

Continuous, Near Real-Time Application and Evaluation of the Community Multiscale Air Quality (CMAQ) Model

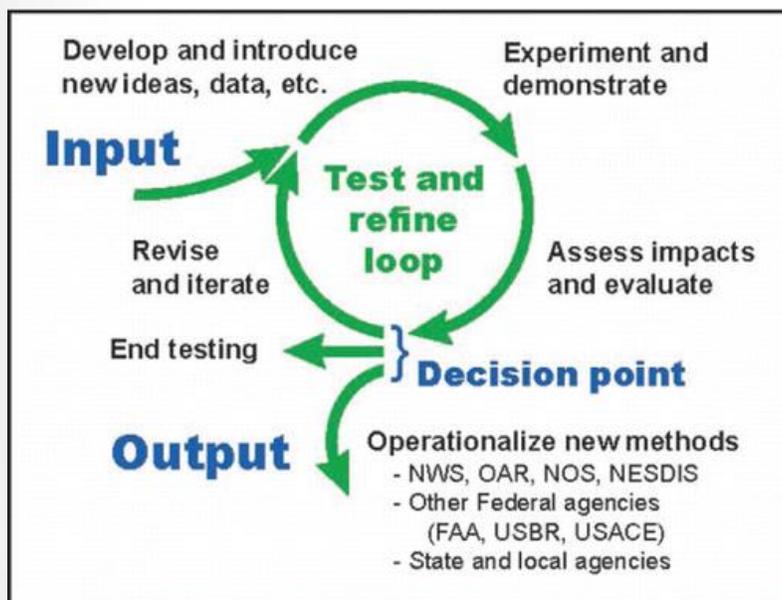
Brian Eder
Robert Gilliam
George Pouliot
Rohit Mathur

Atmospheric Modeling and Analysis Division
National Exposure Research Lab
Office of Research and Development
U.S. Environmental Protection Agency

Research Triangle Park, NC 27711

Historically, AMAD has evaluated retrospective, often annual length, simulations of CMAQ, summarizing the performance using monthly or seasonal statistical summaries.

While informative, such an approach often masks finer scale temporal (i.e., diurnal to weekly) and spatial (meso to synoptic) variability that greatly impacts the atmosphere and hence air quality.



In order to maintain CMAQ’s state-of-the-science status as well as its ability to address emerging Agency needs, it is crucial that newer evaluation approaches are utilized that will allow for more rapid testing and hence more efficient evolution of the modeling system’s science.

Conceptual schematic of the test bed process for a hypothetical project, tool, or concept—including innovation, demonstration, evaluation, and, where suitable, a transition to operations within a federal, state, or local organization.

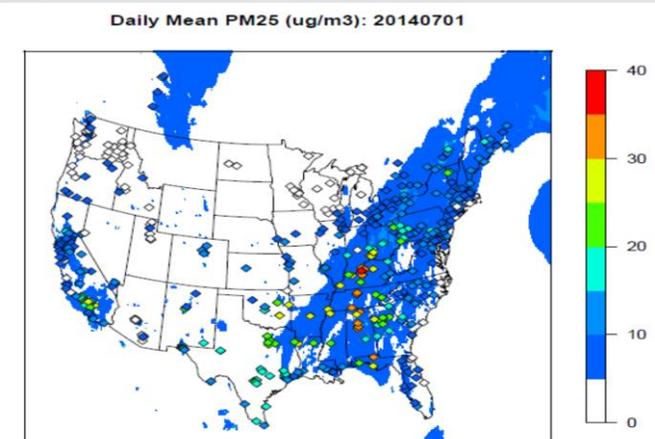
The Emergence of Weather-Related Test Beds Linking Research and Forecasting Operations. *Bull. Amer. Meteor. Soc.*, **94**, 1187–1211. ©American Meteorological Society. Used with permission.

Accordingly, the Division began running CMAQ continuously and in near real-time in 2013, allowing for immediate and ongoing analysis at finer spatial and temporal scales, thereby facilitating model evaluation of **PM_{2.5} mass** and **O₃ concentration**.

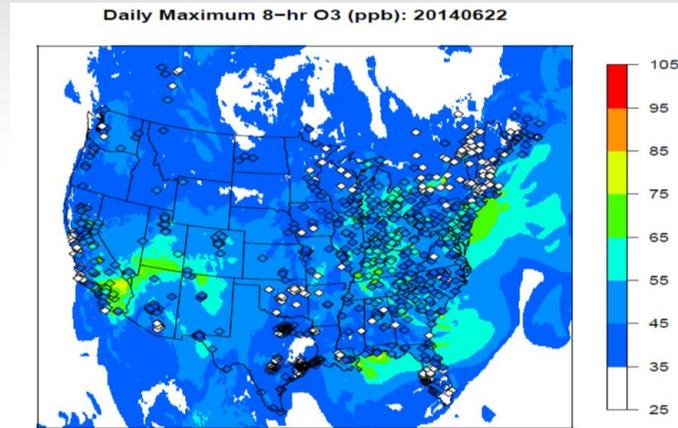
Results from the simulations are examined and discussed by Division scientists in bi-weekly meetings while antecedent meteorological and air quality conditions remain familiar. Advantages of running CMAQ in near real-time are numerous, the simulations:

have led to improvements in characterizing lateral boundary conditions, planetary boundary conditions, lake temperatures and episodic emission events, both natural (i.e. wildfires) and anthropogenic (i.e., residential wood burning);

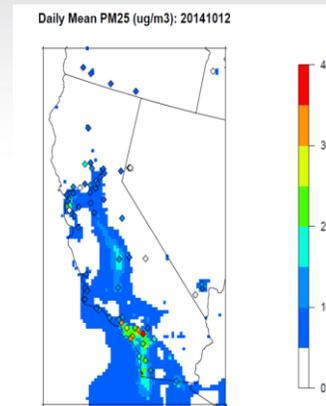
Additionally, output from these simulations is being archived and has been made available for immediate dissemination to scientists across EPA and external agencies.



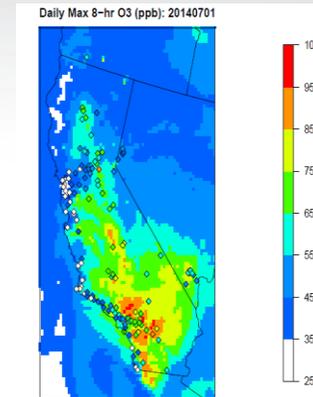
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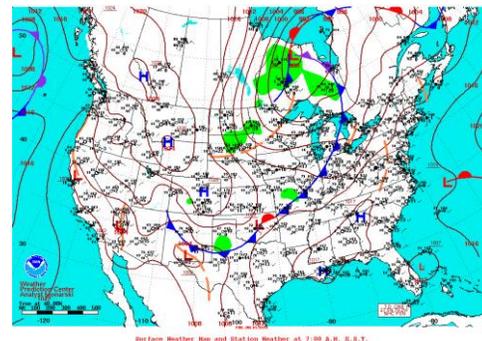
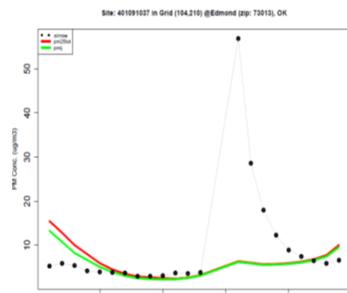
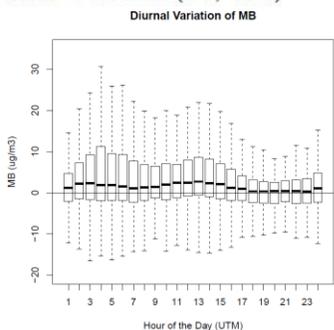
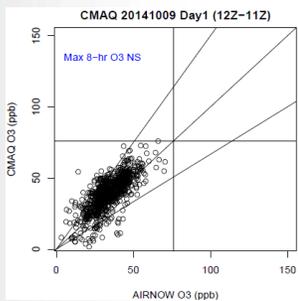
Domain size: 299x459, Max=139.3 at (54, 182)



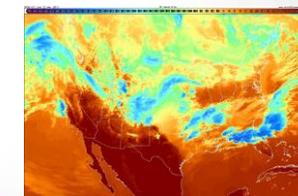
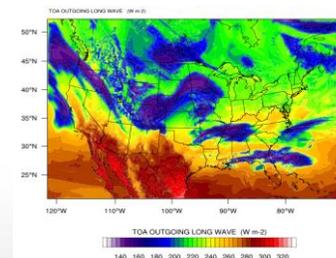
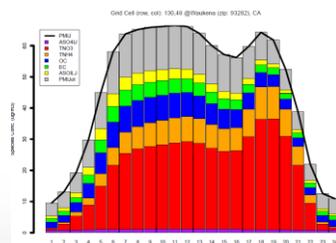
w (84, 199), col (22, 88), Max=46.4 at (94, 89)



v (84, 199), col (22, 88), Max=104 at (140, 132)



O ₃	N	Obs Mean	Model Mean	RMSE ppb	NME (%)	MB ppb	NMB (%)	r
		868	34.5	39.2	9.3	21.3	4.6	13.5
PM _{2.5}	N	Obs Mean	Model Mean	RMSE $\mu\text{g m}^{-3}$	NME (%)	MB ($\mu\text{g m}^{-3}$)	NMB (%)	r
		450	7.4	10.5	8.3	66.9	3.1	41.7



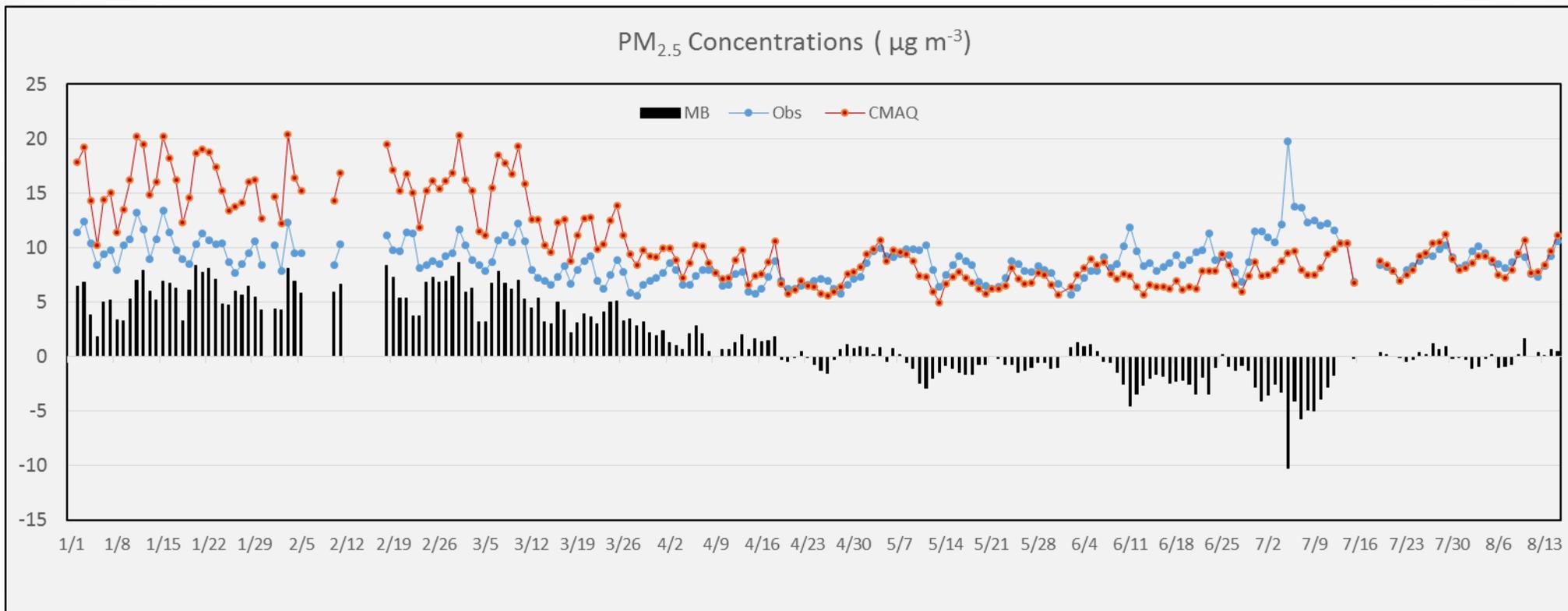
Select highlights to be shown:

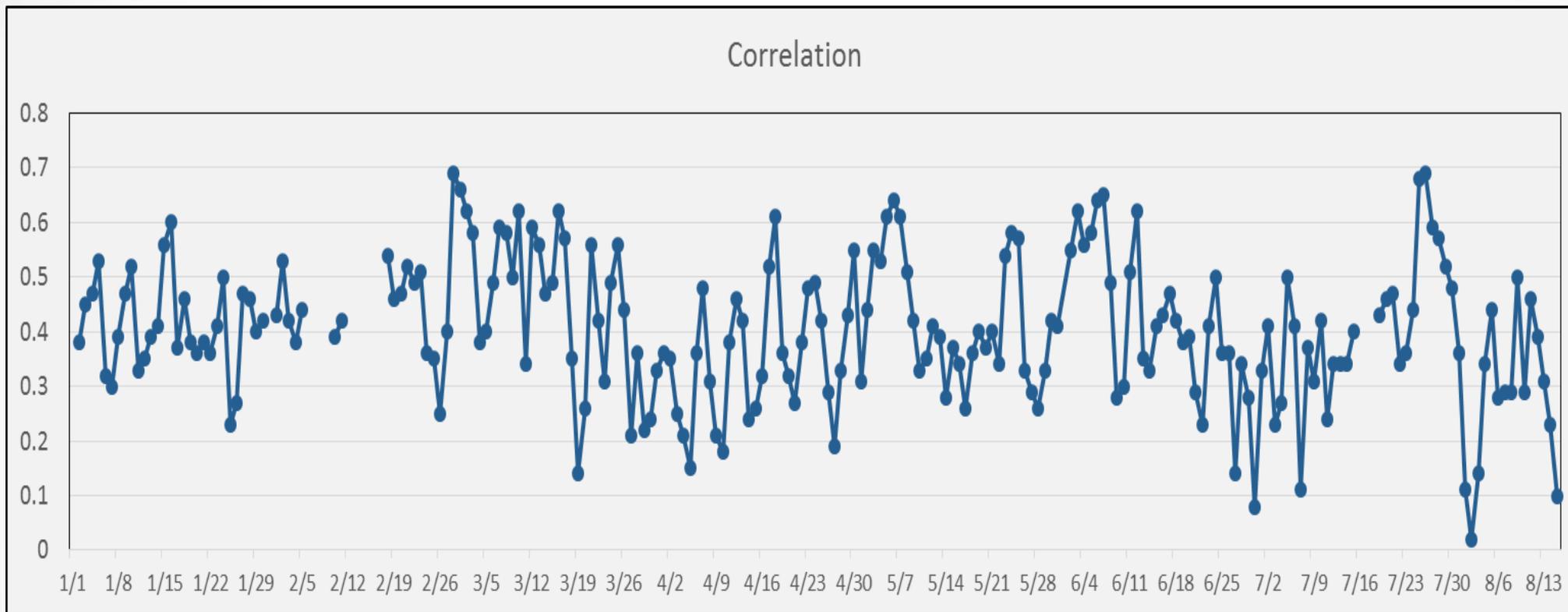
PM_{2.5} errors/biases:

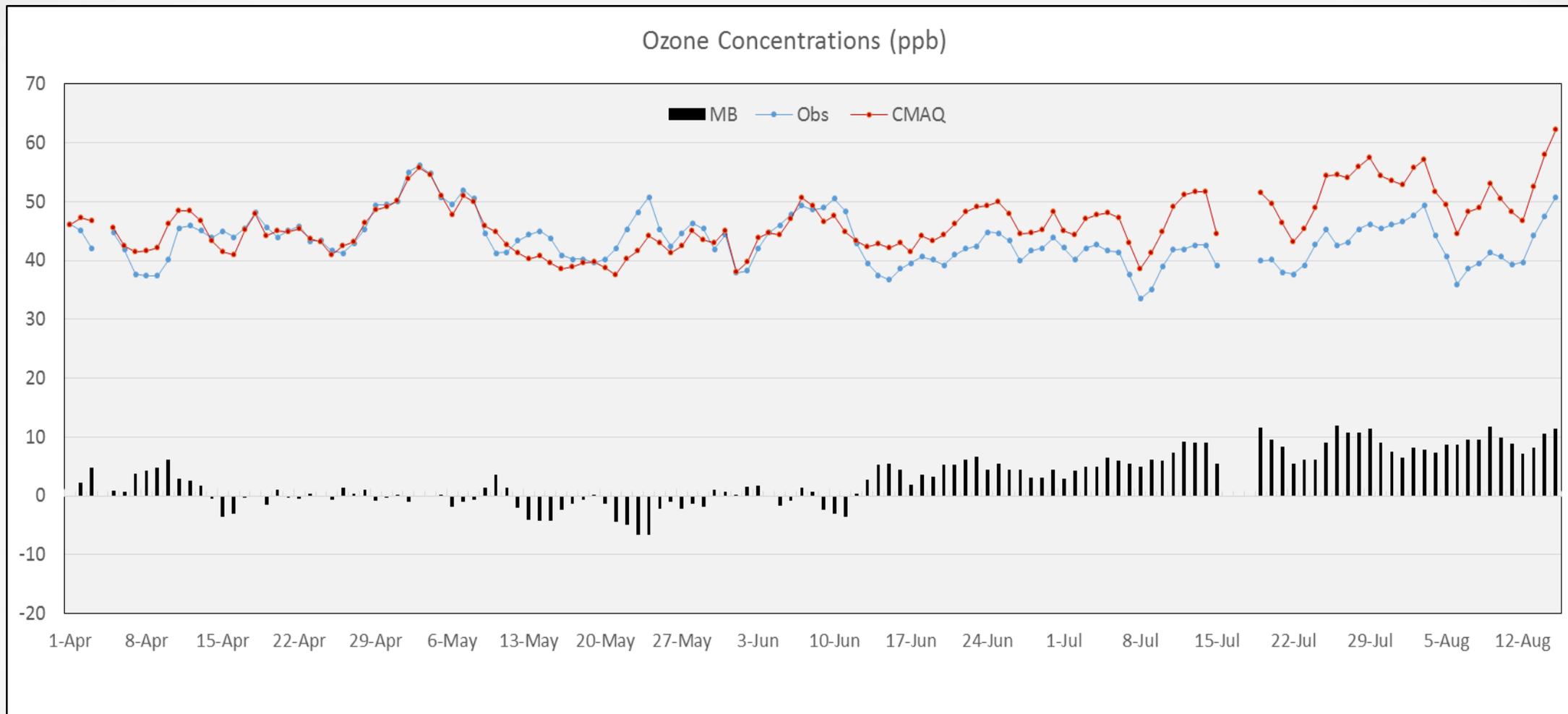
- associated with Midwest NH₃ emissions which were later ameliorated via scientific improvements of bi-directional NH₃ exchange;
- associated with outdated emissions and unrealistic residential wood burning in major metropolitan areas;
- related to unrealistic lateral boundary conditions; agricultural burning and forest fire emission.

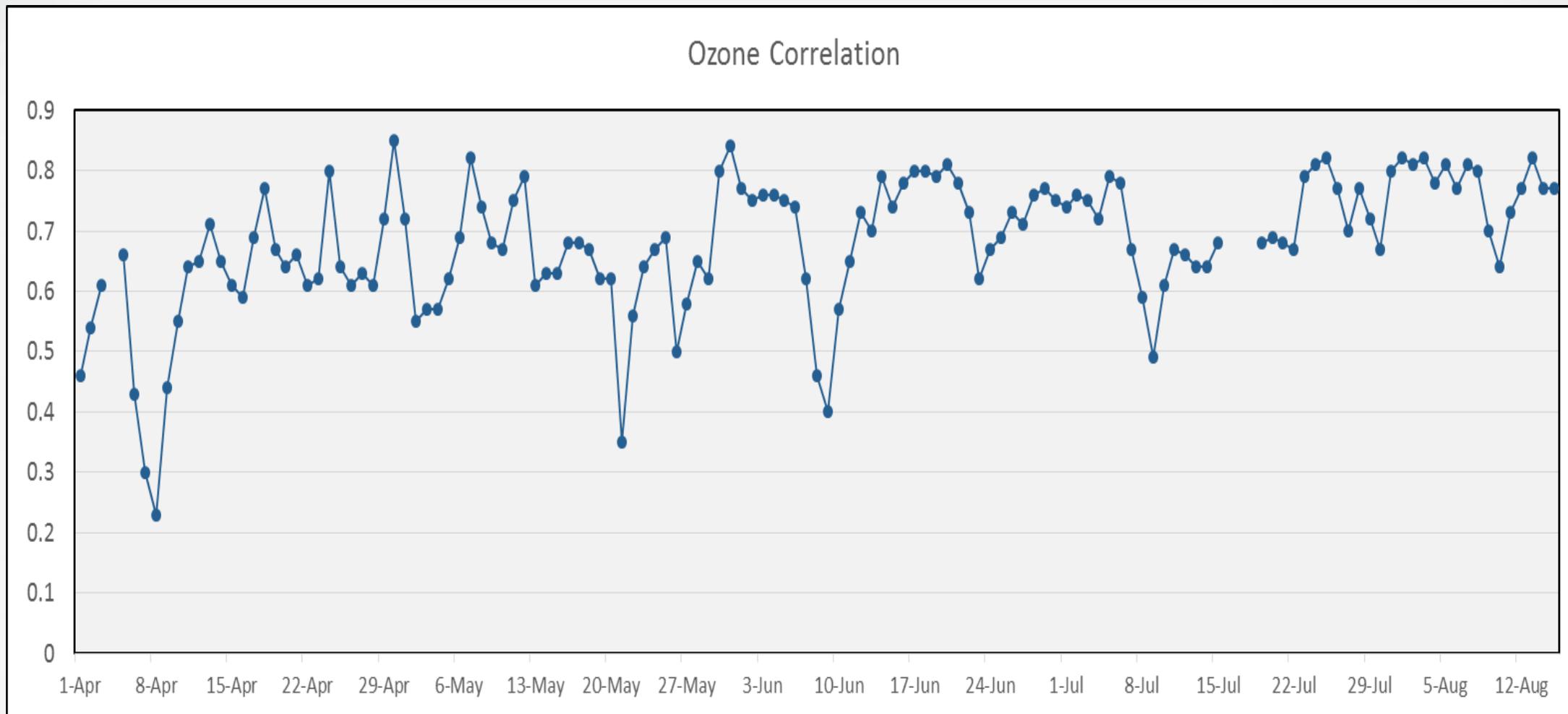
Ozone errors /biases:

- related to meteorology (i.e., cloud cover, frontal passage, precipitation, water temperatures);
- related to unrealistic lateral boundary conditions.

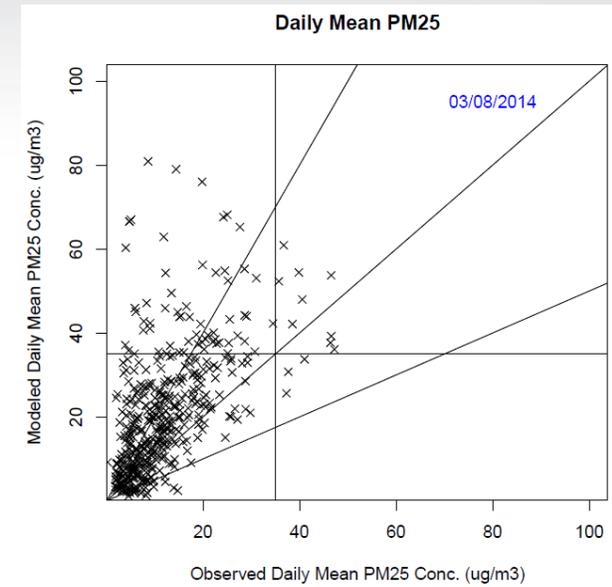
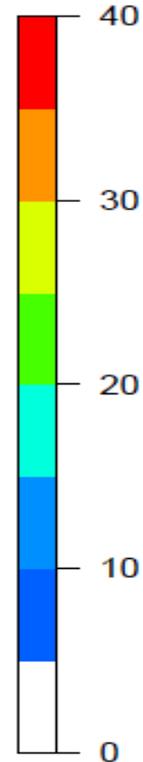
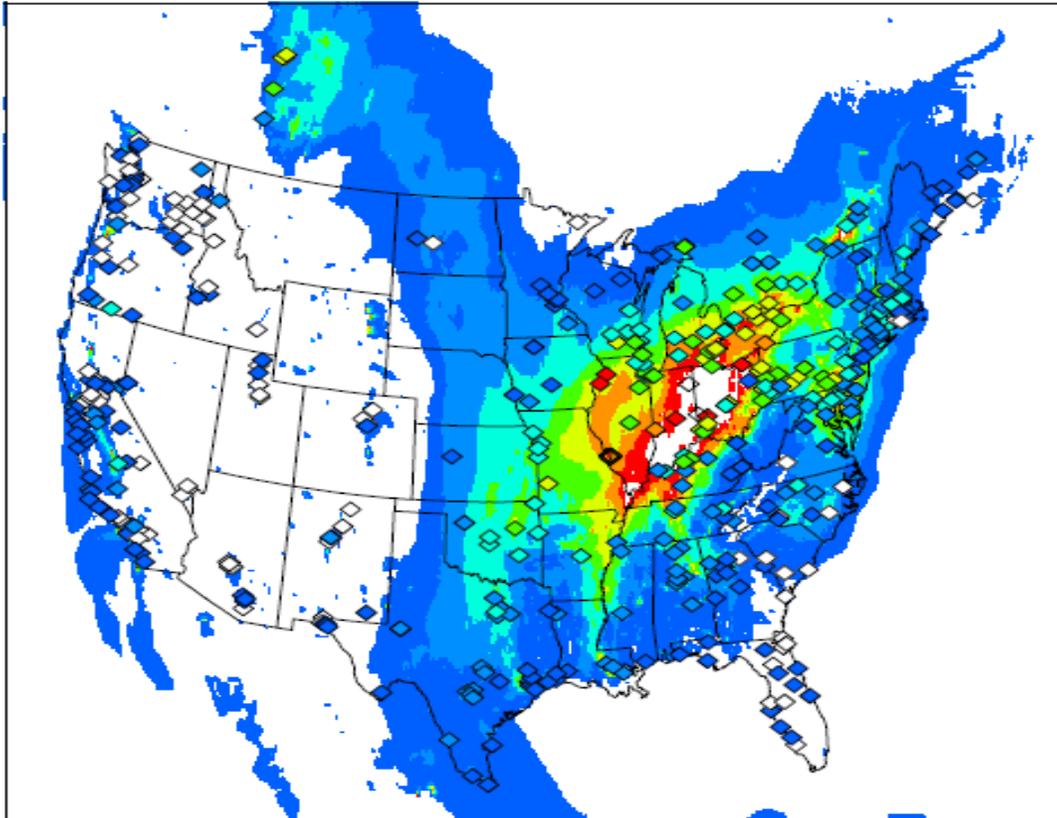




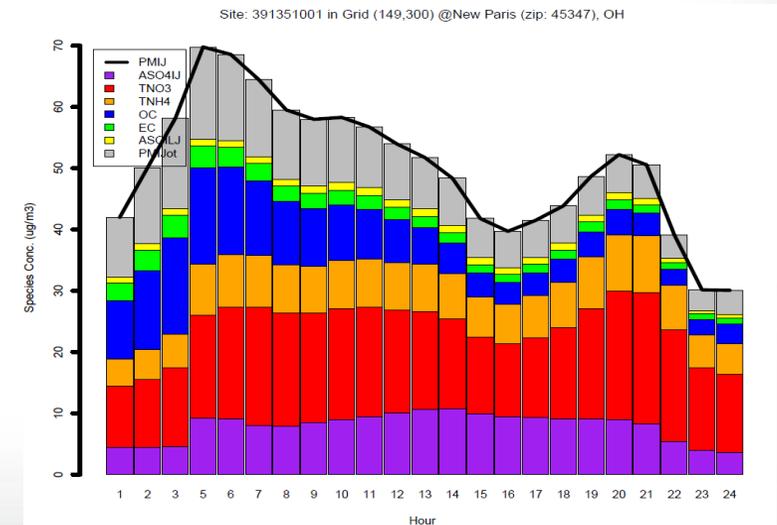




Daily Mean PM25 (ug/m3): 20140308

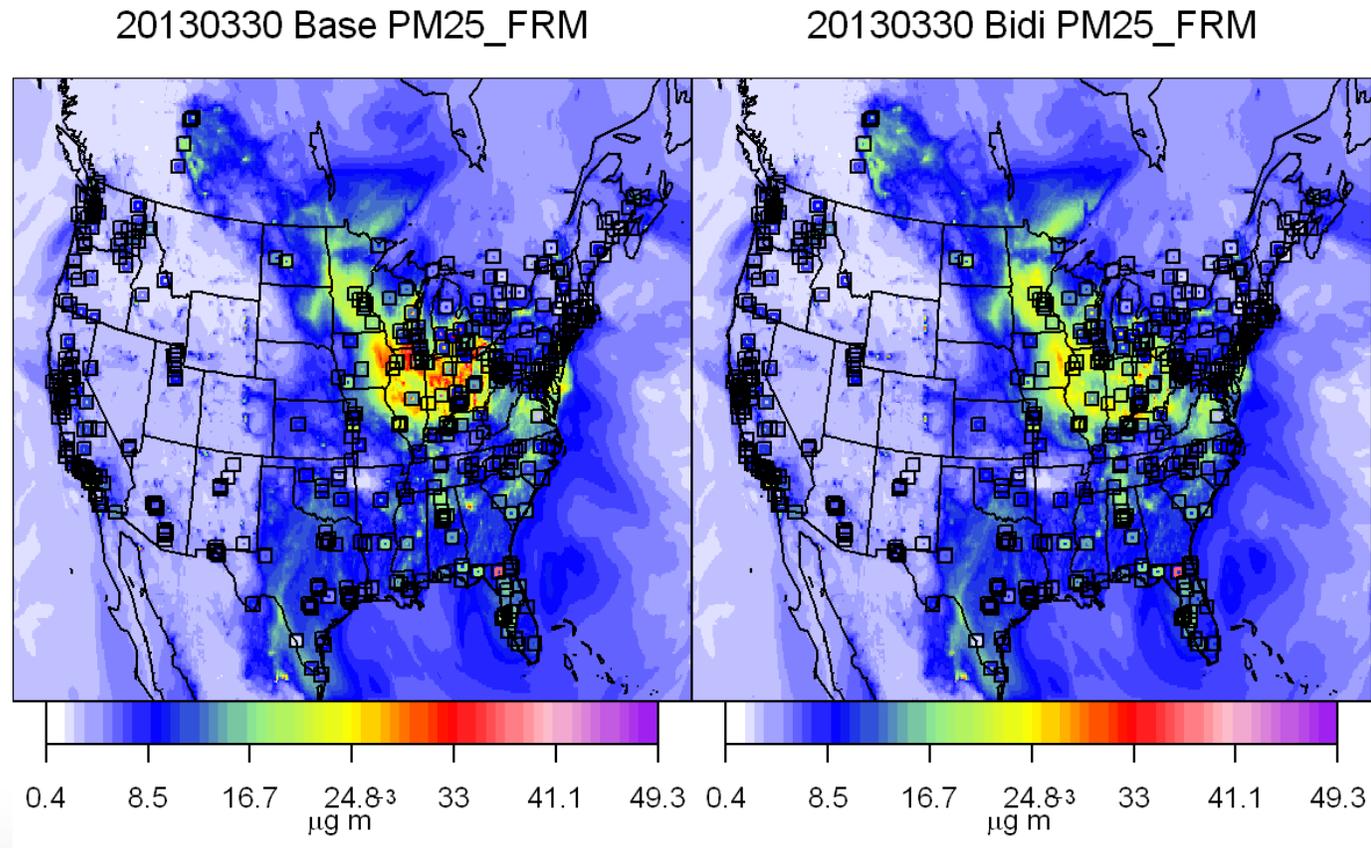


N	Obs Mean	Model Mean	RMSE (ppb)	NME (%)	MB (ppb)	NMB (%)	r
455	12.0	21.0	15.3	87.6	9.0	75.7	0.56



NH₃ emissions and deposition sensitivity performed by Jesse Bash

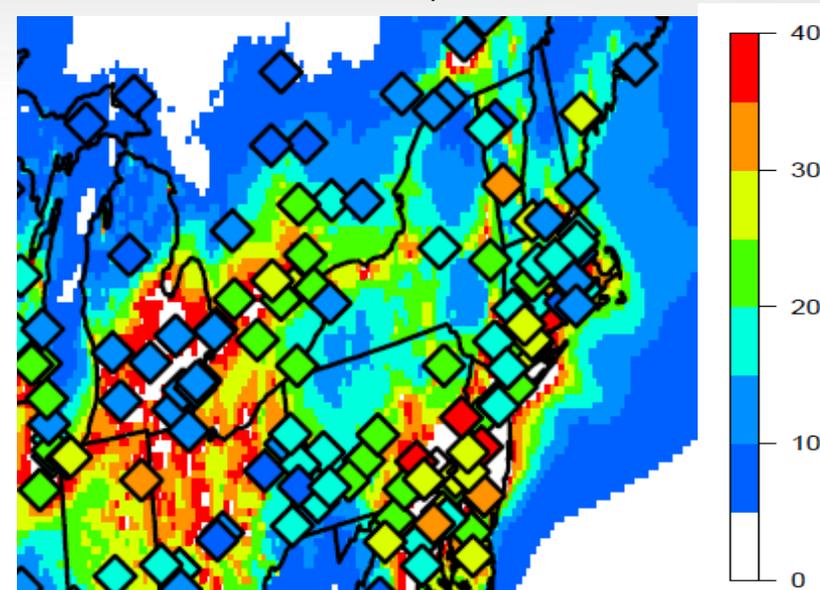
Parallel Run with NH₃ bidirectional exchange (Results 3/19/13-4/04/13)



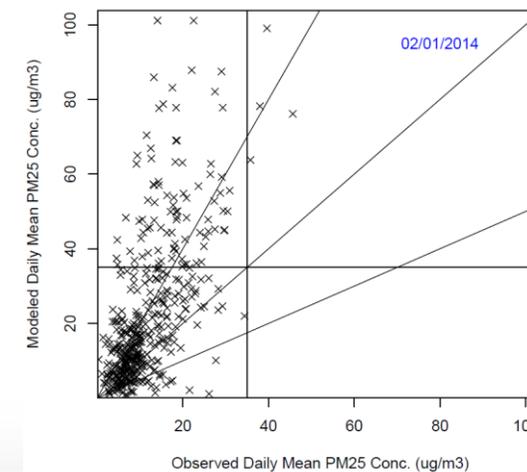
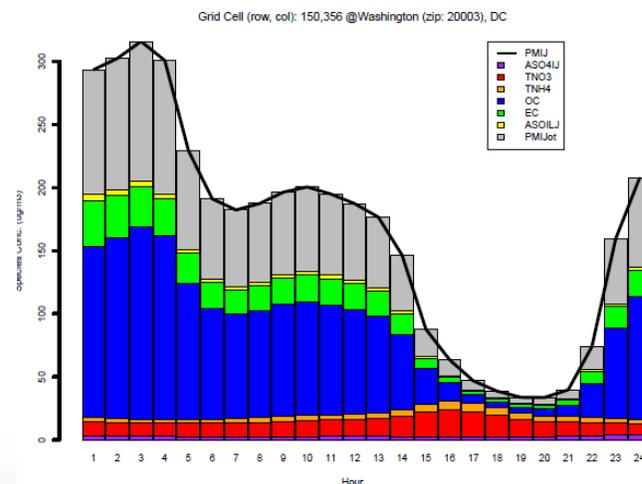
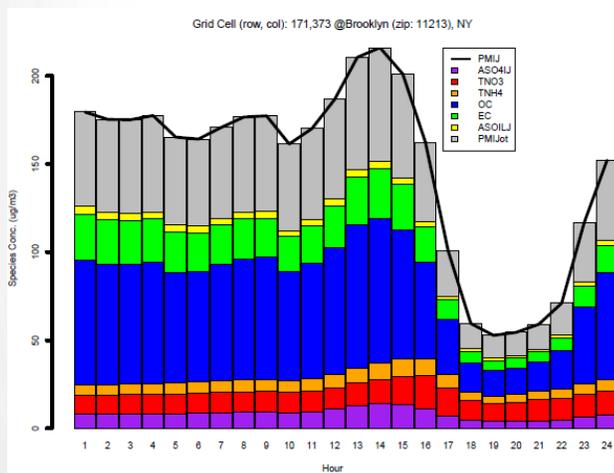
The Residential Wood Combustion (RWC) Emission Inventory methodology greatly overestimated emissions in high-density urban areas because the underlying data is calculated for MSAs. The spatial allocation within each MSA does not account for reduced use of wood for heating in high density areas such as New York City.

The updated NEI2011 Version 2 reduced this high-bias by using an improved spatial allocation of RWC emissions.

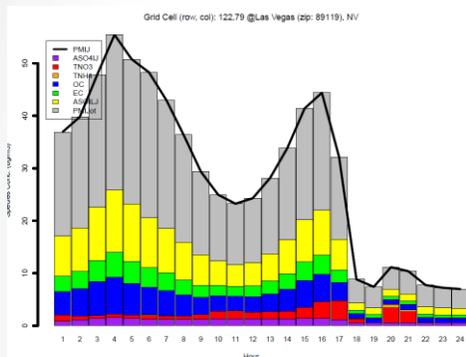
Feb. 1, 2014



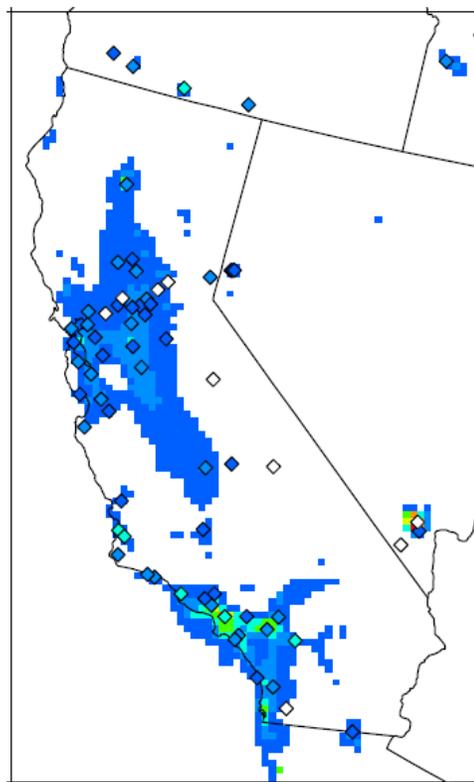
Daily Mean PM25



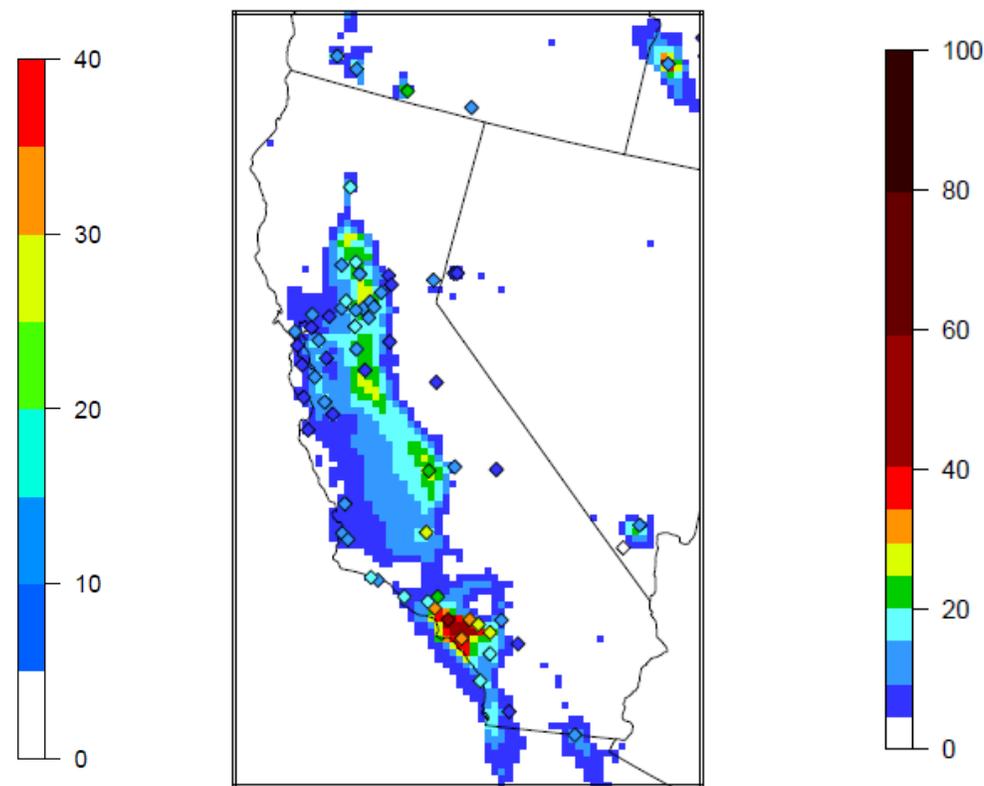
Anthropogenic dust emissions in Las Vegas were found to be outdated (as they were based on “new construction” prior to the economic downturn).



Daily Mean PM_{2.5} (ug/m³): 20140909

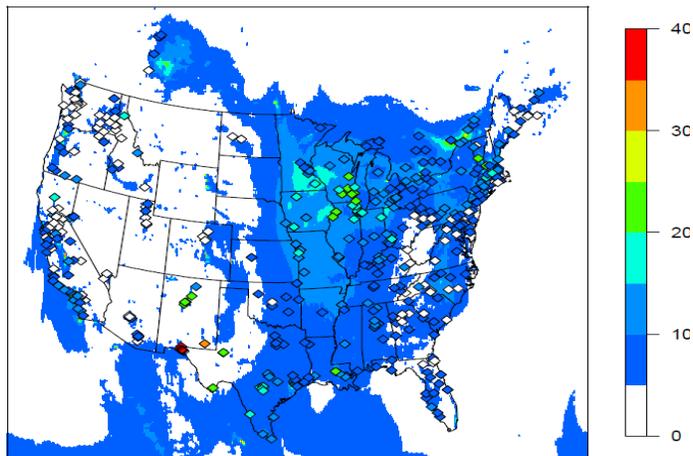


Daily Mean PM_{2.5} (ug/m³): 20150218

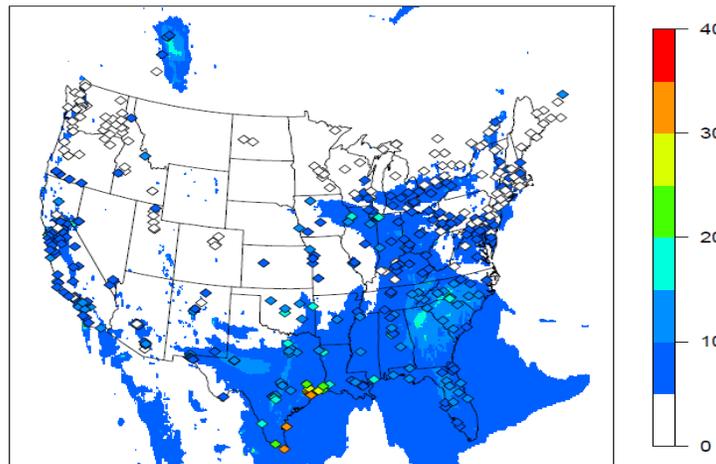


Emissions from Mexico (including the Yucatan Peninsula) posed problems, especially with sustained southerly floe as the BCs had no fire emissions. We now incorporate Fire INventory from NCAR (FINN) emissions with the hemispheric run.

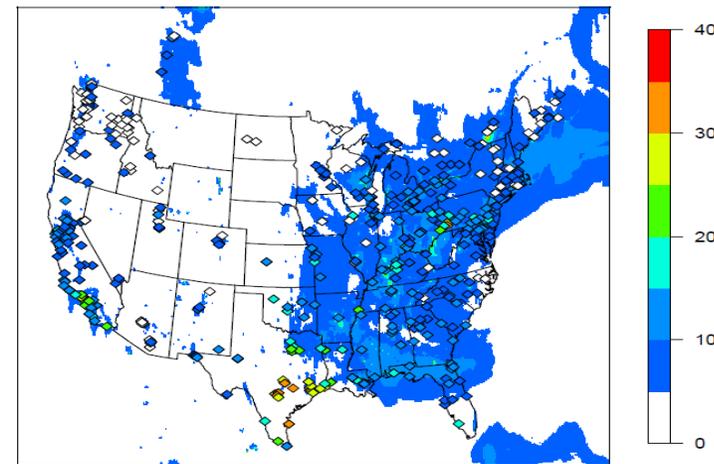
Daily Mean PM25 (ug/m3): 20140319



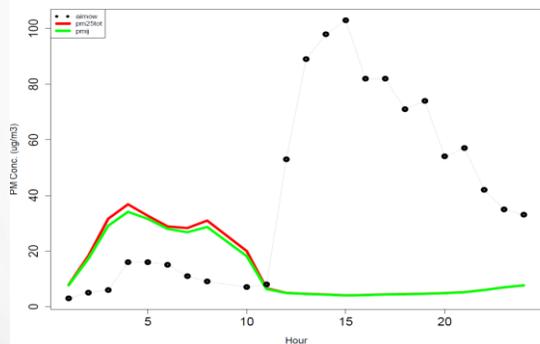
Daily Mean PM25 (ug/m3): 20140428



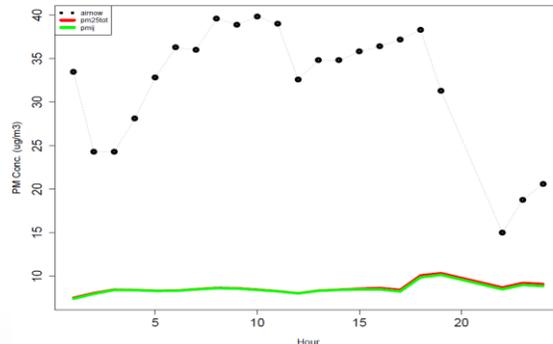
Daily Mean PM25 (ug/m3): 20140622



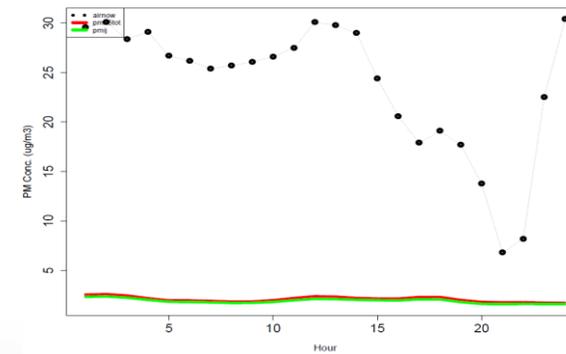
Site: 481410044 in Grid (72,139) @El Paso (zip: 79905), TX



Site: 480610006 in Grid (13,209) @Brownsville (zip: 78520), TX

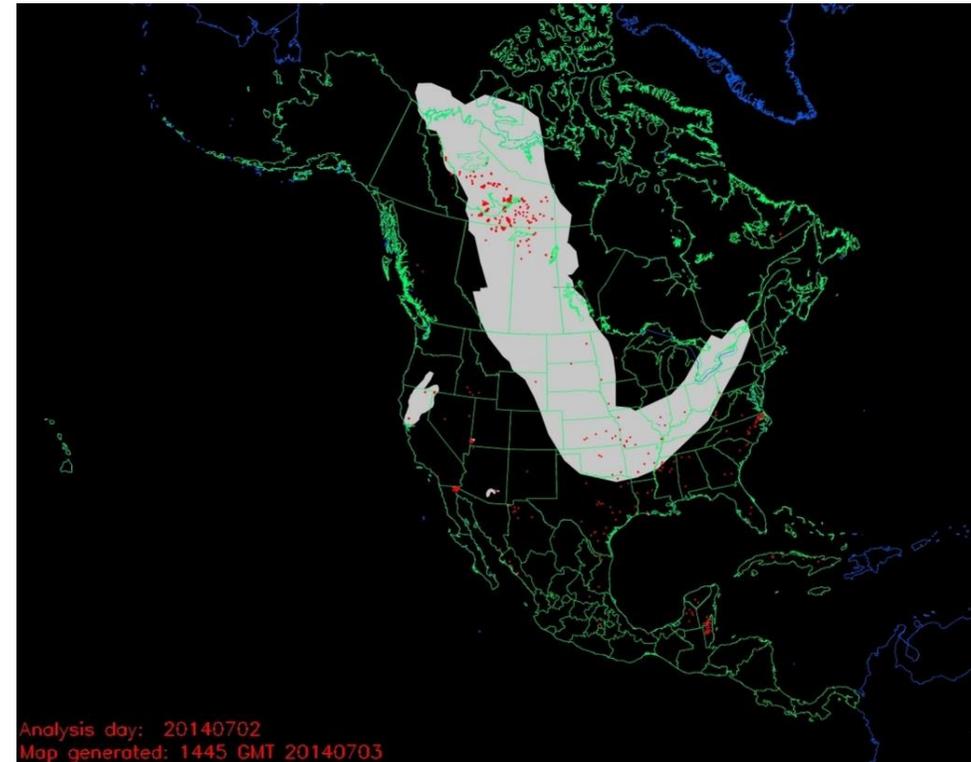
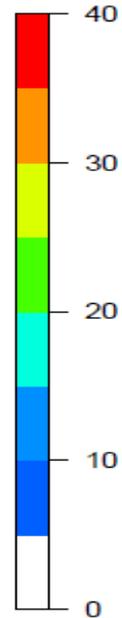
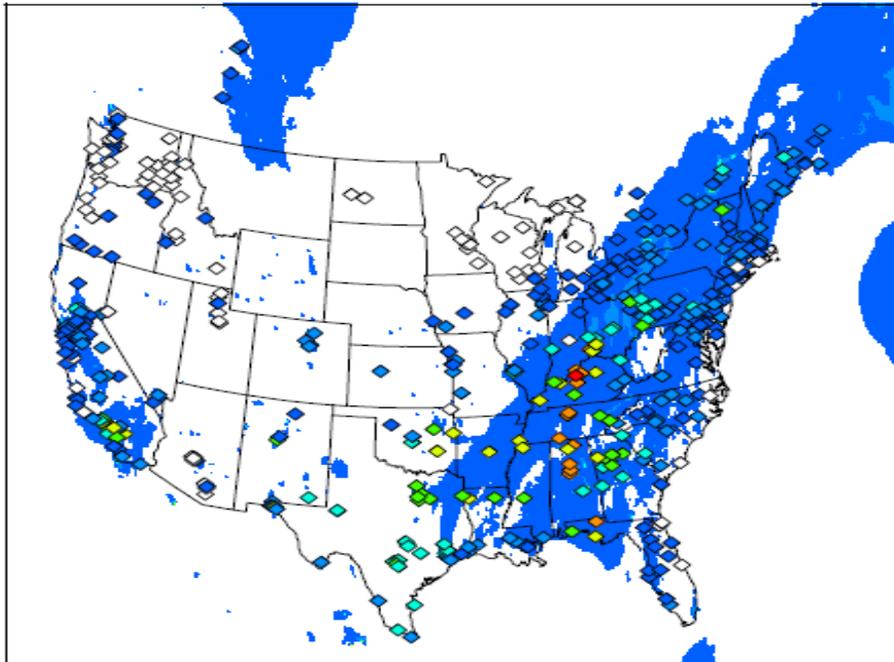


Site: 482011050 in Grid (48,230) @Seabrook (zip: 77586), TX



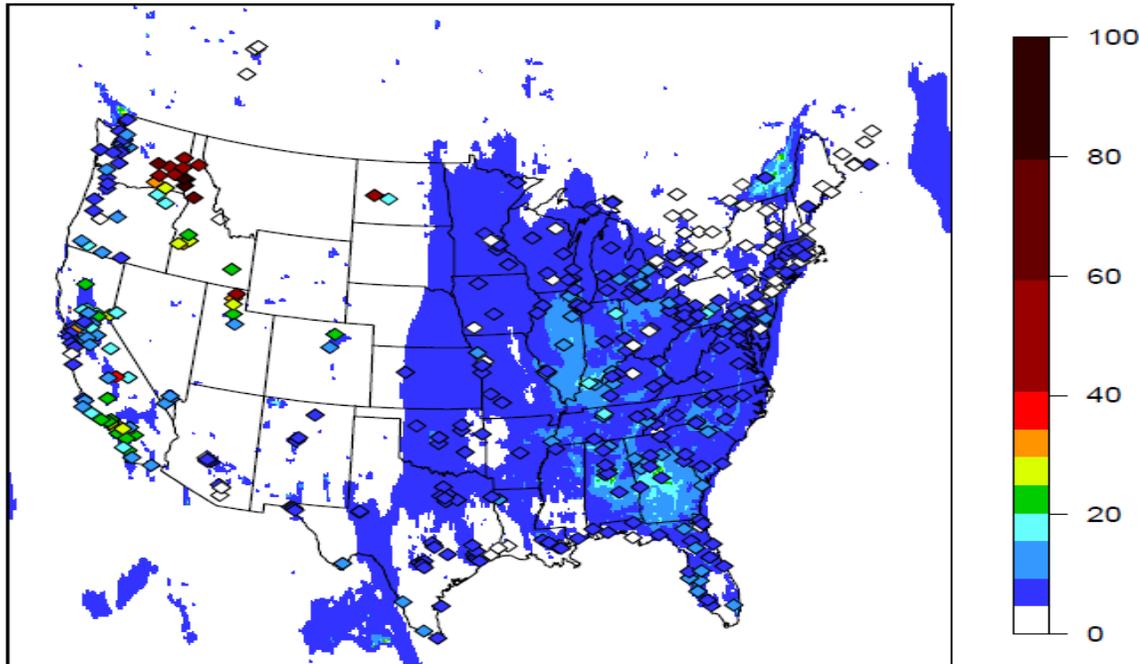
Emissions from prescribed agricultural burning was problematic. This was addressed using NOAA's HMS emissions beginning in the fall of 2014.

Daily Mean PM_{2.5} (ug/m³): 20140701

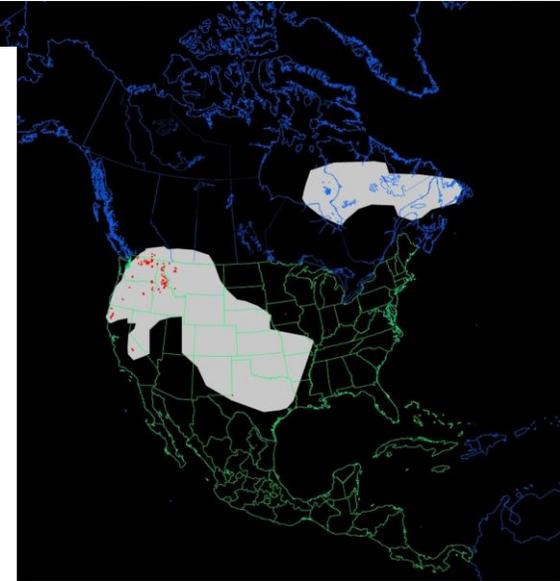
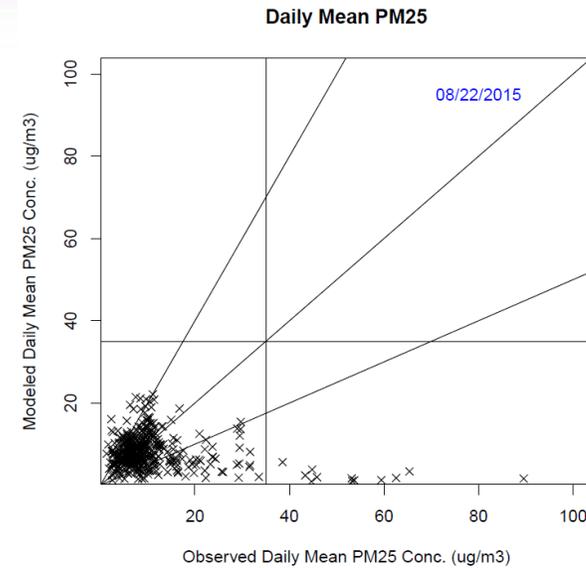


Emissions from active wild fires are still an issue that we are currently addressing.

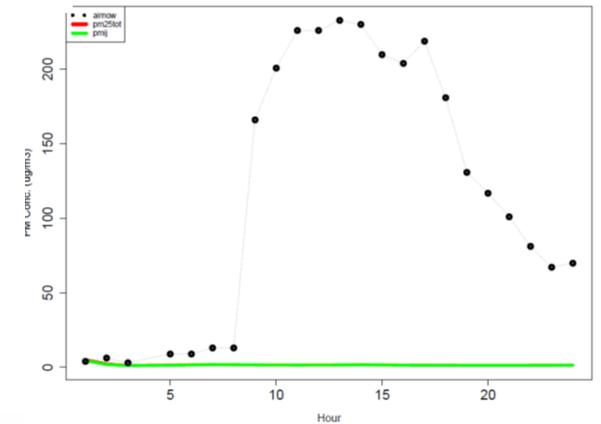
Daily Mean PM25 (ug/m3): 20150822



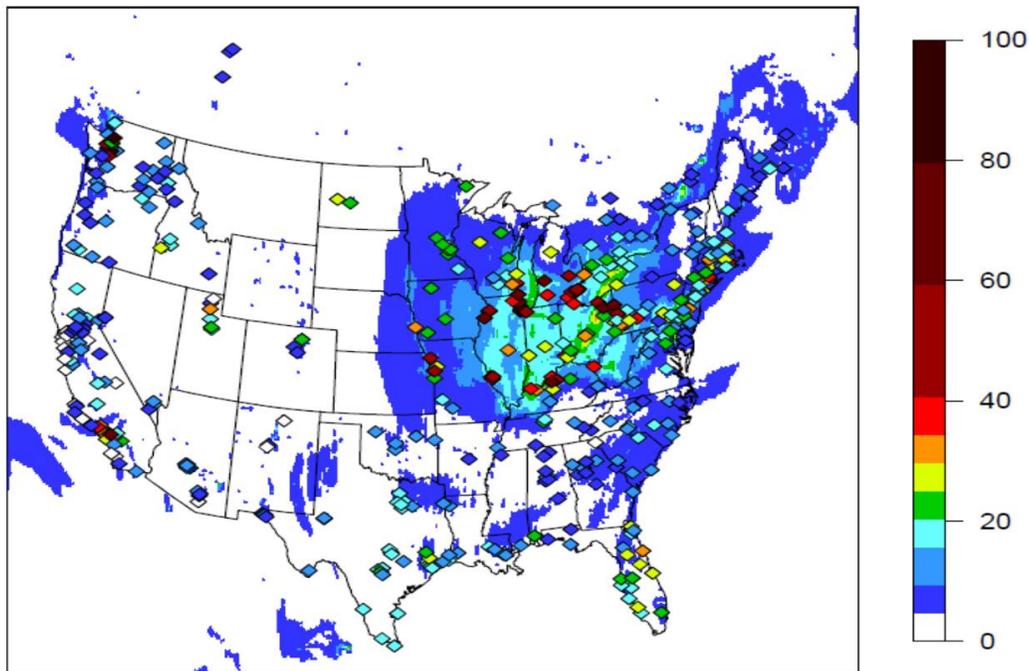
Domain size: 299x459, Max=31.21 at (185, 12)



Site: 160590004 in Grid (202,104) @Salmon (zip: 83467), ID

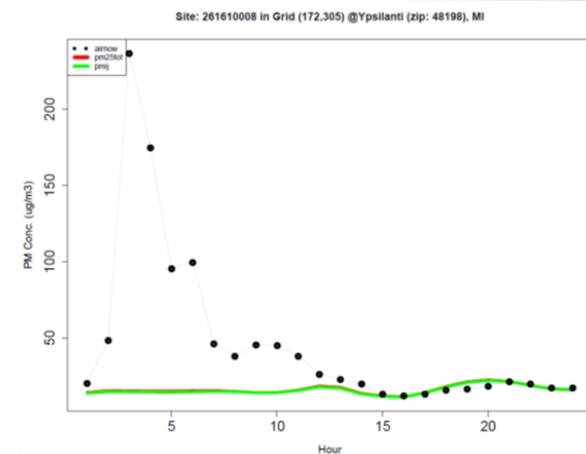
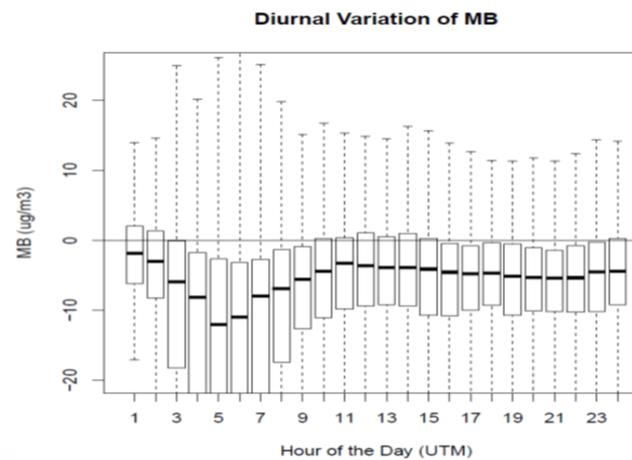
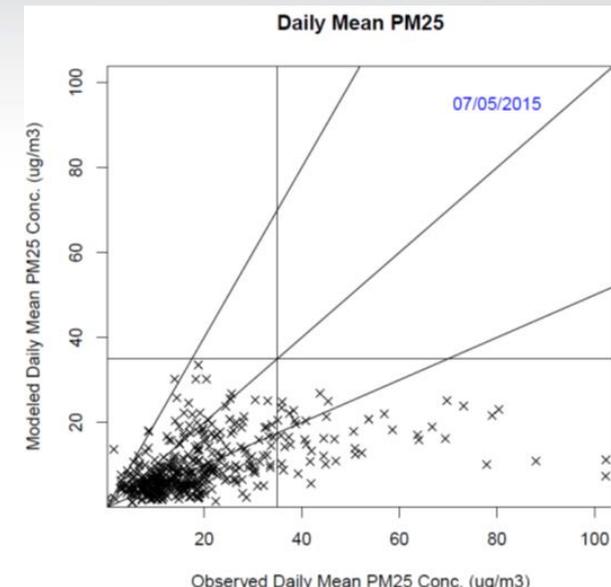
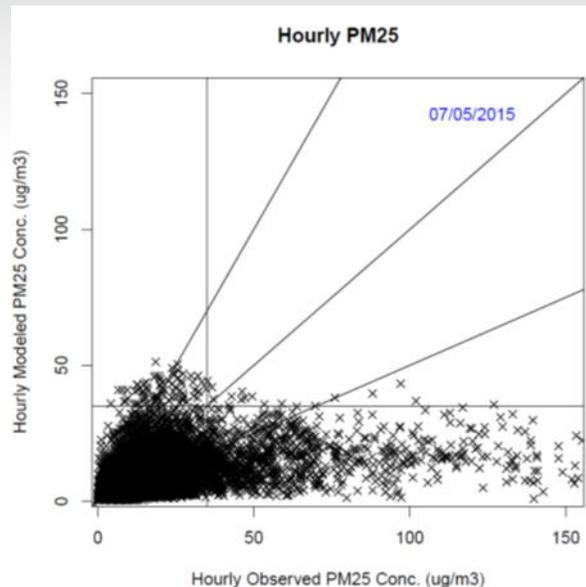


Daily Mean PM25 (ug/m3): 20150705



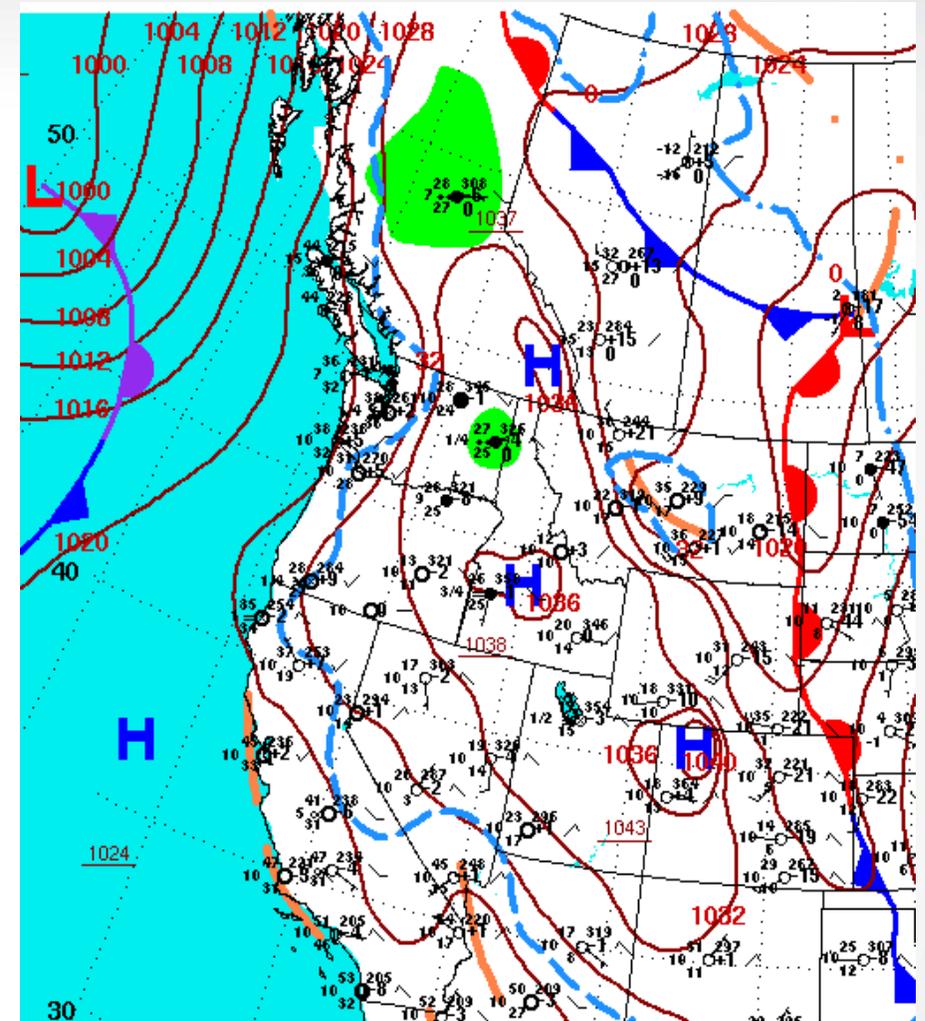
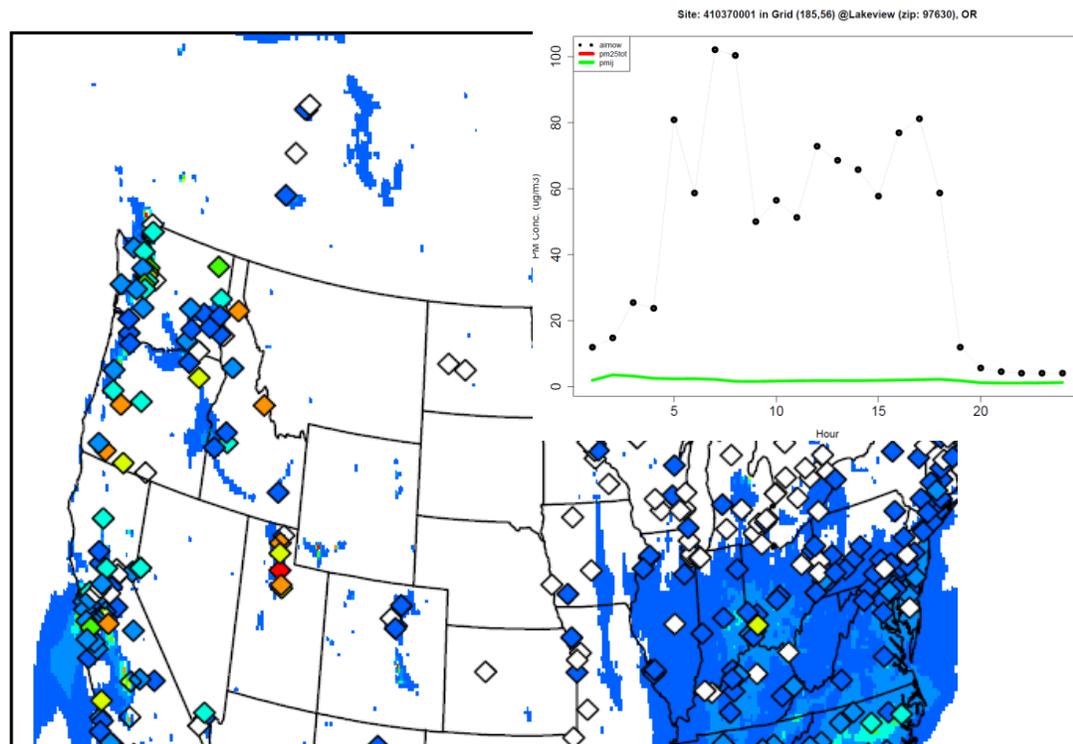
Domain size: 299x459, Max=53.32 at (278, 165)

N	Obs Mean	Model Mean	RMSE $\mu\text{g m}^{-3}$	NME (%)	MB ($\mu\text{g m}^{-3}$)	NMB (%)	r
435	19.8	9.5	17.7	57.0	-10.3	-52	0.5



Model has difficulty capturing cold pools under strong cP air masses

Daily Mean PM_{2.5} (ug/m³): 20140121

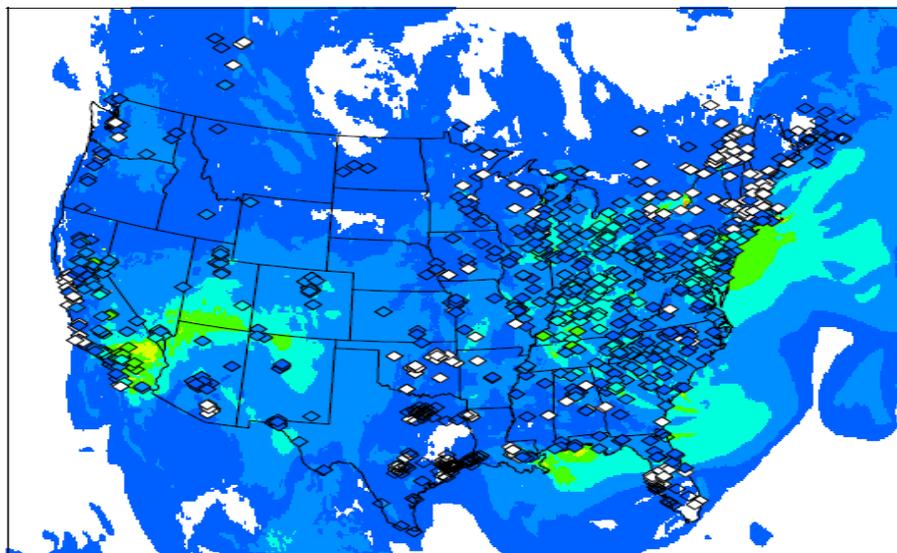


In June 2014, we started using hemispheric boundaries conditions for CMAQ. An evaluation compared to standard (monthly averaged) GEOS-Chem boundaries clearly showed improvements in O₃ particularly in reducing background concentrations over Canada and increasing them over the Eastern Pacific.

GEOS-Chem

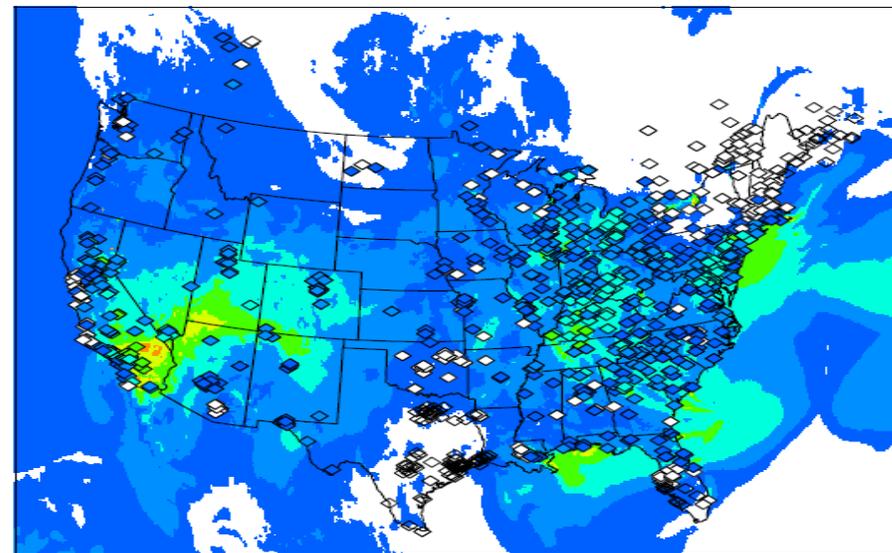
Hemispheric CMAQ

Daily Maximum 8-hr O₃ (ppb): 20140622



Domain size: 299x459, Max=139.3 at (54, 182)

Daily Maximum 8-hr O₃ (ppb): 20140622

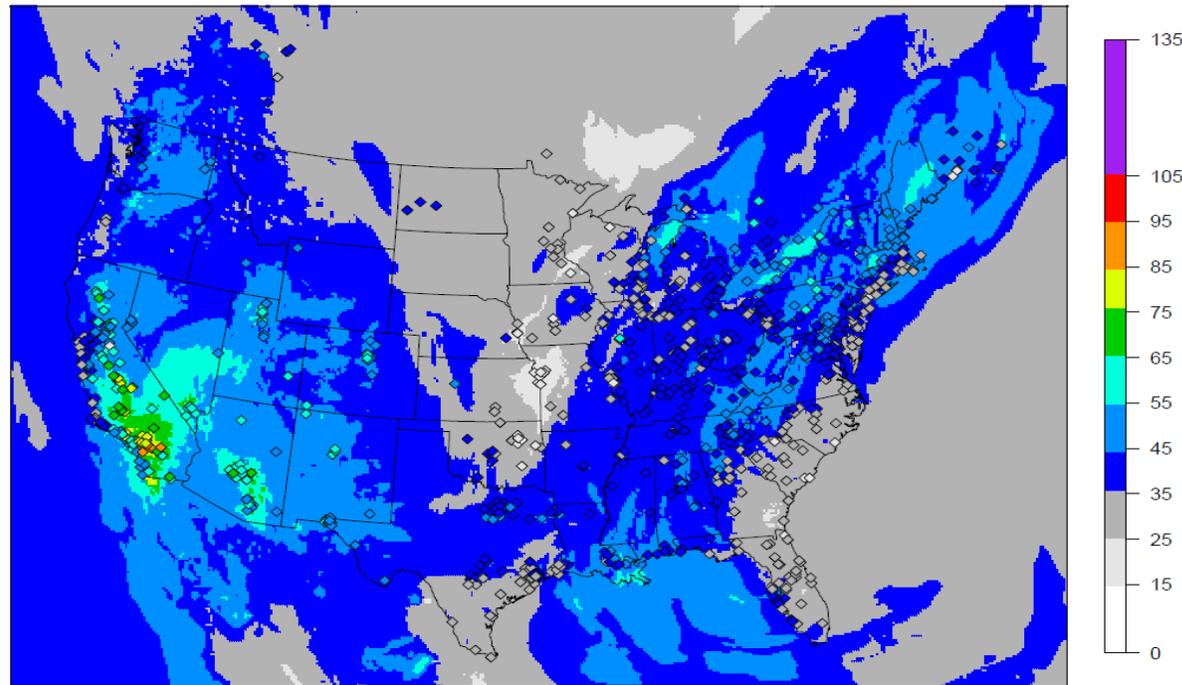


Domain size: 299x459, Max=143.5 at (54, 182)

In May 2015, we starting including halogen chemistry with the hemispheric boundaries. This has significantly reduced boundary layer ozone over marine environments, especially in the Gulf of Mexico region.

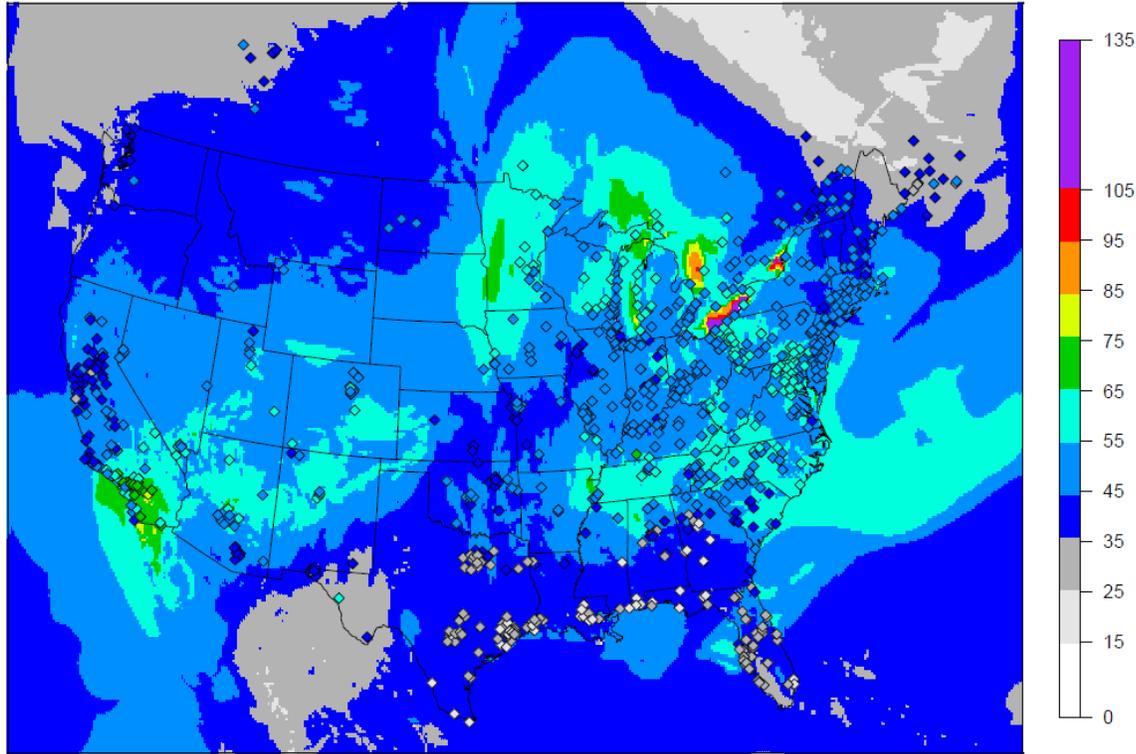
Hemispheric CMAQ with Halogen

Daily Maximum 8-hr O₃ (ppb): 20150530



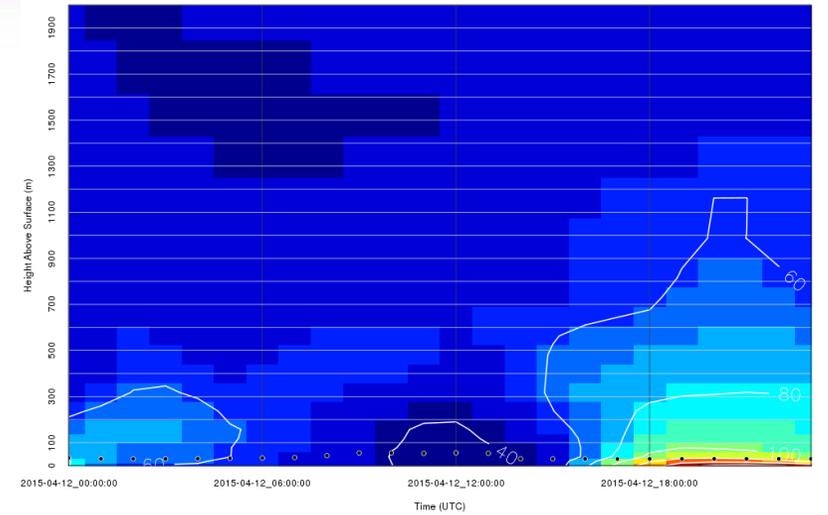
Domain size: 299x459, Max=85.71 at (58, 105)

Daily Maximum 8-hr O₃ (ppb): 20150412



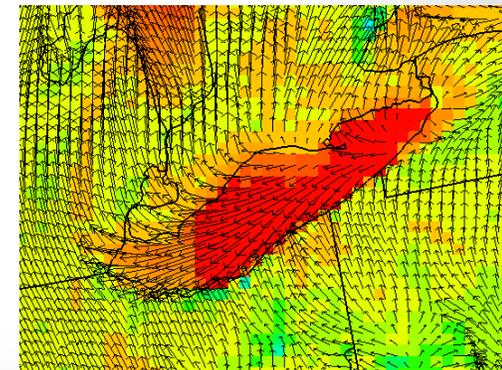
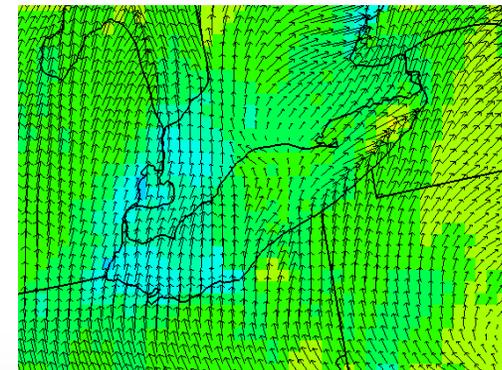
Domain size: 299x459, Max=142.4 at (331, 178)

CMAQ O₃ and PBL Height (m)

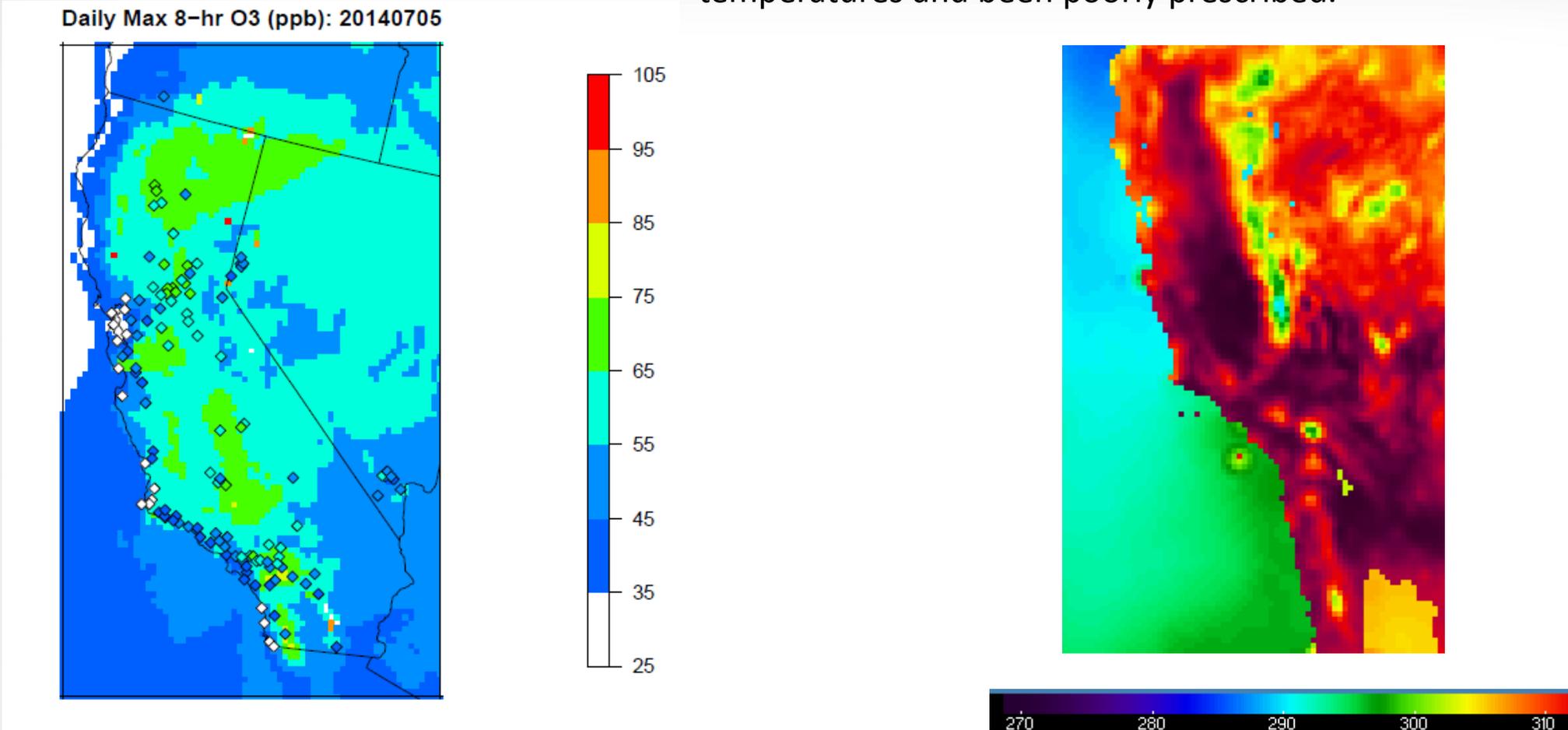


14Z

22Z



Started using real-time GHR SST in October, 2014 because lake temperatures and been poorly prescribed.



Following the:

protocol established when EPA was involved with:

the National Air Quality Forecast Capability (NAQFC), and

recommendations established in the *Bull. Amer. Meteor. Soc.*, **94**, 1187–1211:

the Emergence of Weather-Related Test Beds ...,

EPA has been running CMAQ continuously and in near real-time since 2013, allowing for immediate and ongoing analysis, thereby facilitating model evaluation (both performance and diagnostic) of PM_{2.5} mass and O₃ concentration. These simulations:

- have identified numerous deficiencies in the modelling system that have been targeted for improvement,
- are being archived and disseminated to scientists across EPA and external agencies.