In the 2014 Quarter 4 scheduled upgrade for AQM, although the coupling paradigm between NAM and CMAQ and the meteorological remain unchanged, there are improvements in both the input and modeling system. First and foremost the CMAQ model will be upgraded from version 4.5 to the standard EPA CMAQ version 4.6.0. The main added features are shown in Table 3. For NAQFC application it was further upgrade to a NWS in-house CMAQ version 4.6.3 (See Table 4).This is a quantum leap of including aerosol phase constituents as part of the NAQFC forecast. This is not a new challenge as the experimental version of NAQFC has been testing the aerosol forecast for a few years [available at <http://www.emc.ncep.noaa.gov/mmb/aq/dev/web/html>]. And for its accompanying O3 forecast at <http://airquality.weather.gov/expr/>]. There are also specific features devised for NAQFC that are not standard option in the EPA official version of CMAQ (See Table 4).

Table 3. Major new features when CMAQ was upgraded from version 4.5 to 4.6.0

|  |  |  |  |
| --- | --- | --- | --- |
|  | module | description | remarks |
| Gas chemistry | CB05 | 51 species with 156 reactions, Sarwar et al., 2006 | Linked to aero4 |
| Atmospheric Aerosol  | aero4 | Represent size distribution by log normal distributions of φ, geometric diameter of the particles: Aitken (φ <0.1 μm), accumulation (0.1<φ <2.5μm) and coarse (2.5<φ <10μm). New particle formation: gas conversion and nucleation. | Binkowski and Shankar 1995 |
| Heterogeneous | N2O5 | Heterogeneous hydrolysis reaction of N2O5 is key linkage between gas and aerosol phase reactions | Added temperature and humidity dependences |
| Gas/particulate partitioning | ISORROPIA | Partitioning between inorganic gas and particulate species due to thermodynamic equilibrium | Version 1.7 has updates for numeric stability |

Table 4. Processes and modules added to NAQFC – the so-called NWS CMAQ version 4.6.3

|  |  |  |  |
| --- | --- | --- | --- |
|  | module | description | remarks |
| Time Step | advection | Layer specific time step was added to speed up code | Cut tens of % clock time |
| Shorten NTR | chem | NTR, organic nitrate, biases high and influenced ozone production. It should be photolyzed and be removed quicker (Dickerson et al., 2014) | After Russ Dickerson et al., 2014 shorten NTR life time by a factor of 10. |
| Reduce fugitive dust | Binary on/off  | Modulate fugitive dust emission with a binary switch: whenever there is ice/snow suppress emission  |  |
| Include “real-time” fire | NESDIS’ HMS | Incorporate NESIDS Hazard Mapping System “observed” wild fire |  |

Emission:

For the 2014 NAQFC experimental forecast over the Continental United States (U.S.), the major updates include incorporating new point source measurement data and energy projection for SO2 and NOx.

* **Point sources**: The 2005 National Emissions Inventory Version 1 (NEI05v1) is used as the base year for the Electric Generating Unit (EGU) and non-EGU point sources in the U.S. In Mexico, the 1999 Mexico National Emissions Inventory Version 2.2 used for six boarder states in Northern Mexico, and the Mexico NEI Version 1 was used for interior states. NOx and SO2 emissions from US EGU sources were upgraded with the 2012 Continuous Emission Monitoring (CEM) data. Using the Annual Energy Outlook (AEO) from the Department of Energy released in January of 2012, we projected, on a regional basis, the EGU emissions to the year 2014 using the ratios of 2014 to 2012 emissions taken from the AEO.
* **Area and non-road sources**: Area, except off-road, source emissions use the same emission inventories as in FY2011. The EPA 2005 NEIv1 is used for the U.S. sources, and the 1999 Mexico National Emissions Inventories used for Mexico. The US off-road emissions in the 2005 NEI are replaced with the 2012cs emission data prepared for the Cross-State Air Pollution Rule (CSAPR). These inventory data were processed using SMOKE to represent monthly, weekly, daily and holiday/non-holiday variations that are specific for each year. Emissions from wildfires, prescribed burning, and land clearing are removed from the area source emissions, based on observations of artificial biases introduced by this assumed recurring emissions, which is often not the case.
* **Mobile source emissions**: To reflect the recent change in mobile source emissions, the OTAQ 2005 on-road emission inventory is adjusted using the 2005 to 2012 projection from the CSAPR to generate on-road mobile emissions over the U.S. Again, the time-activity pattern counts for monthly, week/weekend, and diurnal variability of different vehicle types. The 1999 Mexico National Emissions Inventories was used for Mexico.
* **For biogenic sources**, all inputs used in the forecast system were updated to the Biogenic Emission Inventory System (BEIS) version 3.13.
* **Canadian sources**. All area, mobile and point emissions from Canadian sources use 2006 Environment Canada Inventories.
* **Chemistry**. All emission sectors are processed to meet the requirements of the CMAQ CB5 gas and aero4 aerosol chemistry mechanism.

Sarwar, G., D. Luecken, G.Yarwood, G. Whitten, and W. P.L. Carter, 2006.

 Impact of an Updated Carbon Bond Mechanism on Predictions from the

 Community Multiscale Air Quality Model, submitted to the Journal of

 Applied Meteorology and Climatology.