Linking Eta to CMAQ for AQ Forecasting

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Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.
### Practical and Technical Differences (1)

<table>
<thead>
<tr>
<th><strong>Eta</strong></th>
<th><strong>CMAQ</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>60 layers</td>
<td>fewer (~22) layers</td>
</tr>
<tr>
<td>step-mountain vert.</td>
<td>terrain-following vert.</td>
</tr>
<tr>
<td>continental</td>
<td>northeast U.S.</td>
</tr>
<tr>
<td>rotated lat-lon</td>
<td>Lambert Conformal</td>
</tr>
<tr>
<td>Arakawa-E</td>
<td>Arakawa-C</td>
</tr>
<tr>
<td>$P_{TOP} = 25 \text{ hPa}$</td>
<td>$P_{TOP} = 100 \text{ hPa}$</td>
</tr>
</tbody>
</table>
## Practical and Technical Differences (2)

<table>
<thead>
<tr>
<th></th>
<th>Eta</th>
<th>CMAQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-h output</td>
<td></td>
<td>1-h input</td>
</tr>
<tr>
<td>GRIB</td>
<td></td>
<td>I/O API (netCDF)</td>
</tr>
<tr>
<td>pressure-level output</td>
<td></td>
<td>terrain-following input</td>
</tr>
<tr>
<td>operational timelines</td>
<td></td>
<td>research environment</td>
</tr>
<tr>
<td>never linked to AQM</td>
<td></td>
<td>set up for MM5</td>
</tr>
<tr>
<td>one-shot simulation</td>
<td></td>
<td>adjust met as needed</td>
</tr>
</tbody>
</table>
Used by: MM5

Used by: Eta, NMM

Used by: CMAQ, RAMS
Technical Questions...

- Impact of multiple interpolations (horizontal and vertical structures) on mass conservation?
- Forecast model adequate input for CMAQ?
- Absence of FDDA through simulation?
- Handling different prognostic variables?
- CMAQ only “tuned” for MM5?
Why not use available Eta???

- Eta output processed at 3-h intervals for public
- Eta output generally available on pressure levels
- Several variables required for CMAQ not routinely available (e.g., PBL height, variables required for dry deposition velocity calculations)

- Thus...new software NOT “MCIP”
Eta-CMAQ AQF System

- Eta-12
- Eta Post
- PRDGEN
- PREMAQ
- CMAQ
- NetCDF to GRIB
- Verification Tools

Primary Components

- Modified by NOAA for AQF
- Developed by EPA for AQF
- Developed by NOAA for AQF

Modified by NOAA for AQF
Developed by EPA for AQF
Developed by NOAA for AQF
Changes to Eta at NCEP for AQF

- Hourly Eta output
- Hydrostatic $\sigma$-P structure to 100 hPa
- Additional forecast variables (PBL height, canopy conductance, plant canopy water, $K_h$, ...)
- New GRIB grids for AQF
**Forecast Timeline**

Day 1

- 48-hour CMAQ forecast required based on 12Z initialization to get desired 24-hour forecast period
- 24-hour CMAQ forecast for next day 04Z to 04Z (local midnight on East Coast)
- Extra 8 hours for 8-h avg O3
- Products by 1730Z

Day 2

- 30-hour CMAQ forecast required based on 06Z initialization to update current day forecast
- Update to CMAQ forecast for current day 06Z to 04Z (local midnight on East Coast)
- Extra 8 hours for 8-h avg O3
- Products by 1300Z
AQF Operational Timeline

Day 1: Forecast for Day 2

Day 2: Update Forecast for Day 2

Day 2: Forecast for Day 3

Day 3: Update Forecast for Day 3
Northeast U.S. Forecast Domain
AQF System Components

- **Eta Post**: Creates diagnostic variables and performs vertical interpolations from Eta to sigma
- **PRDGEN**: Performs horizontal interpolations to intermediate (Arakawa-A) grid
- **PREMAQ**: Uses Eta output to generate CMAQ-ready meteorology and emissions fields
- **NetCDF to GRIB**: Creates $O_3$ fields for users
Linking Eta to CMAQ: NCEP Software

- **Vertical interpolation – Eta Post**
  - Interpolates Eta output to 22 $\sigma$ layers for CMAQ
    - ~12 layers below 2 km AGL
    - Lowest layer thickness ~39 m

- **Horizontal interpolation – PRDGEN**
  - Uses bi-linear interpolation and nearest neighbor
  - Interpolates to Arakawa-A, Lambert conformal grid for CMAQ model in Northeast U.S. domain
PREMAQ (Pre-processor for CMAQ)

- Equivalent to MCIP processor in standard CMAQ model system
- Places interpolated Eta data into required CMAQ variable structure
- Computes needed derived variables for CMAQ (e.g., air density, deposition velocity)
- New: calculates meteorologically-dependent emissions for CMAQ (biogenic, mobile source)
New in PREMAQ (vs. MCIP)

- GRIB reader (2-D slices vs. full 3-D fields, Arakawa-A)
- Grid geometry calculations
  - Different method of defining grids in GRIB
  - GRIB precision insufficient for lat/lon
- Modifications to use different suite of variables
- New dry deposition routine
- Streamlined to reduce extraneous output
- Meteorology-dependent emissions included
Emissions for AQF

Point Sources
Pre-computed temporal emissions factors with met-dependent plume rise effects calculated each hour

Area Sources
Pre-computed for each day of year

Mobile Sources
Pre-computed emissions factors from MOBILE 5b with hourly temperature-dependent effects

Biogenic Sources
BEIS-3 using Eta temperature and radiation