Development of a 2007-Based Air Quality Modeling Platform

US EPA Office of Air Quality Planning and Standards

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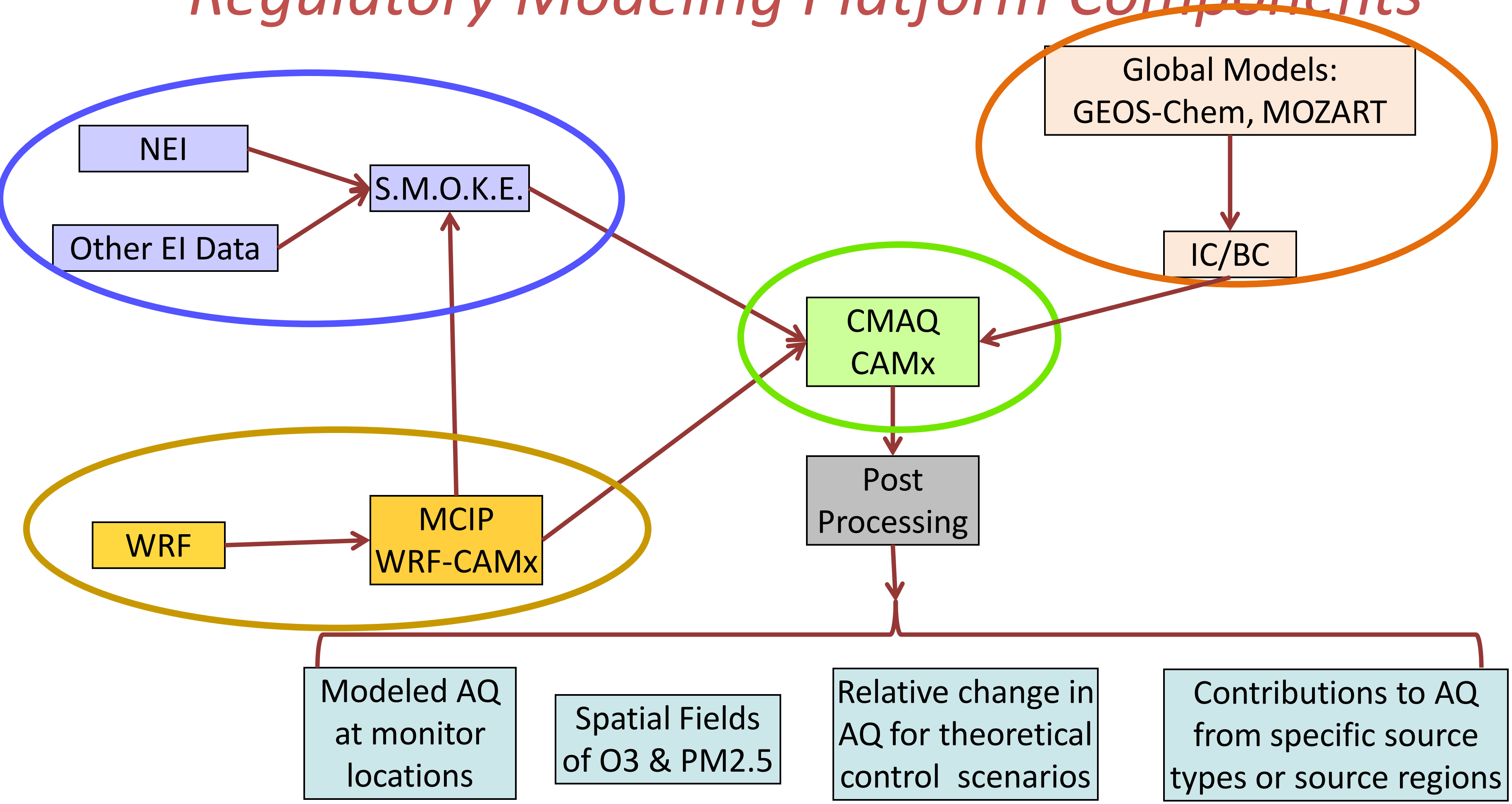
Regulatory Modeling Platform Components



Emissions **Initial and Boundary Conditions**

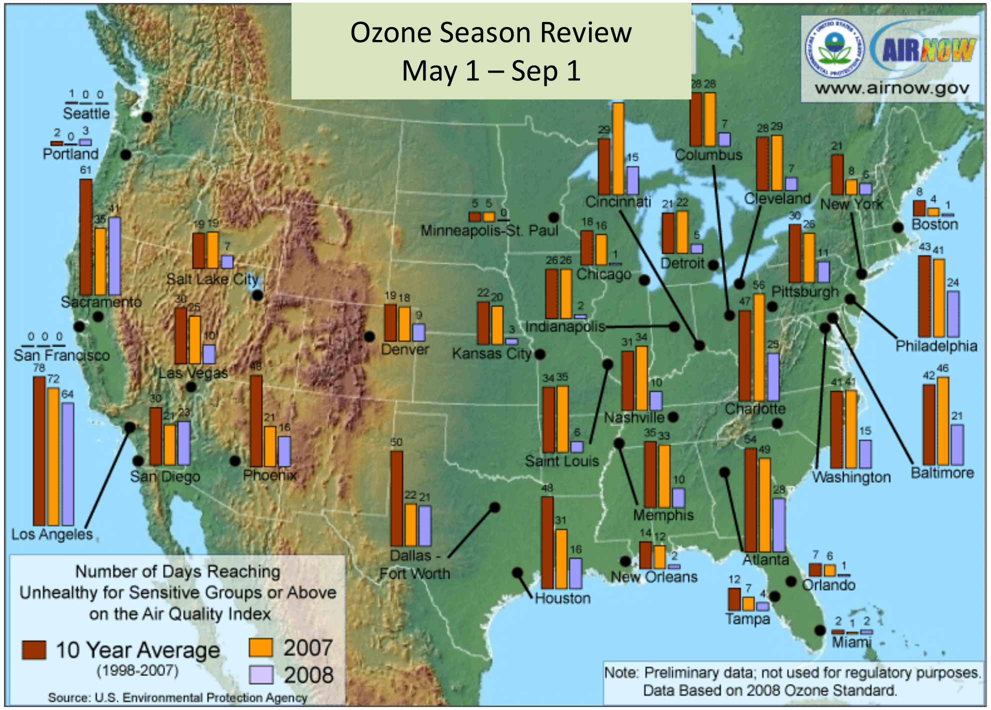
Meteorology **Photochemical Modeling Setup**

How Does AQ Modeling Support EPA Rules?

- Legal and Administrative Requirements
  - AQ Modeling can provide the legal and technical justification and basis for Agency rules
  - Executive Order 12866 - Regulatory Planning and Review: requires that EPA conduct a cost-benefit analysis of major rules as part of a Regulatory Impact Analysis (RIA) – AQ modeling provides critical inputs to this process
- Inform Policy Development & Implementation
  - National Ambient Air Quality Standard (NAAQS) Reviews: AQ modeling provides input for identifying "cost-effective" control measures and for assessing the benefits of "illustrative" future year control strategies to achieve revised standard(s)
- Communication and Outreach
  - AQ modeling provides answers to the questions from stakeholders and the public about effectiveness and impacts of EPA actions (e.g., future projections of nonattainment and attainment with regulation).

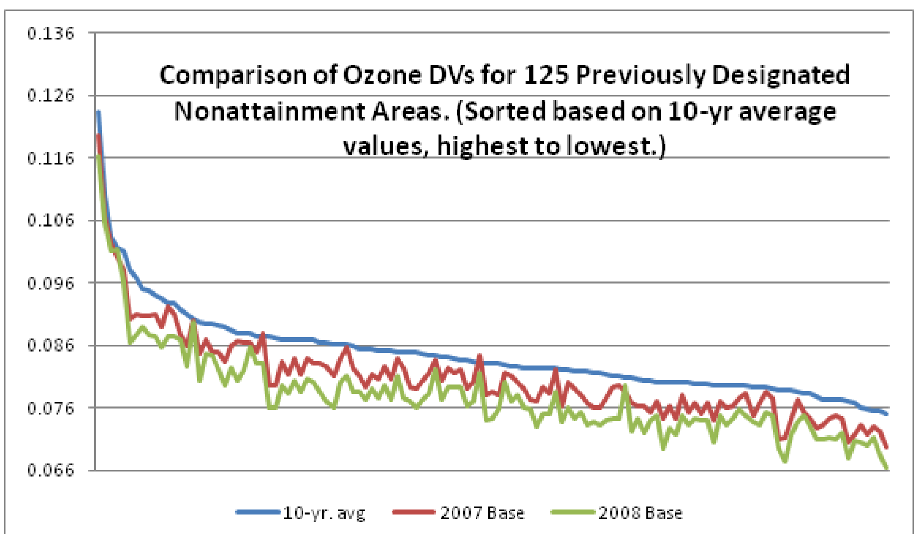
Key Air Quality Issues Addressed by Regulatory Modeling

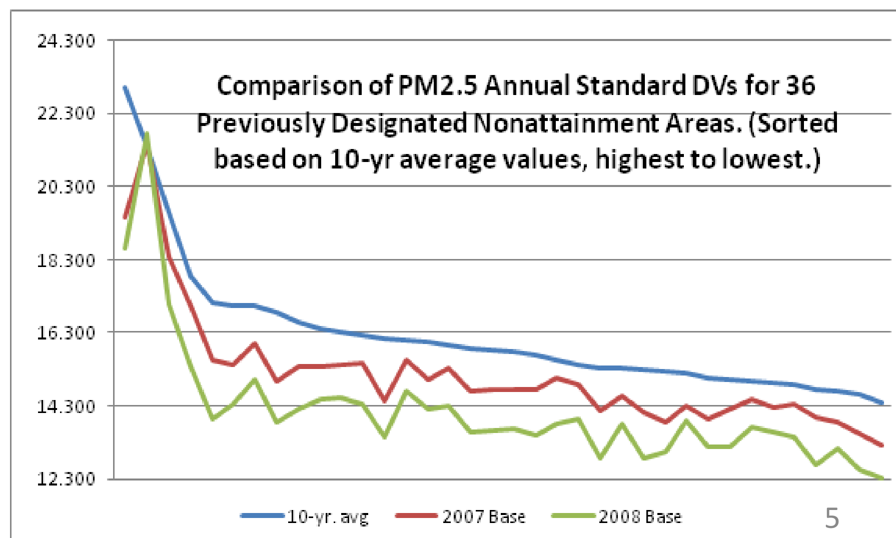
- What is the extent of the air quality problem?
- Who contributes to the problem?
- What are the most cost-effective controls to achieve attainment (NAAQS Reviews)?
- What are the health/welfare benefits of control programs?



2007 was selected because

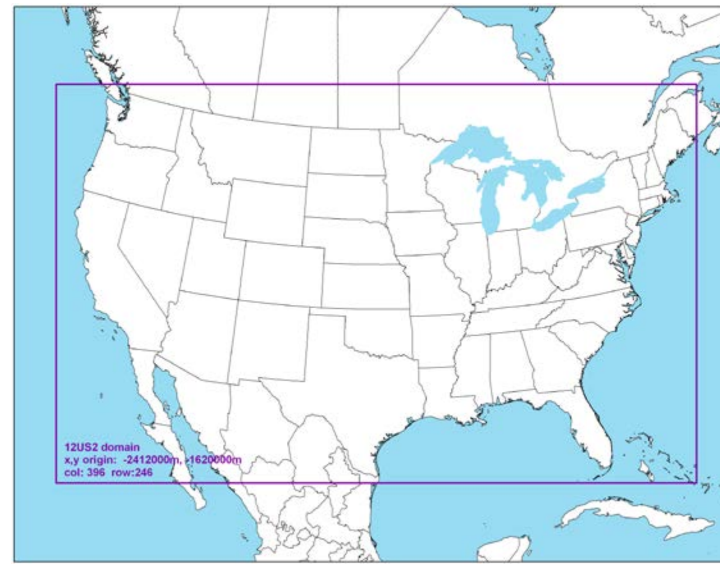
- We can utilize/leverage 2008 National Emissions Inventory (NEI)
- 2007 aq-related meteorology was more representative of average conditions than 2008 (2008 had generally "unconducive" met in most of the US)





Model Configuration

- 12 km continental US Domain
- Annual runs with10 ramp-up days
- 2007 Emissions built off 2008 NEI v2
- 2007 WRF Meteorology
- Boundary Conditions from global GEOS-Chem modeling run
- CMAQv5.0.1 (released Feb 2011)
  - CB05-TU gas-phase chemistry
  - Updates to aqueous and aerosol chemistry
  - ISORROPIA II inorganic aerosol module
  - AERO6 aerosol module tracks SO_4, NO_3, NH_4, EC, OA species, Na, Cl, and 8 crustal elements
  - SOA formation from toluene, xylene, benzene, alkanes, isoprene, monoterpenes, sesquiterpenes, methylglyoxal and glyoxal
  - SOA and POA aging
  - Inline photolysis (aerosol feedbacks, snow albedo)
  - New scheme for stable boundary layer in WRF and CMAQ
    - More mixing after evening transition
    - Lower minimum Kz to reduce over-night mixing
  - Science options:
    - Bi-directional surface flux for NH3 and Hg
    - Options for lightning NOx emissions
    - Wind-blown dust algorithm



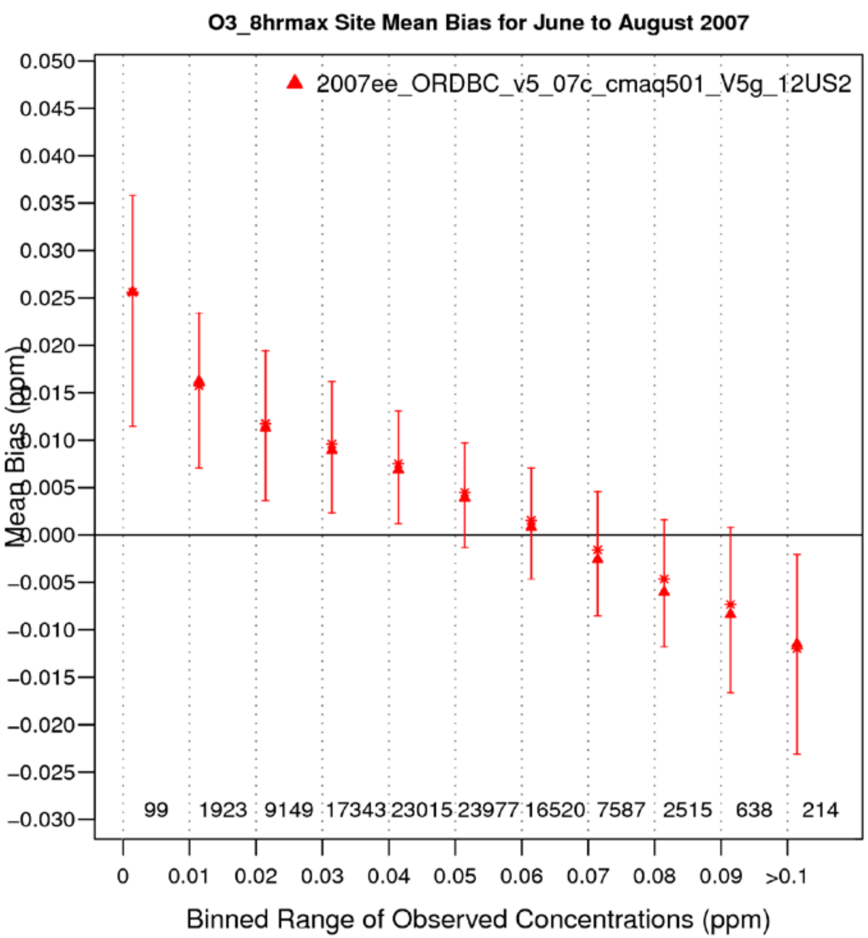
Emission Inputs

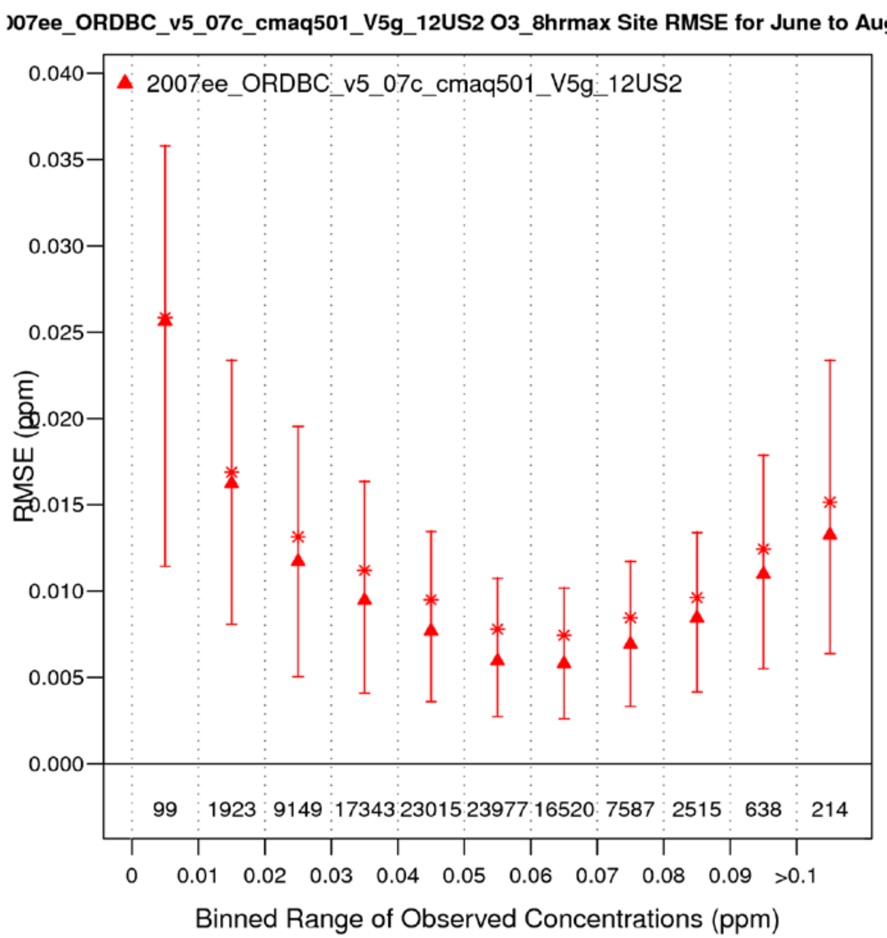
- 2008 NEI v2 Provides “starting point” emissions used in the platform
  - Emissions are less than 2005 NEI for most pollutants
- NEI data replaced with 2007 year-specific data for some sources
  - Year-specific emissions monitoring data for power plants
  - Onroad mobile source emissions calculated using MOVES with 2007 meteorology, emissions factors, and VMT
  - NONROAD model
  - Fires
- Non-NEI emissions components
  - Regional and state air quality modeling inventories for select sources
  - 2006 WRAP phase III oil and gas inventory
  - EPA default data where appropriate
  - Biogenics: BEIS 3.14 run for 2007
  - Area fugitive dust updated with land-use and meteorological adjustments
  - Canada: 2006 Inventory
  - Mexico: projected 2008 from 1999

Information and data files available at: http://www.epa.gov/ttnchie1/emch/

Ozone Performance Summary (8-hr max) Benchmark Simulation

Summer 2007: Jun/Jul/Aug

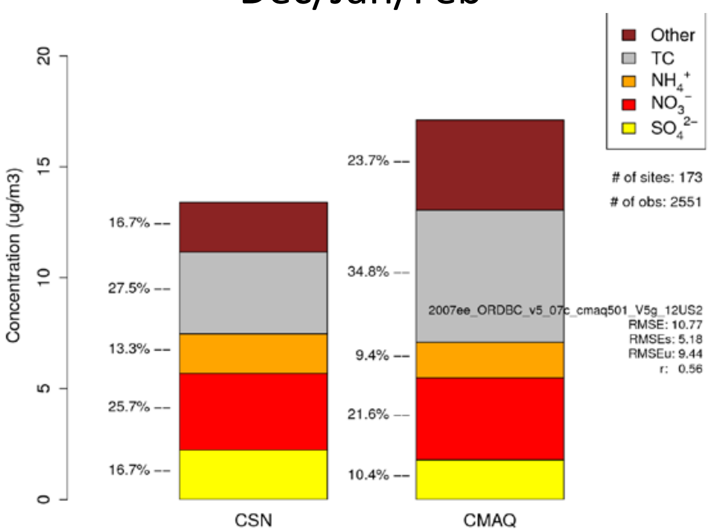




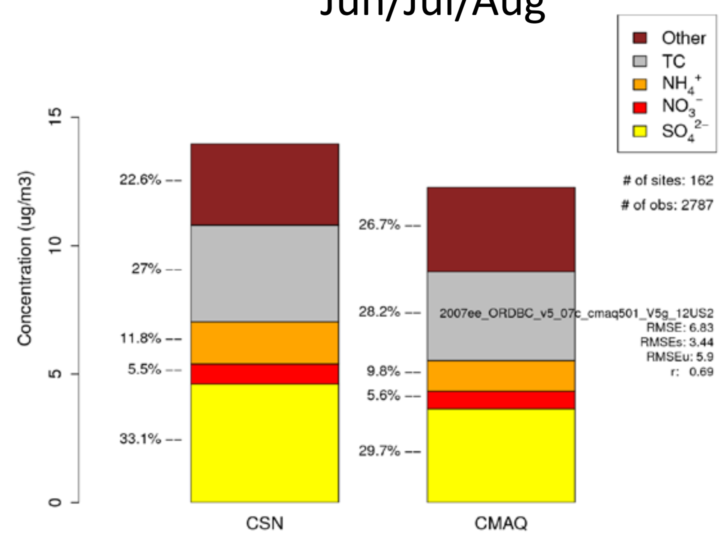
2007 PM Performance Summary: Benchmark Simulation

Month	Sulfate				Nitrate				OC			
	MB (ug/m^3)		ME (ug/m^3)		MB (ug/m^3)		ME (ug/m^3)		MB (ug/m^3)		ME (ug/m^3)	
	CSN	IMPROVE	CSN	IMPROVE	CSN	IMPROVE	CSN	IMPROVE	CSN	IMPROVE	CSN	IMPROVE
Winter	-0.4	-0.1	0.9	0.4	**0.2**	**0.3**	**1.8**	**0.8**	**1.3**	**0.4**	**2.4**	**0.7**
Spring	**-0.6**	**-0.2**	**0.9**	**0.5**	0.2	0.1	1.0	0.5	**-0.2**	**-0.2**	**1.5**	**0.7**
Summer	**-1.0**	**-0.5**	**1.5**	**0.8**	-0.1	0.1	0.5	0.3	**-1.0**	**-0.3**	**1.5**	**1.0**
Fall	-0.3	0	0.9	0.5	**0.3**	**0.2**	**1.1**	**0.5**	**0.2**	**0.2**	**1.5**	**0.8**

Dec/Jan/Feb



Jun/Jul/Aug



MODEL SENSITIVITY RUNS

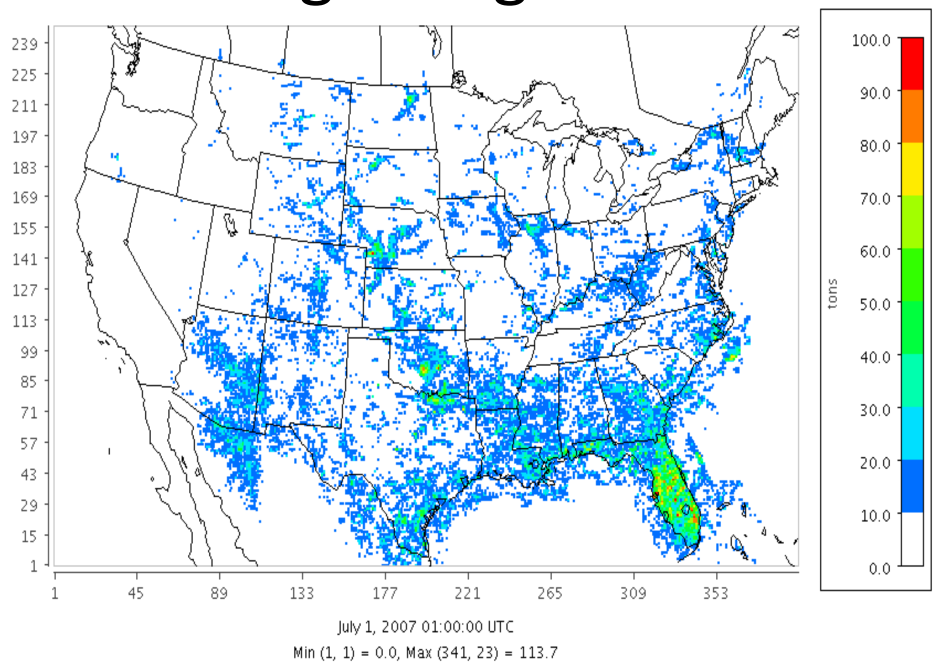
Description of Current Model Sensitivities

Focus on Ozone Performance

	Model	Meteorology	Emissions	IC /BC
2007 Benchmark	• CMAQ v5.0.1 - CAPs - AERO6 - inline photolysis	• 2007 WRF v3.1 • MCIP v3.6 • 38 meter 1st layer thickness •34 vertical layers	• 2007 Emissions built off 2008 NEI v2	• 2007 24-layer GEOS-Chem v8-03-02 using GEOS2CMAQ tool
Sensitivity 1: Lightning	Same as Benchmark	Same as Benchmark	• 2007 Emissions built off 2008 NEI v2 • Lightning NO emis	Same as Benchmark
Sensitivity 2: Meteorology	Same as Benchmark	• 2007 WRF v3.3 • MCIP v4.1.2 • 20 meter 1st layer thickness •35 vertical layers	Same as Benchmark	Same as Benchmark

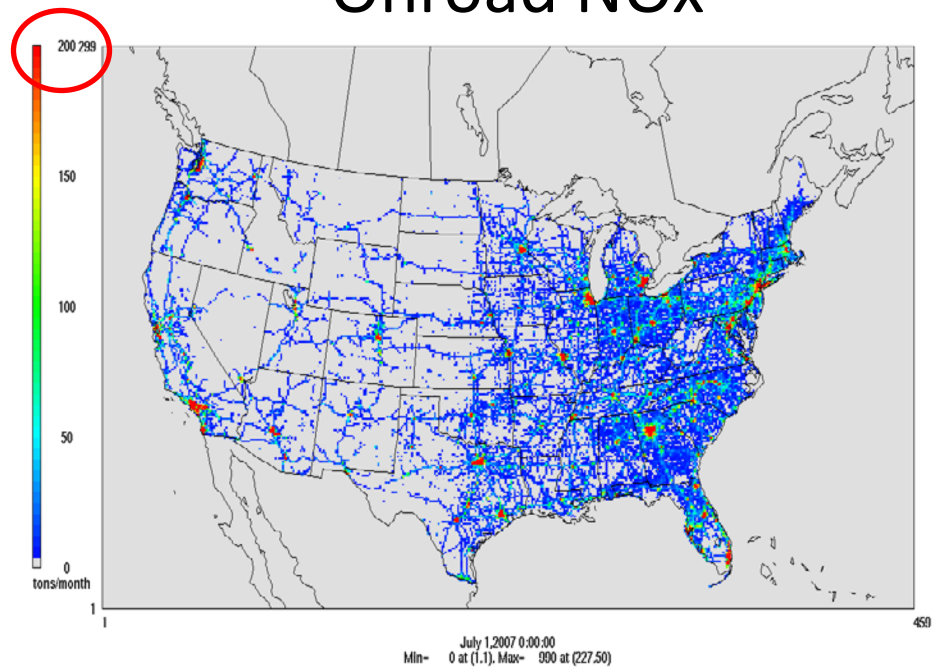
2007 July Total emissions (tons)

Lightning NO



2x larger

Onroad NOx



Note: July total lightning NO emissions domain wide is 471,493 tons

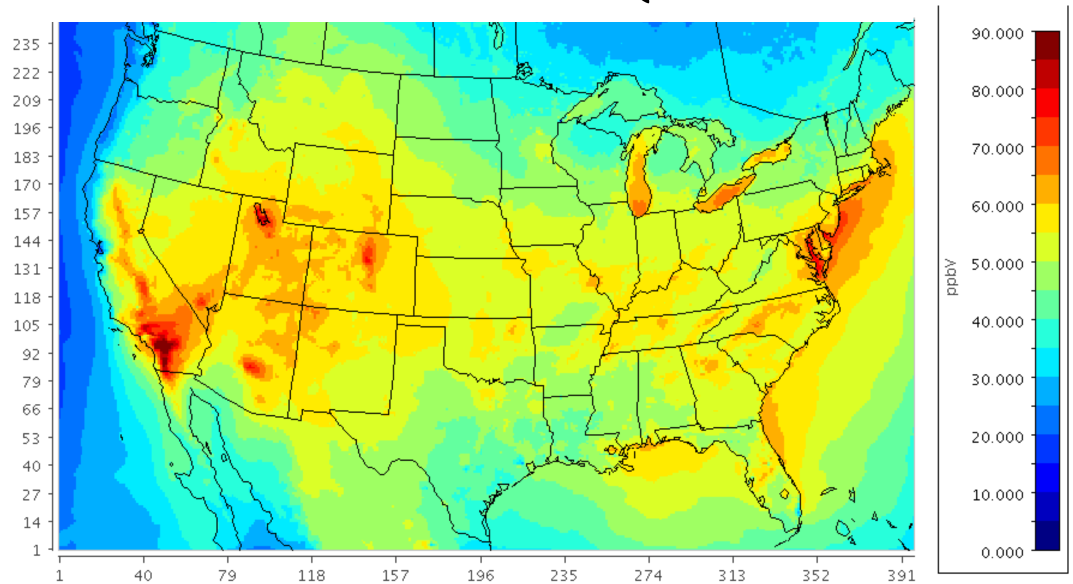
Lightning NO emissions parameterization described in: Allen, D.J., Pickering, K.E., Pinder, R.W., Henderson, B.H., Appel, K.W., Prados, A. (2012) Atmospheric Chemistry and Physics, 12, 1737-1758

Meteorology Updates

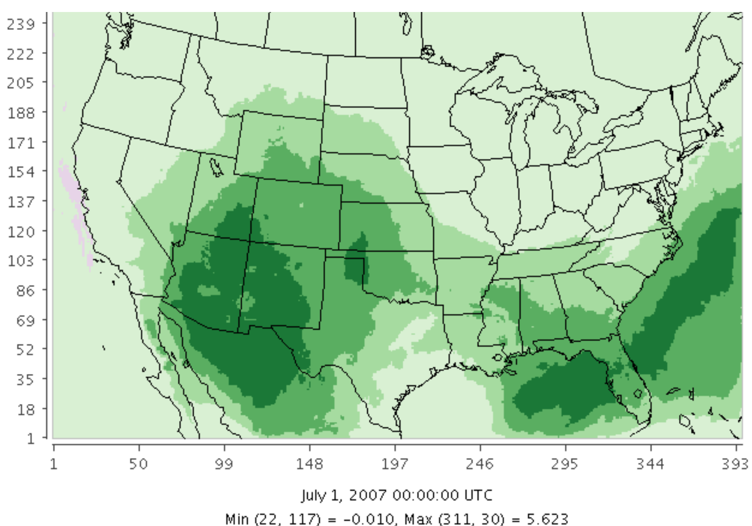
- Update from WRF 3.1 to WRF 3.3
  - Ingestion of Additional Wind Profiler Data for FDDA
    - VAD and UHF profiler additions aid in resolving low-level jet
- Update from Kain-Fritsch Cumulus Parameterization with No Trigger to Ma and Tan (2009) Trigger
  - Moisture-advection based trigger
  - Shows better spatial performance of precip. fields
- Update from 34 to 35 Vertical Layers
  - 34 layer structure: 40-m lowest layer
  - 35 layer structure: 18-m lowest layer
  - Note CMAQ runs had 24 and 25 layers respectively.
    - Structure of lowest layers preserved
    - Upper layers condensed

July Monthly Avg of 8-hr Daily Max Ozone

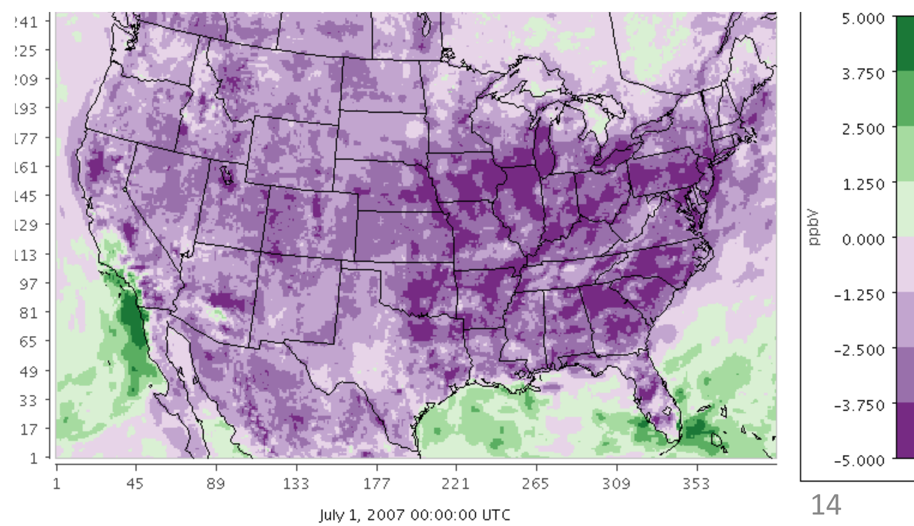
2007 Benchmark CMAQ v5.0.1



LTNG NO - Benchmark

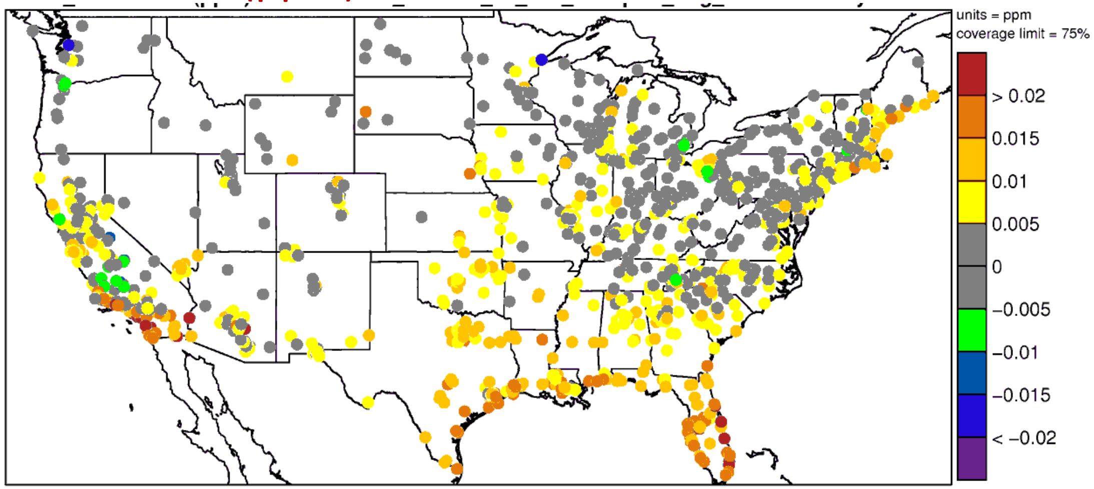


Meteorology – Benchmark



July 8-hr max Daily Ozone
Δ Absolute Bias

Mean Bias (ppm) 2007 Benchmark CMAQv5.0.1

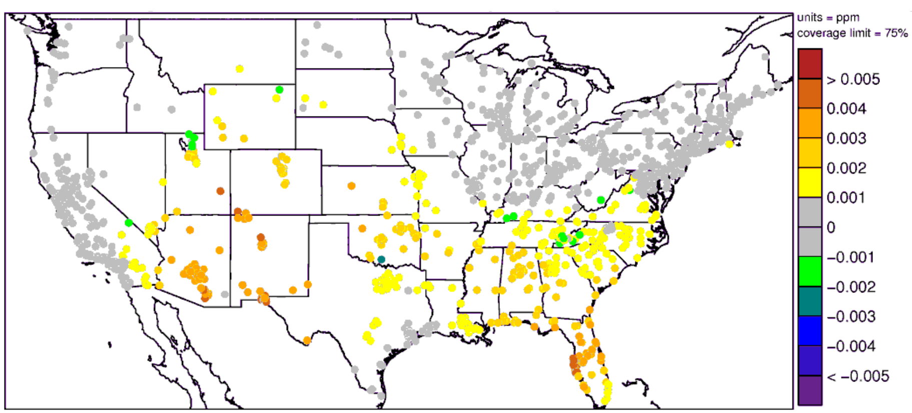


CIRCLE=AQS_Daily;

Key issues for coastal ozone performance:

- Deposition Velocity too low over water
- Missing marine halogen chemistry in CMAQ and GEOS-Chem

Δ|MB| : LTNG NO – Benchmark



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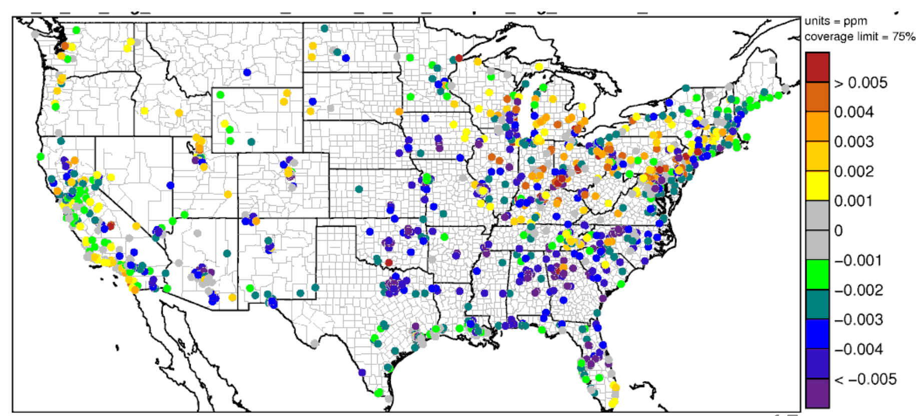
Δ|MB| : Meteorology – Benchmark

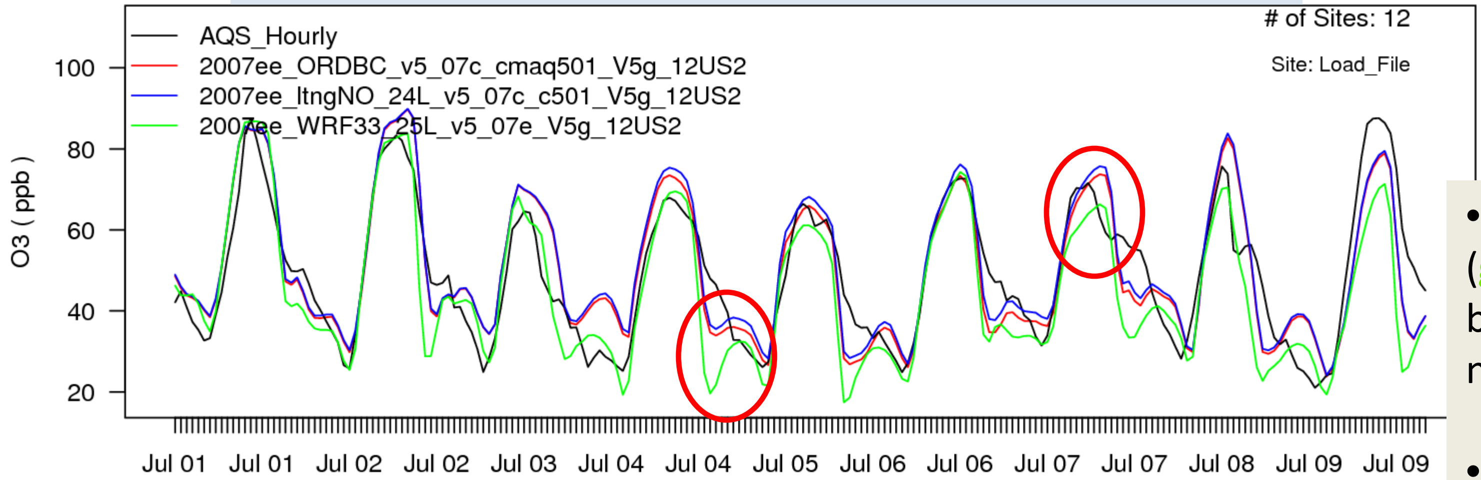


CIRCLE=AQS_Daily;

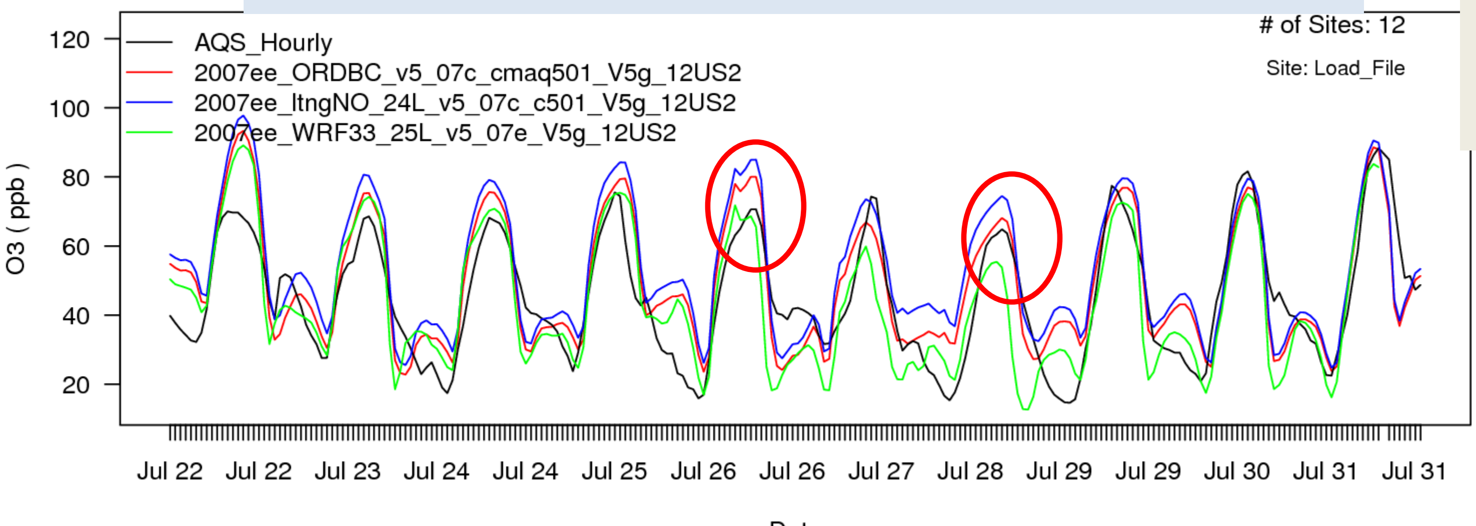
Denver - 2007 July Hourly Ozone

v5.0.1 vs LTNG NO vs Meteorology

July 1st – 9th



July 22nd – 31st



- New meteorology (**green**) tends to lower both daytime and nighttime ozone
- Lightning NO emissions (**blue**) cause small increases in Denver area ozone on some July days

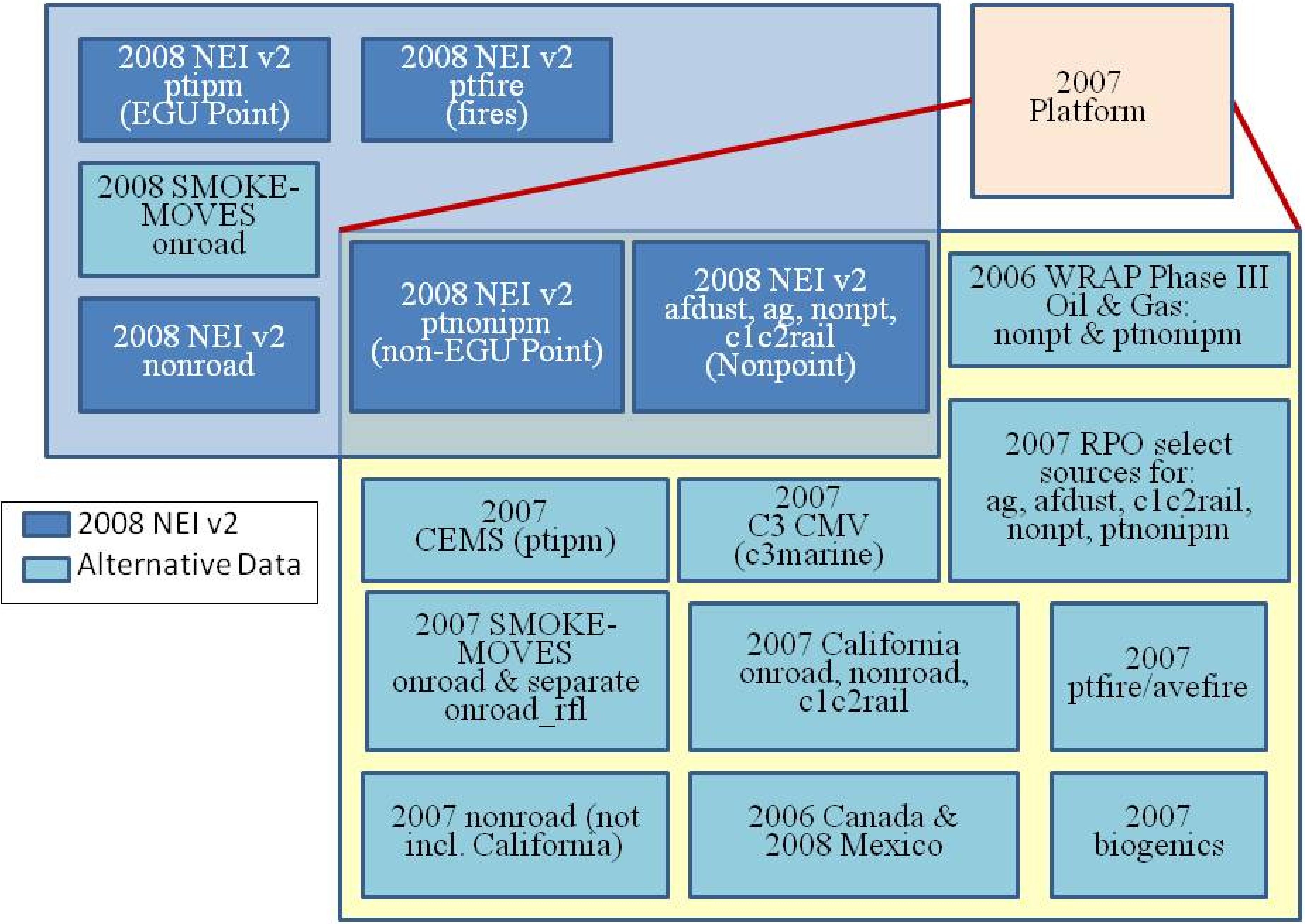
Summary of Findings

- Overall, Lightning NO emissions produced small changes in model predictions
  - substantial changes at isolated locations and times (sporadic)
- Updated Meteorology and shallower surface layer lowered ozone (day and night) and improved performance on average
- Future work will evaluate PM species and will look at sensitivity runs with:
  - Updated Meteorology
  - Bi-directional flux for fertilizer NH_3 emissions
  - Wind-blown dust emissions

Acknowledgements

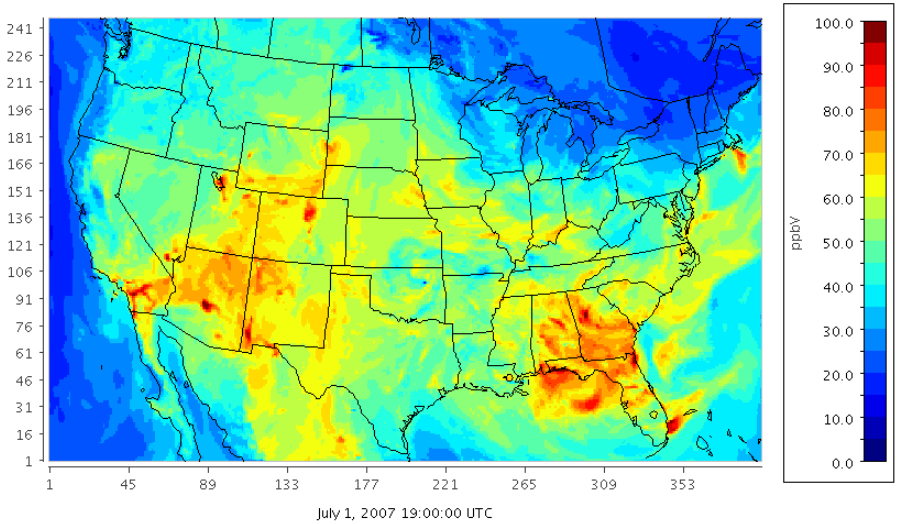
- Rich Mason
- Chris Misenis
- Pat Dolwick
- Kirk Baker
- James Kelly

APPENDIX

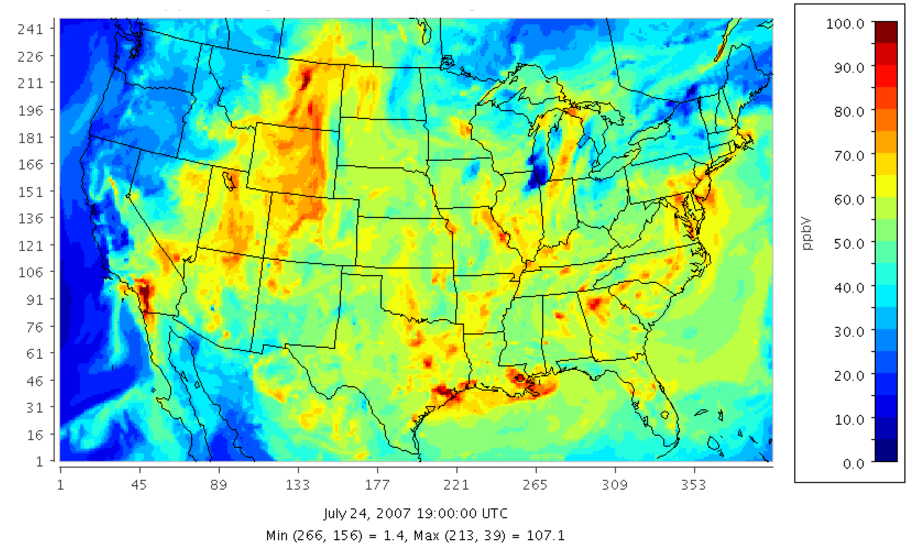

2008 NEI v2 ptipm (EGU Point)
2008 NEI v2 ptfire (fires)
2007 Platform
2008 SMOKE-MOVES onroad
2008 NEI v2 nonroad
2008 NEI v2 ptnonipm (non-EGU Point)
2008 NEI v2 afdust, ag, nonpt, c1c2rail (Nonpoint)
2006 WRAP Phase III Oil & Gas: nonpt & ptnonipm
2007 RPO select sources for: ag, afdust, c1c2rail, nonpt, ptnonipm
2008 NEI v2
Alternative Data
2007 CEMS (ptipm)
2007 C3 CMV (c3marine)
2007 SMOKE-MOVES onroad & separate onroad_rfl
2007 California onroad, nonroad, c1c2rail
2007 ptfire/avefire
2007 nonroad (not incl. California)
2006 Canada & 2008 Mexico
2007 biogenics

July Monthly Avg Ozone (2 specific days/hours)
Effect of Lightning NO

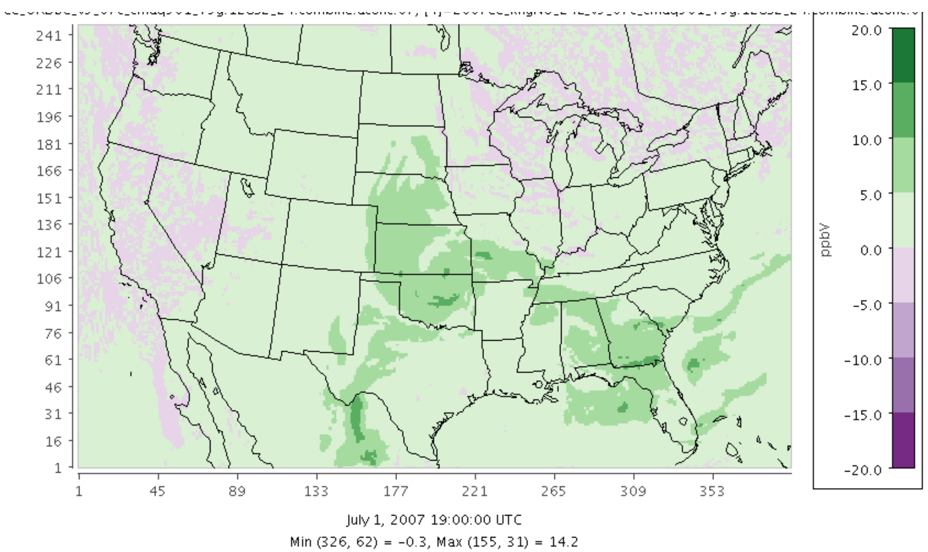
LTNG NO – July 1st 19 UTC



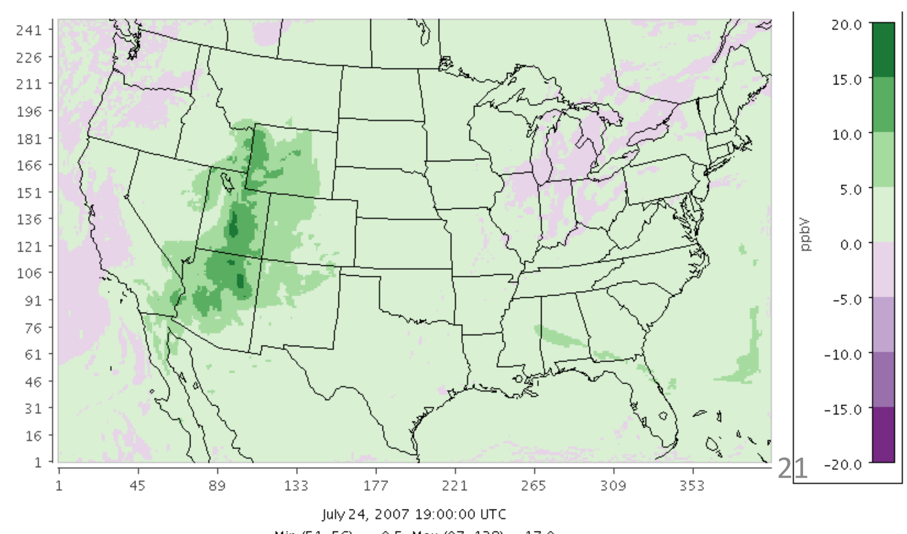
LTNG NO – July 24th 19 UTC



(LGTN NO – Benchmark) – July 1st 19 UTC



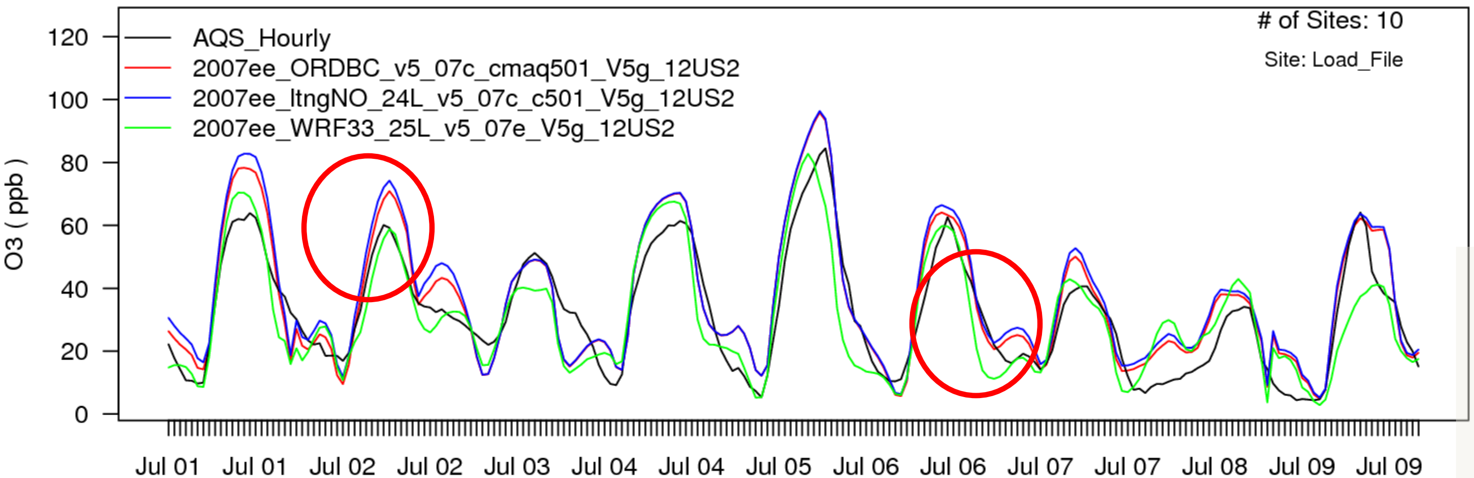
(LGTN NO – Benchark) – July 24th 19 UTC



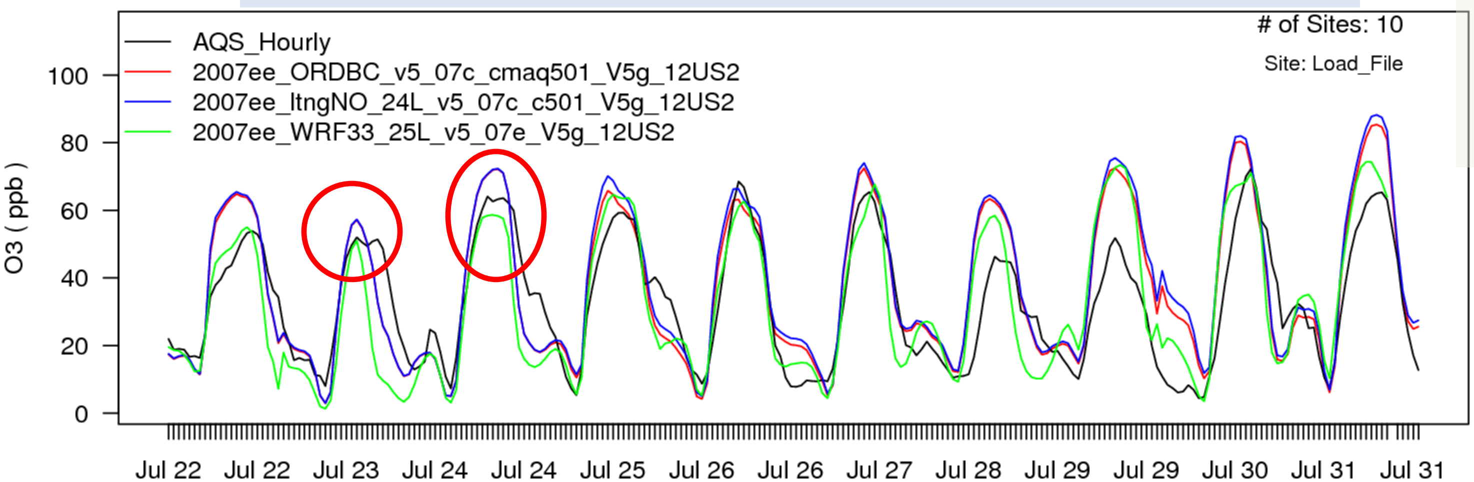
Atlanta - 2007 July Hourly Ozone

v5.0.1 vs LTNG NO vs Meteorology

July 1st – 9th



July 22th – 31st



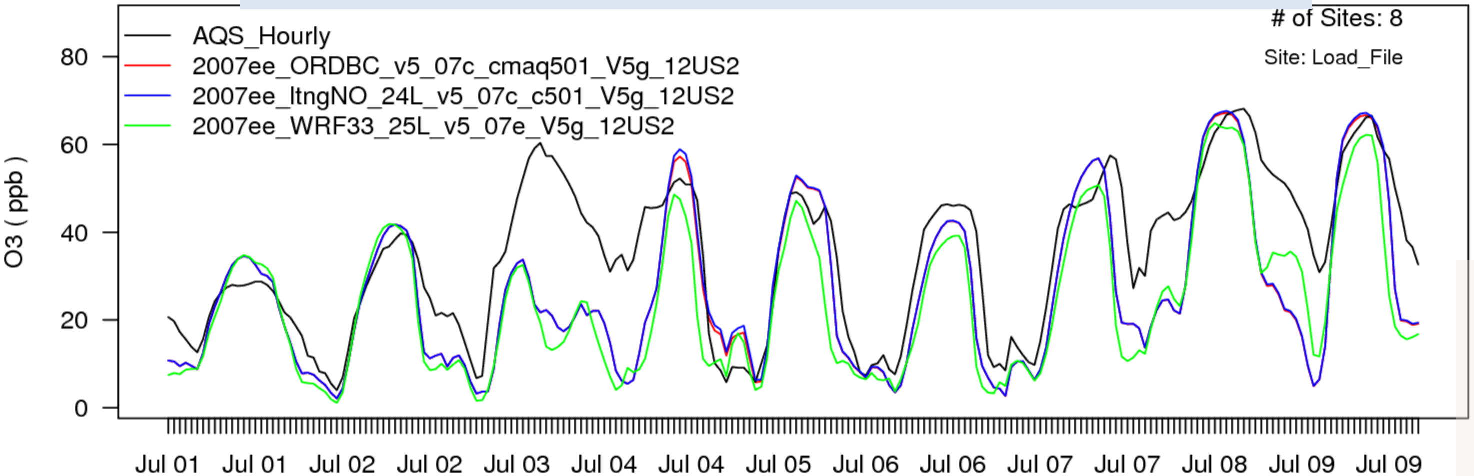
- New meteorology (**green**) tends to lower both daytime and nighttime ozone

- Lightning NO emissions (**blue**) cause small increases in ozone on select days

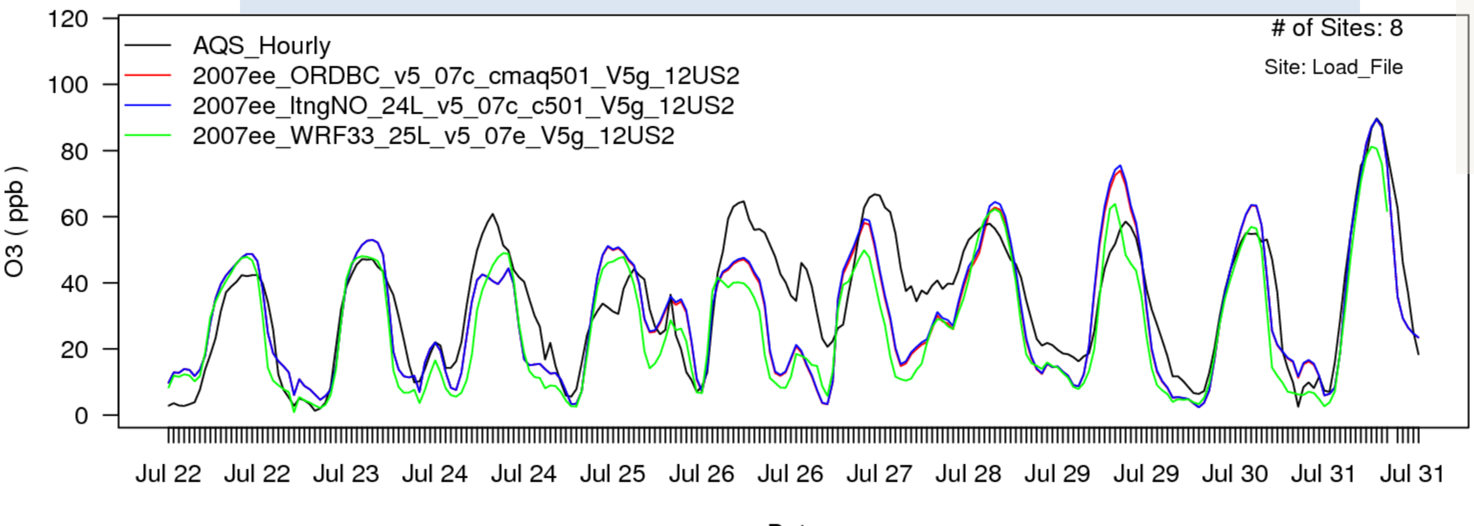
Detroit - 2007 July Hourly Ozone

v5.0.1 vs LTNG NO vs Meteorology

July 1st – 9th



July 22nd – 31st



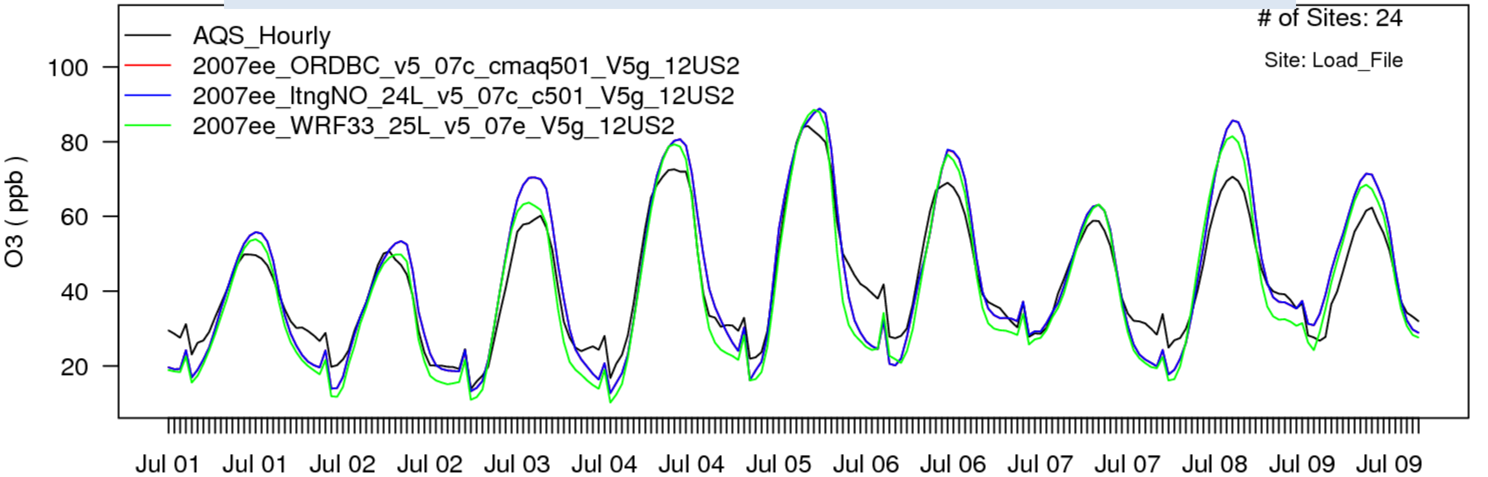
- New meteorology (**green**) tends to lower both daytime and nighttime ozone

- Lightning NO emissions (**blue**) cause little change in ozone on select days

Sacramento - 2007 July Hourly Ozone

v5.0.1 vs LTNG NO vs Meteorology

July 1st – 9th



July 22th – 31st