Testing of AQM V5.1 & Version 8  KFAN bias correction for $O_3$ and PM2.5
July-August 2017

Verification Stats:

Spatial Maps:

03/09/2018
Team

- Jianping Huang, EMC: code design/transition
- Ho-Chun Huang, EMC: wild fire smoke emission development
- Jeff McQueen, ARL: system evaluation, graphics web page support
- Pius Lee, ARL: OAR/ARL team leader, oil/gas emissions development
- Youhua Tang & Daniel Tang, ARL: Emissions development
- Li Pan, ARL/EMC: research system development and testing
- Jim Wilczak, Irina, Djalalova, Dave Allerud, ESRL/PSD: bias correction development
- Ivanka Stajner, Sikchya Udap, NWS/STI: AQ program management
Summary of work performed

• Completed EXP AQM V5.1 testing for July-Aug. 2017; Dec-Present
  – Oil & gas sector emission update to 2017 from NEI 2011
  – Bug correction for Colorado winter VOC emissions

• Completed the O₃ and PM₂.₅ V8 EXP bias correction testing for July 2017 – Feb 2018 with unified ESRL KFAN
  – Corrected from Operational CMAQ V5.0.2
  – V8 w/ Jan. 19 patch for rare events
  – 900 sites
  – V5 training data
  – Use of SW rad for analog selection
Diurnal prod, EXP and EXP bias corrected O₃ forecasts: July 2017

WEST U.S.

EAST U.S.

Exp Unified Bias Correction near perfect
Prod & V5.1: - typical over-prediction East
- under-prediction West
Prod, V5.1, Exp bias corrected \( \text{O}_3 \)

Day 2 Daily Time Series

July 2017

AQM Exp V5.1 raw predictions: small impact
BC: Overpredictions corrected esp over East
CSI skill score: Day 2 8 hr avg O₃
July 2017

Improved Skill mainly over West where many more episodes occurred
- V5.1: Slightly more ozone in W. VA from oil/gas sector updates
July 19  2017 Day 2   8 hr max O3

- BC: no longer overcorrects day 2 max O3
Bias Correction reduces large overpredictions over East
Prod, V5.1, *Exp bias corrected* \( \text{O}_3 \)

8h avg Daily Max Day 2 Hit rate

August, 2017

WEST

EAST

BC: - Improved Skill over West for all thresholds
- Over East only 35 events for code orange
Aug 1, 2017 NAM-CMAQ V5
Day 2  8 hr max O$_3$

- BC: Better Agreement over W. PA & W. VA
- BC: helps correct underprediction over California valleys
- Fire influenced O3 production
1h avg O₃ Diurnal Time Series
Prod and EXP bias corrected
September 2017

WEST

1-h Avg OZON obs (PPB) avged by fcst hrs
20170901 to 20170930
West-US

EAST

1-h Avg OZON obs (PPB) avged by fcst hrs
20170901 to 20170930
East-US

O3 Bias Correction - Near perfect
1h avg O₃ Day 2 Daily Time Series BIAS
Prod and EXP bias corrected

September 2017

WEST

DAY 2 -1 Avg OZON BIAS (PPB) 1500 --> 1200 UTC
West-US

- OPERATIONAL 27 --> 48 hrs BIAS
- Unif-Bias-corrected-V8 27 --> 48 hrs BIAS

EAST

DAY 2 -1 Avg OZON BIAS (PPB) 1500 --> 1200 UTC
East-US

- OPERATIONAL 27 --> 48 hrs BIAS
- Unif-Bias-corrected-V8 27 --> 48 hrs BIAS

O₃ Bias Correction - Improved, similar trend to raw except underprediction in East later in month
8 h avg Daily Max O₃ Day 2 CSI Prod and EXP bias corrected
September 2017

WEST

O3 Bias Correction - Larger improvement for all thresholds esp over West
- BC: helps correct under-prediction over California valleys
- But reduced ozone near fires East of San Francisco
BC: helps correct overprediction over LI and CT coasts and DC area
Raw PM Production vs
PM Operational Bias correction vs
Exp. unified Bias Correction (V8)
Predictions
Large improvement with Exp. Bias correction esp. over East

*Note: Operational bias correction still using old V4 training predictions*
1 h max PM2.5 hit rate
Prod, \textit{Prod bias correction} vs \textit{Exp bias correction}

July 2017

- Large improvement with Exp. Bias correction esp. over West
- \textit{Note: Operational bias correction still using old V4 training predictions}
Montana local maxima not seen in production BC outputs but bullseye pattern weakened by August and later
PM BC: Less of an impact…reduces overprediction near California fires
Improvement with Exp. Bias correction over West compared to prod BC
All BC results are degraded compared to raw predictions over West
- Extensive fires over NW US
Note: Operational bias correction still using old V4 training prediction
1h PM Day 1 Prod vs Exp BC

Daily Time Series

August 2017

Exp Bias correction
- West: - Removes post wild-fire event noise
  - Overcorrects some fire events
- East: Similar to prod BC, some improvement around 8/25/17
1 h max PM2.5 Day 2 CSI
Prod, Prod bias correction vs Exp bias correction
August 2017

Exp Bias correction:
- Significant improvement esp. over West except for highest concentrations
- Degradation for higher PM concentrations over East ??
- Reduced POD (not shown)
• Note: Operational bias correction still using old V4 training predictions
Fire case: some improvement over Washington and Western Montana w/ bias correction
August 14, 2017 Prod vs Bias Correction

1 hr daily MAX PM25 (Day 1)

EXP BC: reduces overcorrection after fire events compared to production BC
August 22, 27 2017 Prod vs V8 EXP BC

1 hr day 1 daily MAX PM25

- V8 PM bias correction can still overcorrect raw PM forecasts
1 h avg PM2.5 Diurnal time series
Prod, Prod bias correction vs Exp bias correction
September 2017

- Improvement with Exp. Bias correction over West during the daytime compared to prod BC
- Best improvement over East with bias correction
- Note: Operational bias correction using old V4 training prediction ??
1 h avg PM2.5 Daily time series

Prod, *Prod bias correction* vs *Exp bias correction*

September 2017

- Improvement with Exp. Bias correction over West compared to prod BC
- Similar results over East
- *Note: Operational bias correction using old V4 training prediction??*
Exp Bias correction:
- Significant improvement esp. over West except for highest concentrations
- Degradation for higher PM concentrations over East ??
- Reduced POD (not shown)

• Note: Operational bias correction still using old V4 training predictions
EXP PM bias correction overcorrects raw forecasts over East OR/West ID (due to night-time overcorrection ?)
September 5 2017 Prod, Prod BC, V8 EXP BC

33 (day) vs 45 hr (night) 1 hr ave PM2.5 forecast

Prod & EXP BC: worse at night during fire event (too much smoke) but more PM & better during day
September 16 2017 Prod, Prod BC, V8 EXP BC

33 (day) vs 45 hr (night) 1 hr ave PM25 forecast

Prod BC best: less PM during fire event for day and night
January 2018 PM25 Performance

Prod, *Prod BC*, vs EXP BC
1 h avg PM2.5 Diurnal Time series

Prod, Prod bias correction vs Exp bias correction

January 2018

- Less PM (improved) over East with experimental bias correction processing

Note: Operational bias correction now using correct V5 training predictions
1h PM  Prod vs Exp BC
Day 2 Daily Time Series
January 2018

Exp: Bias correction
- West: reduces noise seen after high events
- East: Improved over prod BC especially mid-January
1 h max PM2.5 Day 1 hit rate
Prod, Prod bias correction
vs Exp bias correction
January 2018

- Large improvement over raw predictions with Exp. Bias correction mainly over West
  Note: Operational bias correction using V5 training predictions but less sites, not using SW radiation for analog identification and w/o rare event patch (may explain degradation over East)
Bias correction better captures stagnation episode in Central Valley
Bias correction over-corrects stagnation episode over NE US
But better prediction for Jan. 22
Why was this case missed?
Raw vs Bias Correction PM
Day 2 daily MAX 1hr PM25
January 28, 2018 NE high pm event

Significant improvement with Bias correction
### Results

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<th>July</th>
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- **Ozone BC**: Largest improvement over West where ozone is underpredicted
- **PM EXP BC**:  
  - Largest improvement over East for July/Jan  
  - Degradation from raw prod over West Aug (fires)
Summary

• **Ozone Bias Correction:** Large improvement without degrading exceedence cases in Summer

• **Summer PM bias correction:**
  – Overall improvement statistically correcting raw model over-predictions (still too much PM near fires at night)
  – Still some overcorrection during fire events but improvements after high PM events
  – Local PM maxima for several cases in July (12th-15th) for one site in Eastern Montana (Not as evident from August onward)

• **Winter PM bias correction:**
  – Improved over west with bias correction but still mixed for some stagnation episodes over North East
Winter Colorado Ozone Plume
Day 1 daily MAX 8hr Ozone
February 23, 2018

CO ozone plume still too strong but improved with VOC ratio updates to oil/gas sector emissions.
Web pages
AQM V5.1

• Real-time prod vs prod BC runs (July 2016-Present)

• Prod vs para pm/ozone BC
  • July, Aug, Sept 2017, Jan. 2018, Mar->present

• Verification statistics (prod vs parabc for pm/ozone
  • Jul 2017-Feb 2018
BACKUPS
August 2017 Prod vs Bias Correction PM

1 hr day 1 daily MAX PM25

- Fire cases: persistent local max in western MT but overall improvements
Ozone Errors: July 2017
Obs vs Raw vs Bias Corrected

East: Overprediction overall but underprediction for July 10-12 exceedences
West: Continued underprediction

O3 BIAS CORRECTION:
→ Diurnal performance good, overcorrects some events (July 10-12, 18-21)
July 12, 2017 NAM-CMAQ V5 Performance

- Continued less ozone predicted for day 2
- O3 Bias correction improved over LI

Bias Corrected 8h Ozone Max: Day 2

8h Ozone Max: Day 1 Mdl-Obs
July NAM-CMAQ V5 Performance

- Continued less ozone predicted for day 2
- BC: Overcorrected in Sacramento & Ohio Valleys