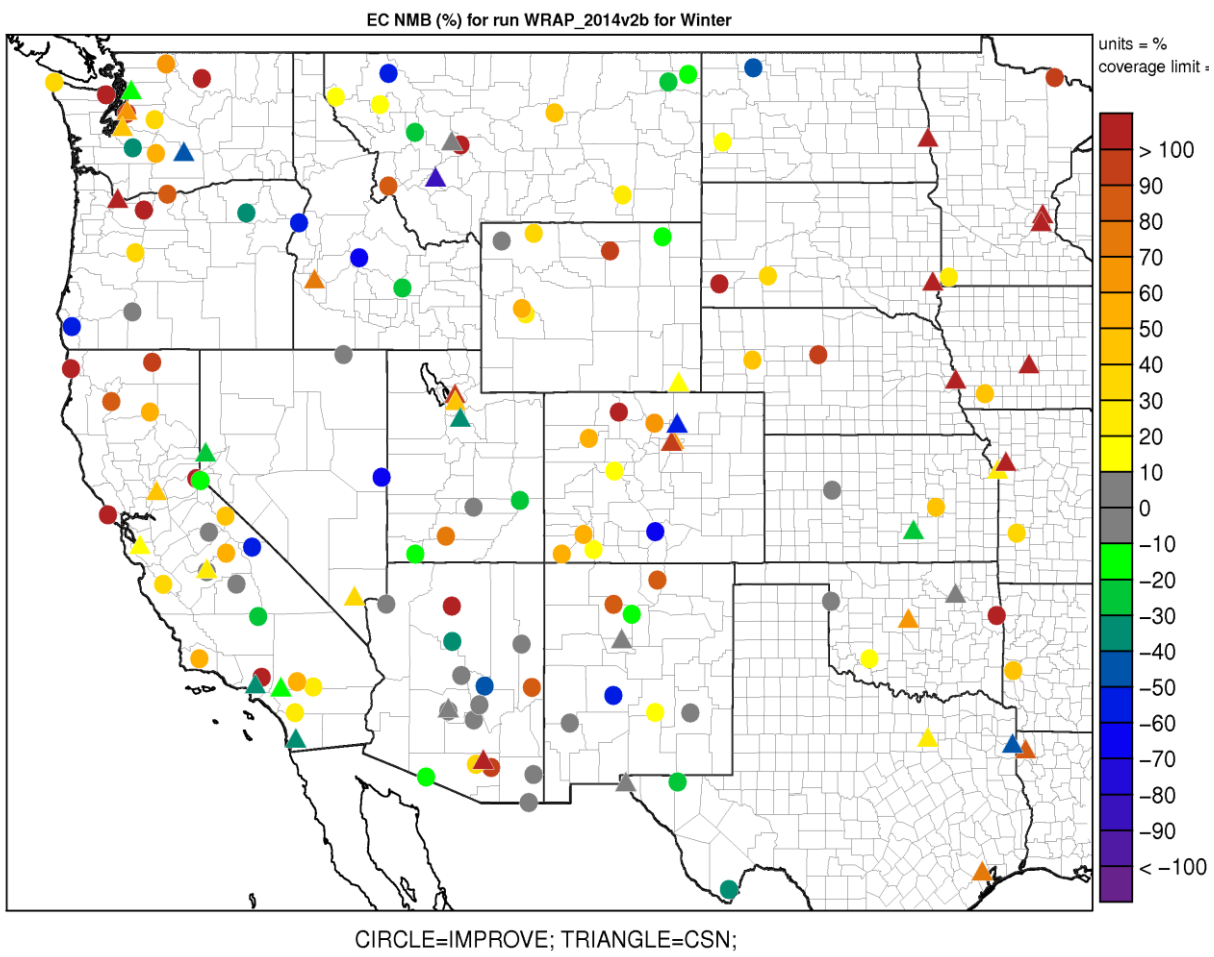


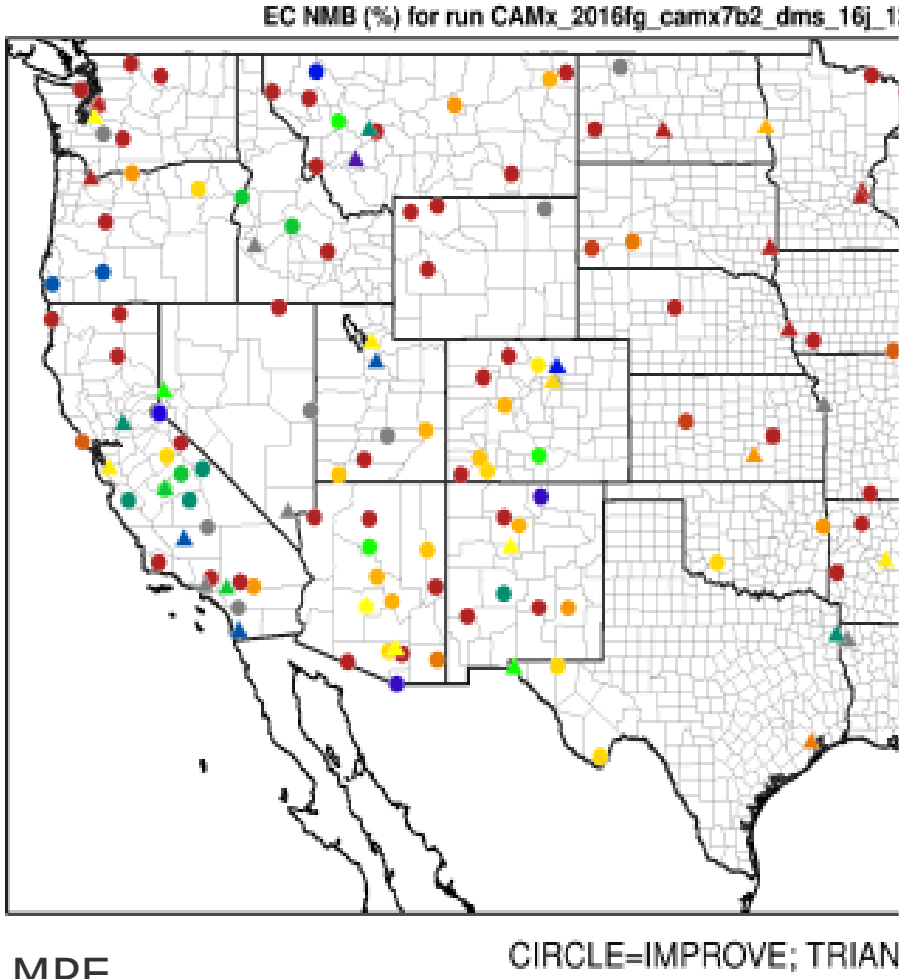






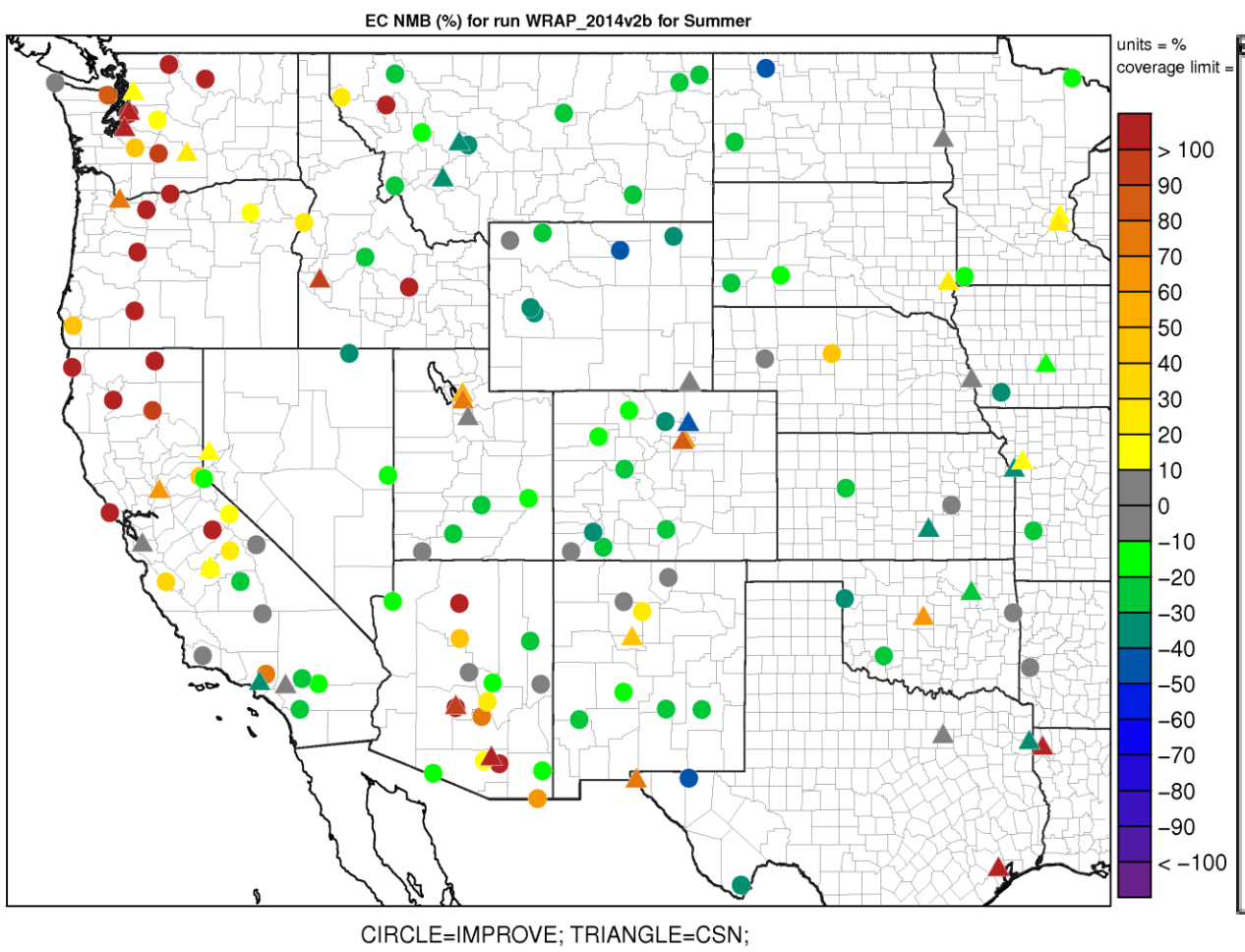
EC NMB Winter -- Spatial Maps of MPE Statistics for WUSA

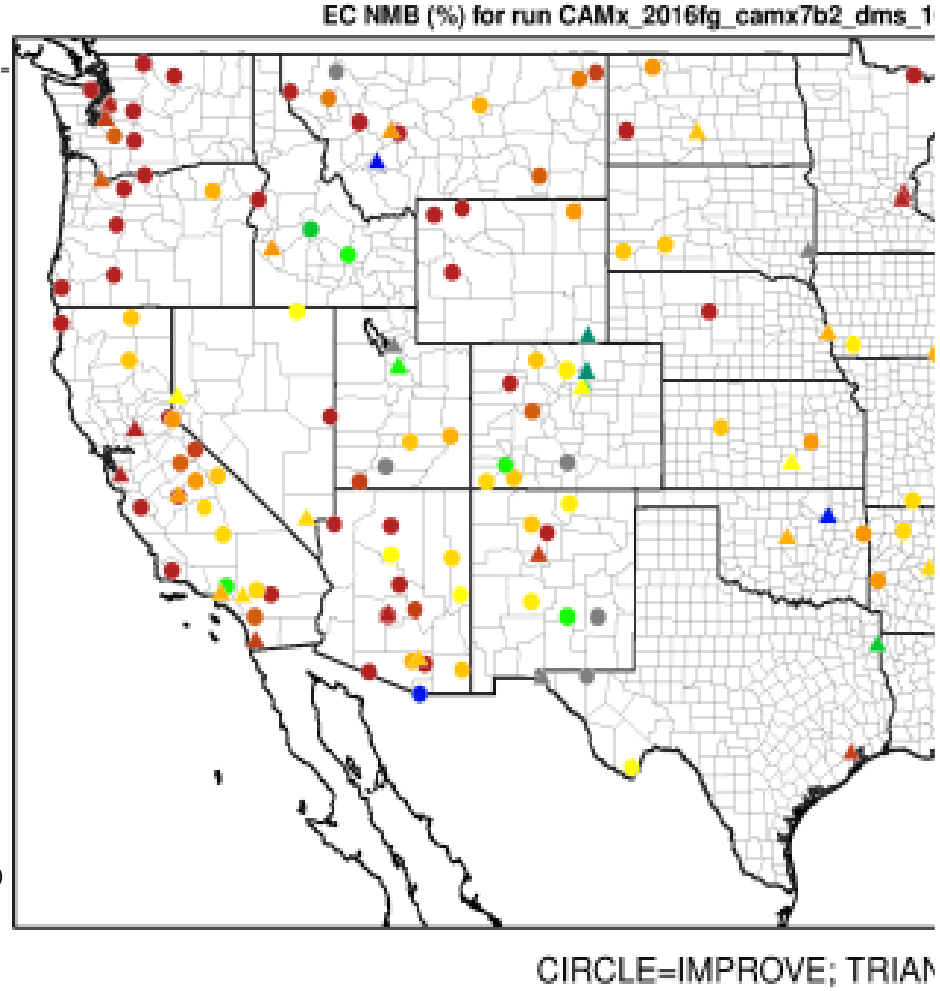




EC NMB MPE
Goal ≤±20%
Criteria ≤±40%

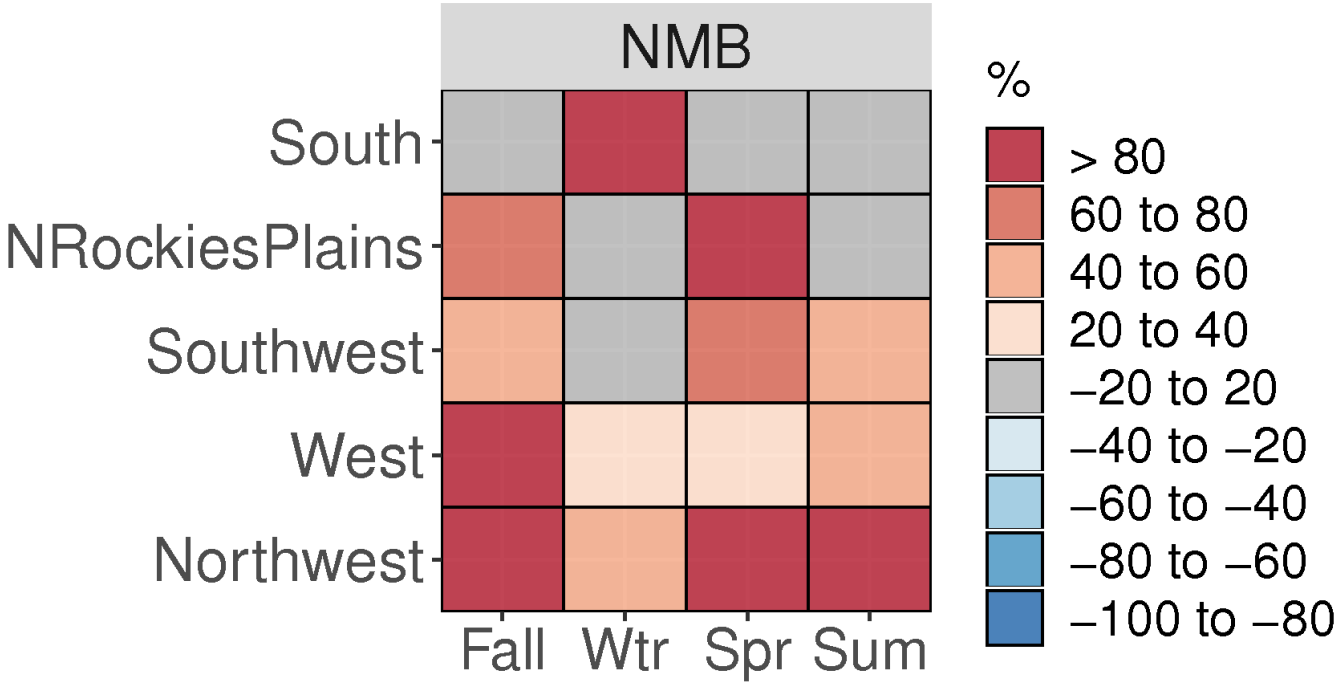
EC NMB Summer -- Spatial Maps of MPE Statistics for WUSA

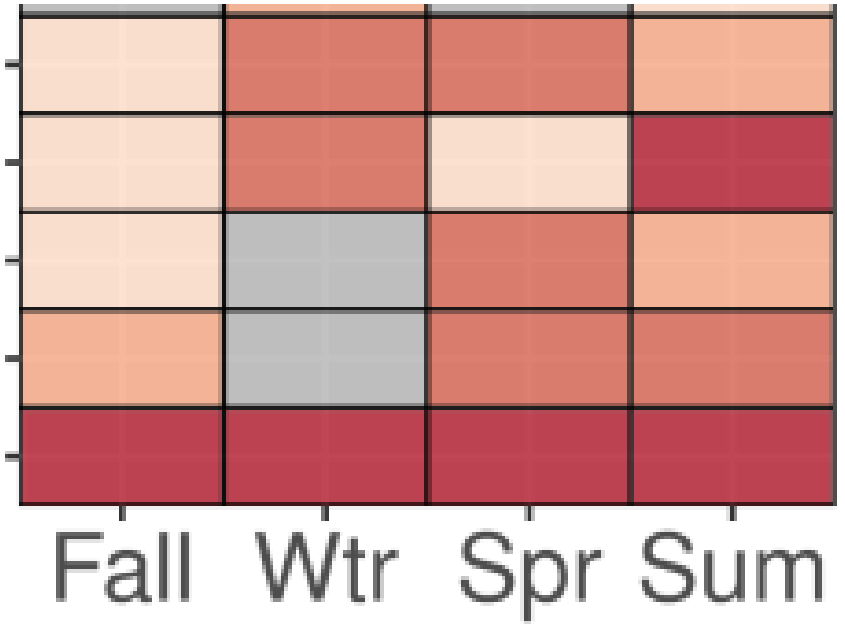




EC NMB MPE
Goal ≤±20%
Criteria ≤±40%

EC NMB Kellygrams -- IMPROVE Regional Model Performance





EC NMB MPE
Goal ≤±20%
Criteria ≤±40%

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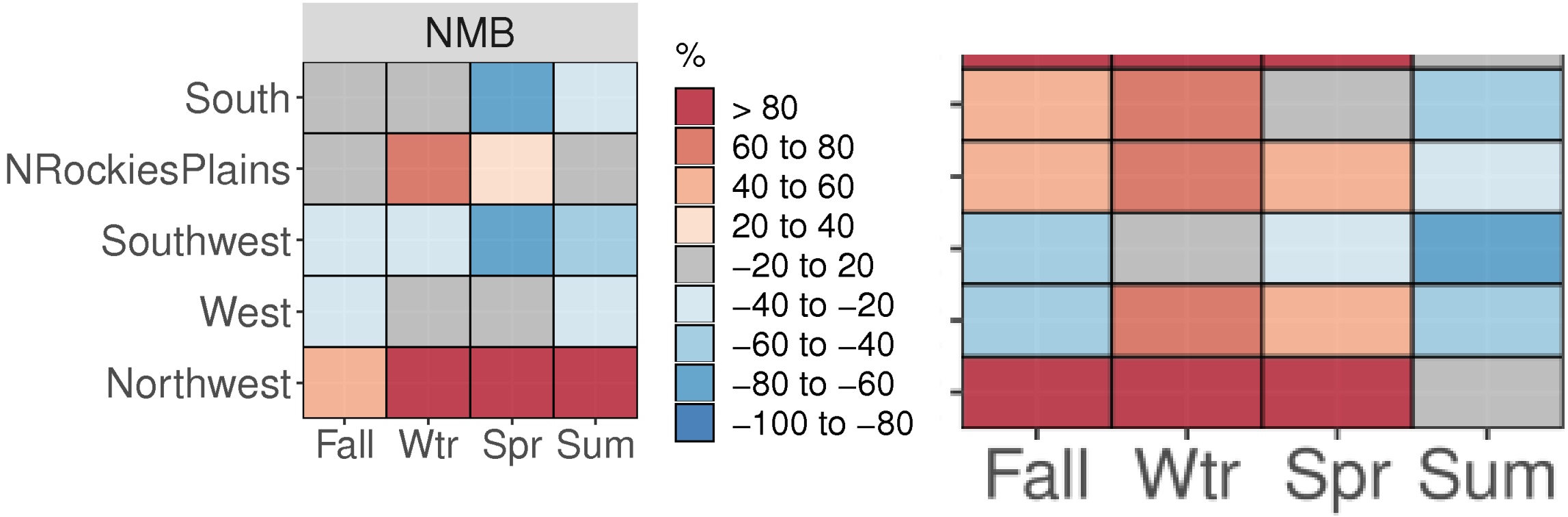
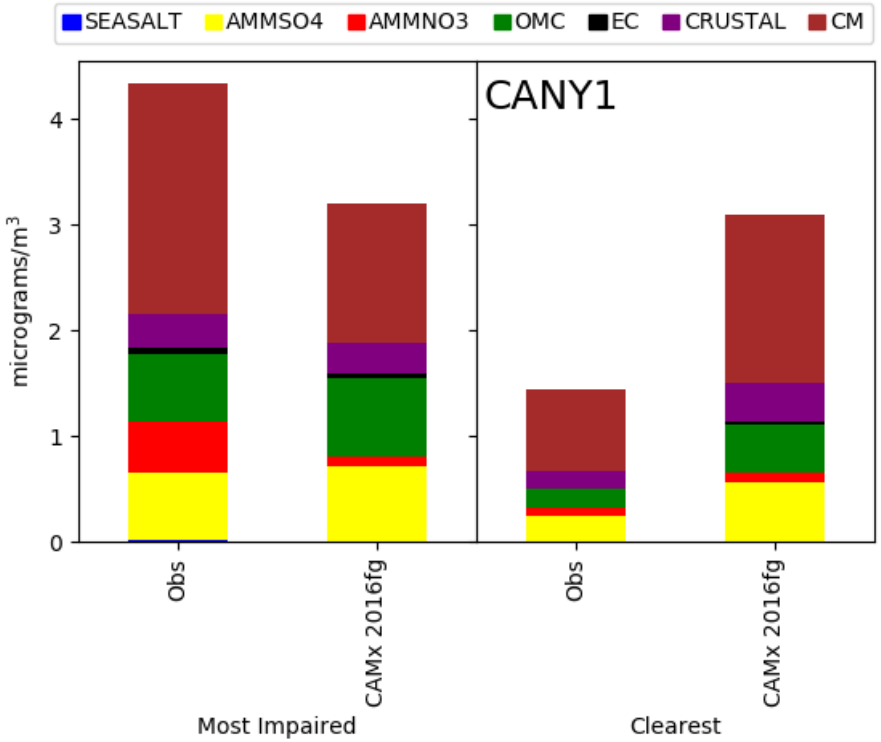
Soil NMB Kellygrams -- IMPROVE Regional Model Performance

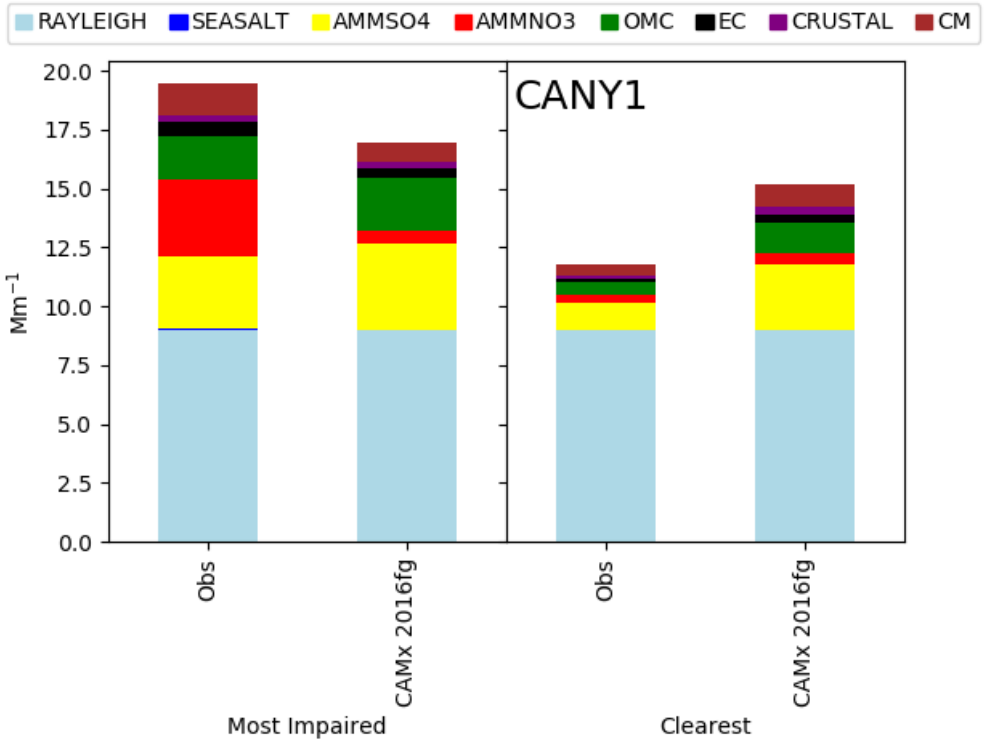


Soil NMB MPE
Goal ≤±??%
Criteria ≤±??%

Next Steps: CAMx 2014v2 Base Case MPE

- Evaluate for IMPROVE 2014 Most Impaired Days (MID) and Clearest Days (B20%)
  - Recent update to IMPROVE data included filling/patching
    - Changed the MID for some sites and years
    - IMPROVE data in AMET is older IMPROVE data
  - Hold off on 2014v2 MPE for MID until get new updated IMPROVE





Next Steps: CAMx 2014v2 Base Case MPE

- Develop CAMx 2014v2 MPE Webpage and post on IWDW
  - Similar to WRAP 2014v1 Shake-Out Study Webpage
  - Describe 2014v2 modeling:
    - Sensitivity tests to segue from 2014v1 to 2014v2
    - CAMx 2014v2 final configuration
    - CAMx 2014v2 MPE approach
  - CAMx 2014v2 MPE products:
    - Example displays
    - Image Browser – TimeSeries, ScatterPlots, SpatialStats, Kellygrams (static .png files)
    - Model-to-Obs Tool – User can make own Pred-Obs time series plots with statistics
    - MID/B20% MPE products

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Current Status – Phase III 2014 Modeling

- CAMx Representative Baseline (RepBase) 2014 Met 36/12-km Simulation Completed
  - Emissions representative of 2014-2018 baseline period
  - Biggest difference are for fires: RepBase from FSWG vs. 2014v2 Actual (Bluesky)
- Finished design of RepBase Source Apportionment Simulation (Task 1.8)
  - Review Run Specification Sheet for RepBase SA Modeling
- Details on design for Task 1.7 Natural (NAT) and No International Anthro (ZROW, Zero-Out Rest of World) simulations
  - 2014 GEOS-Chem NAT and ZROW simulations completed
  - Still some outstanding issues in design of CAMx NAT and ZROW runs:
    - Use RepBase Emissions
    - Assume emissions from CMV C3 Ocean Going Vessels (OGVs) within Emissions Control Area (ECA; i.e., within 200 nautical miles of coastline) are U.S. Anthropogenic emissions so are retained in CAMx ZROW run
    - How to treat NO emissions from anthropogenic sources (i.e., atmospheric deposition and fertilizer application) from BEIS biogenic soil NOx emissions in CAMx NAT run?

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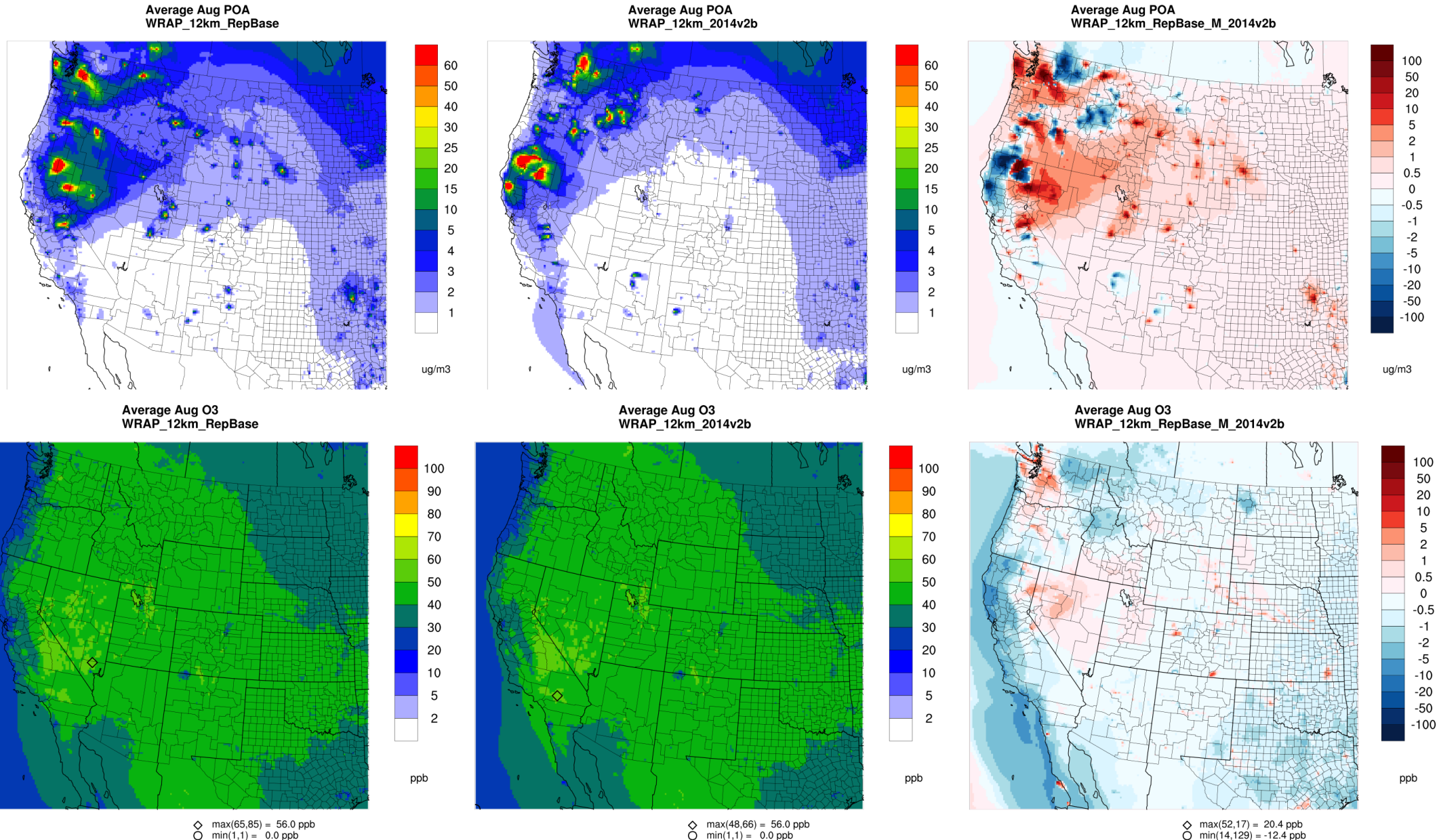
RepBase – 2014v2 Differences: August Average Concentrations



Next Steps: WRAP 2014 Phase IV

- 2002 Dynamic Evaluation -- Ongoing
- 2028 Emissions Modeling -- Ongoing
- 2028 CAMx Modeling – Not started
- 2028 Visibility Projections – Not Started
- 2028 Source Apportionment – Not Started
- IWDW/PGM Verification – About to Start
- AOI/WEP Analysis – On hold while resolve issues with updated IMPROVE data