Adjusting Numerical Model Data in Real Time: AQMOS

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Introduction

What: The Air Quality Model Output Statistics (AQMOS) forecasting tool provides air quality model predictions adjusted in real time.

Why: Gridded numerical weather and air quality models have some errors in their predictions.

How: AQMOS uses regression equations to correct for air quality model errors.

AQMOS is
- Automated
- Dynamically updated after each model run
- City-, pollutant-, and model-specific
How AQMOS Works

• AQMOS calculates regression equations from recent air quality observations and numerical model predictions.

• The forecasting tool applies these equations to the current numerical model predictions.

Many days of observed and predicted data

\[ \text{AQMOS} = \text{Numerical model prediction} \times (\text{correlation factor} + \text{constant}) \]

(4-step process)
AQMOS Data Sources

- Air quality observations from
  - Peak daily 8-hr ozone
  - Daily 24-hr PM$_{2.5}$
- Model data
  - NOAA Air Quality Forecast Guidance (6Z and 12Z)
  - BlueSky Gateway Experimental CMAQ (0Z)
Step 1 – Acquire Data

**Observations:** peak 8-hr ozone and 24-hr PM$_{2.5}$ concentrations

- **AQMOS Observations:**
  - Peak 8-hr ozone: 57 ppb
  - 24-hr PM$_{2.5}$: 15 µg/m$^3$

**Predictions:** peak next-day ozone and PM$_{2.5}$ forecasts

- **AQMOS Predictions:**
  - Peak next-day ozone: 53 ppb
  - PM$_{2.5}$ forecast: 13 µg/m$^3$

Extract maximum predicted concentration in the area.
Step 2 – Separate Data by Season

- AQMOS uses data for the past 180 days from the same season.
- Seasons
  - Warm: April through October
  - Cool: November through March
Step 3 – Calculate Regression

- Match recent forecasts (within the last year) with observations.
- Regressions for high prediction days are calculated using previous high prediction days.
- Threshold between low and high prediction days is determined by the distribution of data at a given forecast city.

![NOAA 6Z 8-hour Ozone - Dallas](image)

Top 15% threshold (88 ppb for Dallas)
Step 4 – Compute Each Day

AQMOS bias corrections are calculated for

• All NOAA and BlueSky model runs
• Same-day and next-day forecasts
• Ozone and PM$_{2.5}$
• Predictions for all cities in the United States AIRNow system
AQMOS Website (1 of 2)

Original NOAA forecast in AQI

AQMOS prediction = current model prediction \times \text{slope} + \text{constant}

62.8 ppb = 89.0 ppb \times 0.73 + (-2.36 \text{ ppb})

NOAA prediction: 89.0 ppb
AQMOS prediction: 62.8 ppb
Verification: 60.0 ppb
AQMOS Performance

AQMOS Improvement (ppb)

- >-4 and ≤-2
- >-2 and ≤0
- >0 and ≤2
- >2 and ≤4
- >4 and ≤6
- >6 and ≤8
- >8 and ≤10
- >10 and ≤12
- >12 and ≤14
- >14 and ≤16
- >16 and ≤18

Improvement = \( \text{avg (abs (raw model – observed))} - \text{avg (abs (AQMOS – observed))} \)
AQMOS Performance (2 of 5)

AQMOS Improvement (µg/m³)

- >-2 and ≤0
- >0 and ≤2
- >2 and ≤4
- >4 and ≤6
- >6 and ≤8

BlueSky Gateway 0Z Next-Day PM₂.₅
April 1-October 31, 2009

Improvement = \( \text{avg (abs (raw model – observed))} - \text{avg (abs (AQMOS – observed))} \)
AQMOS Performance (3 of 5)

Days on which either observed or model-predicted air quality was high

- **Green** – forecast improved on at least 75% of these days
- **Yellow** – forecast improved on 50-75% of these days
- **Red** – forecast improved on fewer than 50% of these days

<table>
<thead>
<tr>
<th>City</th>
<th>NOAA 6Z Ozone</th>
<th>NOAA 12Z Ozone</th>
<th>BlueSky 0Z PM$_{2.5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta</td>
<td>92%</td>
<td>90%</td>
<td>33%</td>
</tr>
<tr>
<td>Houston</td>
<td>50%</td>
<td>50%</td>
<td>67%</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>82%</td>
<td>67%</td>
<td>100%</td>
</tr>
<tr>
<td>Sacramento</td>
<td>76%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>St. Louis</td>
<td>63%</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>Salt Lake City</td>
<td>60%</td>
<td>38%</td>
<td>----</td>
</tr>
</tbody>
</table>
AQMOS Performance (4 of 5)

Atlanta Next-Day 6Z NOAA Ozone Model
April 1-October 31, 2009

\[ y = 1.3404x \]
\[ R^2 = 0.2704 \]

\[ y = 0.965x \]
\[ R^2 = -0.0223 \]
AQMOS Performance (5 of 5)

Salt Lake City Next-Day 6Z NOAA Ozone Model
April 1-October 31, 2009

$y = 0.9689x$
$R^2 = 0.2133$

Observed ozone (ppb)
Predicted ozone (ppb)

Model
Linear (Model)
Linear (AQMOS)
Summary

• On most days, AQMOS shows improvement over the raw model output in predicting air quality for specific cities.
• AQMOS showed improvement on at least 50% of critical days in the six cities evaluated.

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