

The Impact of Biogenic VOC Emissions on Tropospheric Ozone Formation in the Mid-Atlantic Region



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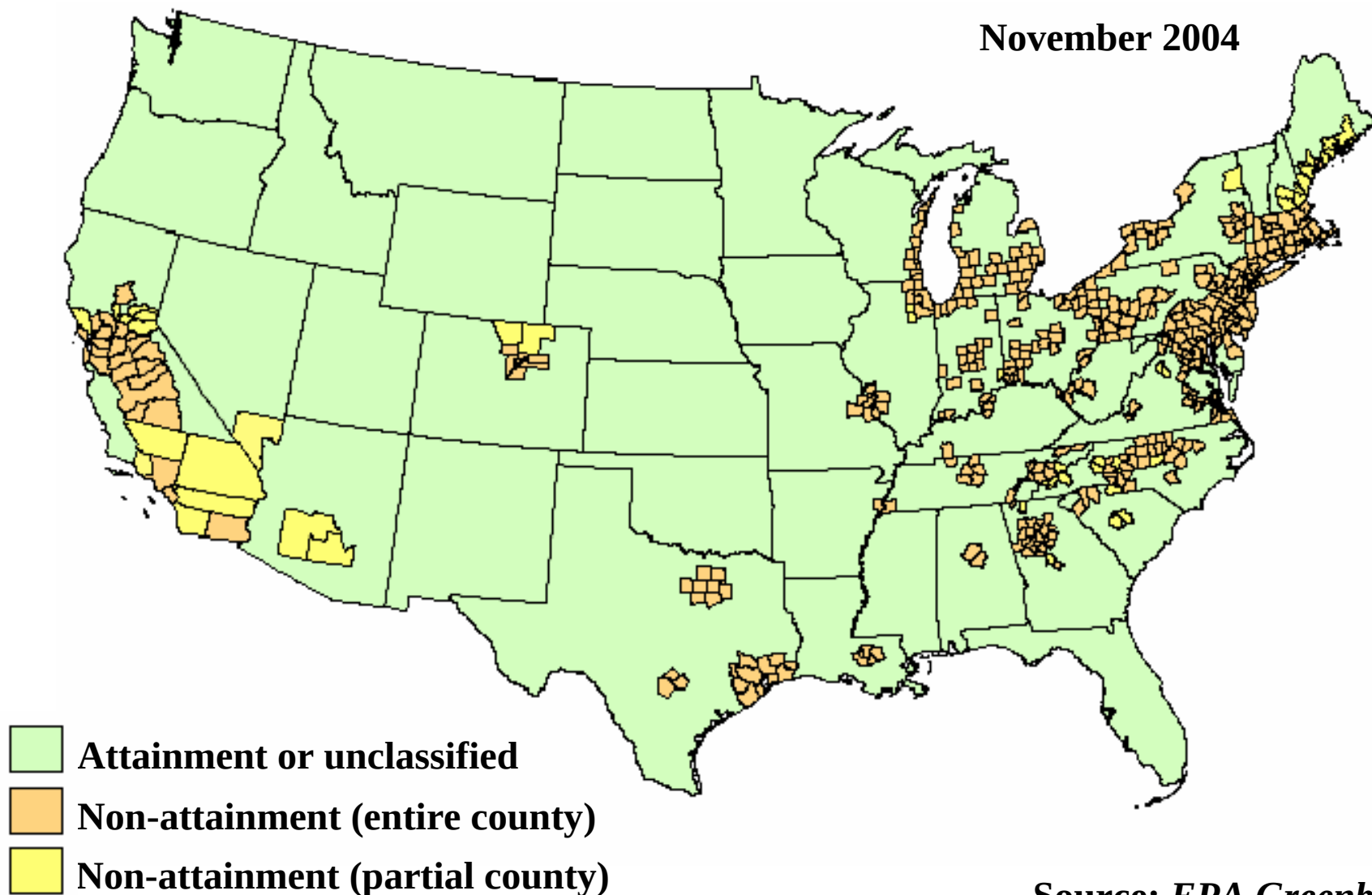
Air Pollution 2005
May 17, 2005

Tropospheric Ozone (O₃)

- Secondary pollutant formed by complex chemical reactions including NO_x and Volatile Organic Compounds (VOCs)
- Linked to human health effects including decreased lung function and increased emergency room visits
- Subject to NAAQS under the U.S. Clean Air Act
- Estimating O₃ concentrations important from a public health and regulatory standpoint

Attainment of 8-Hour Standard

November 2004



Source: *EPA Greenbook*

Air Quality Modeling

Inputs:

Meteorology
Wind
Precipitation
Solar Radiation

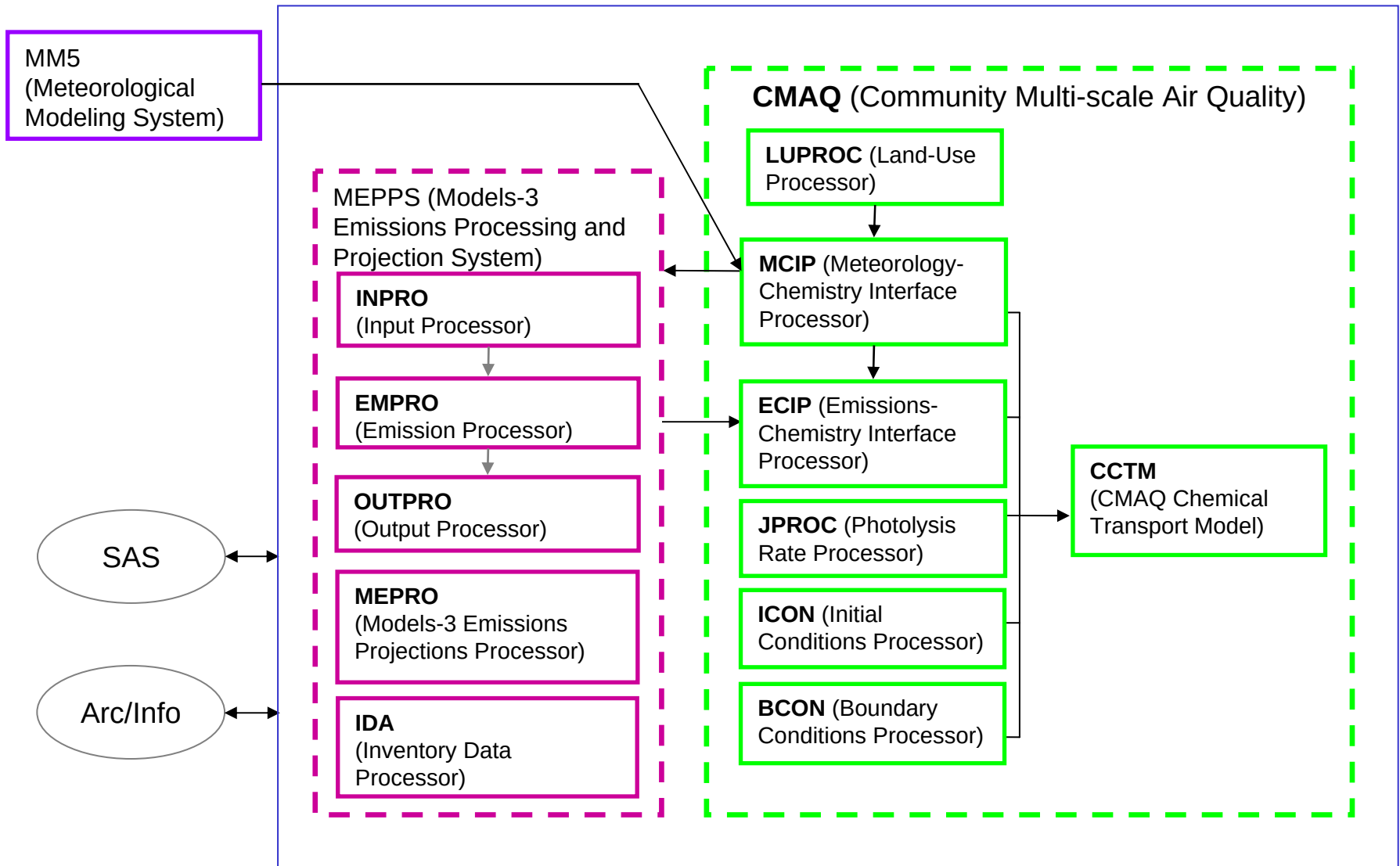
Emissions:
Transportation
Industry
Biogenic

Land-Use

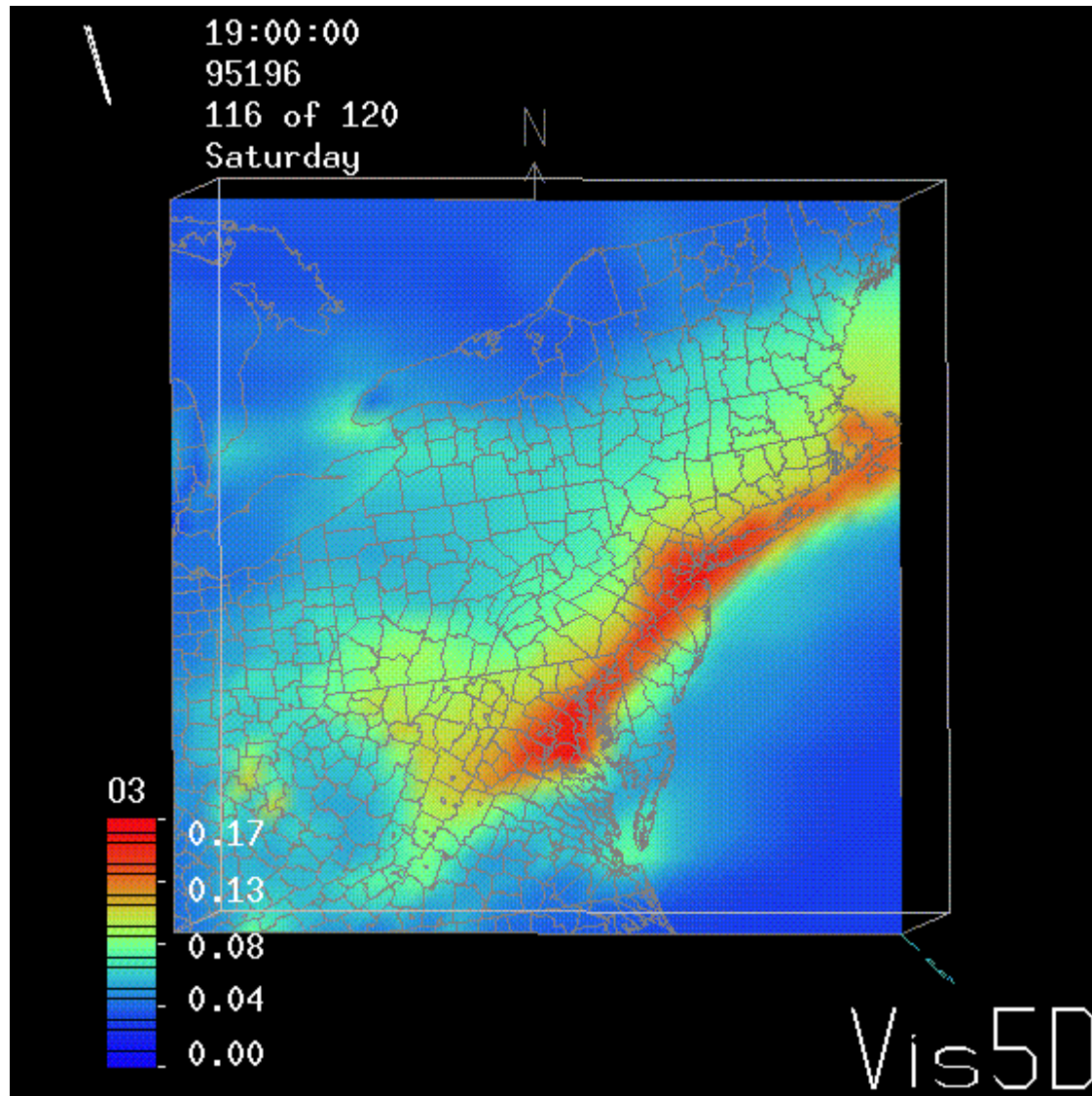
Terrain



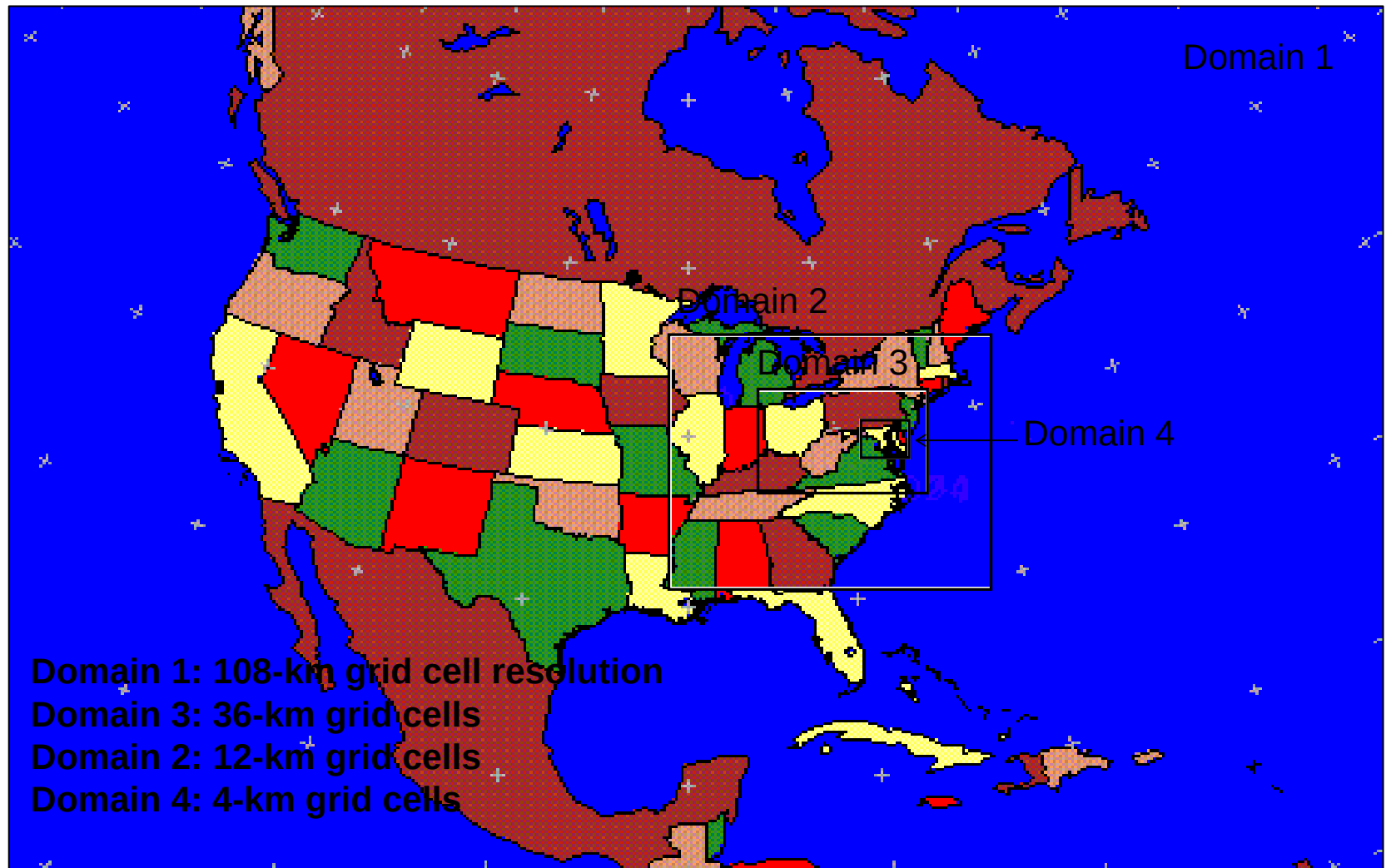
Models-3 Framework



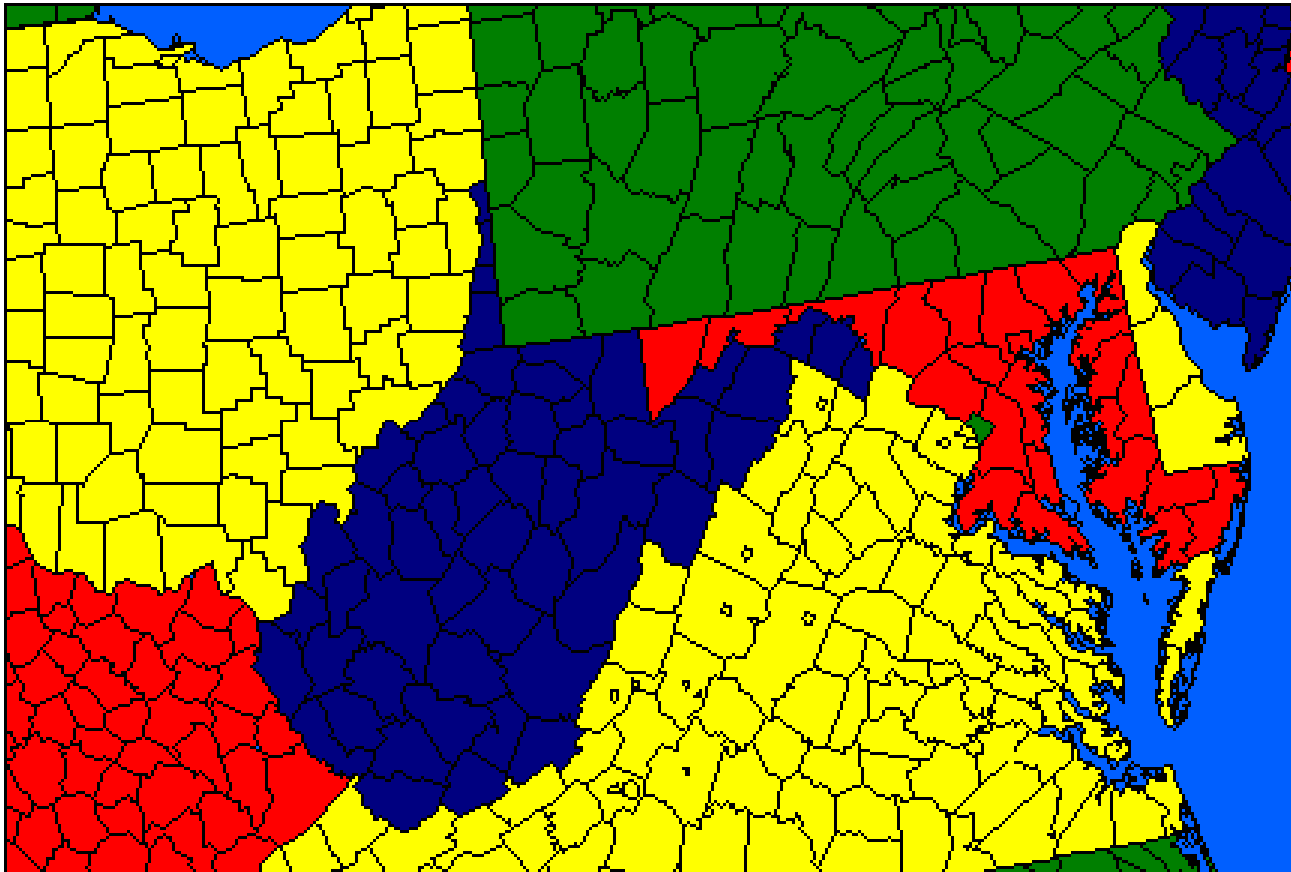
Sample Output



Case Study Area (Mid-Atlantic, USA)

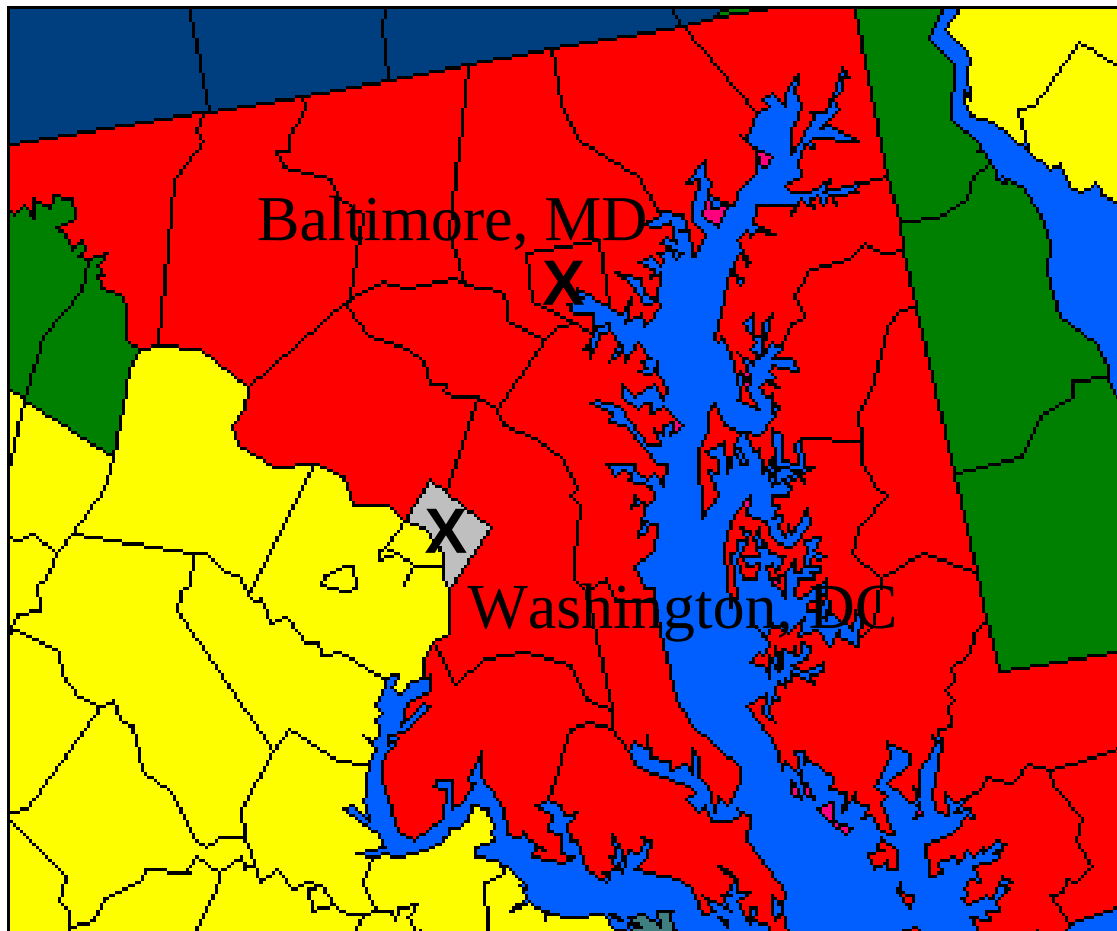


12-km Resolution Domain



42 Rows
69 Columns
2898 Cells

4-km Resolution Domain (Maryland)



45 Rows
60 Columns
2700 Cells

Model Evaluation

- How well does the modeling system perform?
- Are ozone estimates reasonable approximations of monitor values?
- Several approaches applied comparing model estimates to monitor measurements

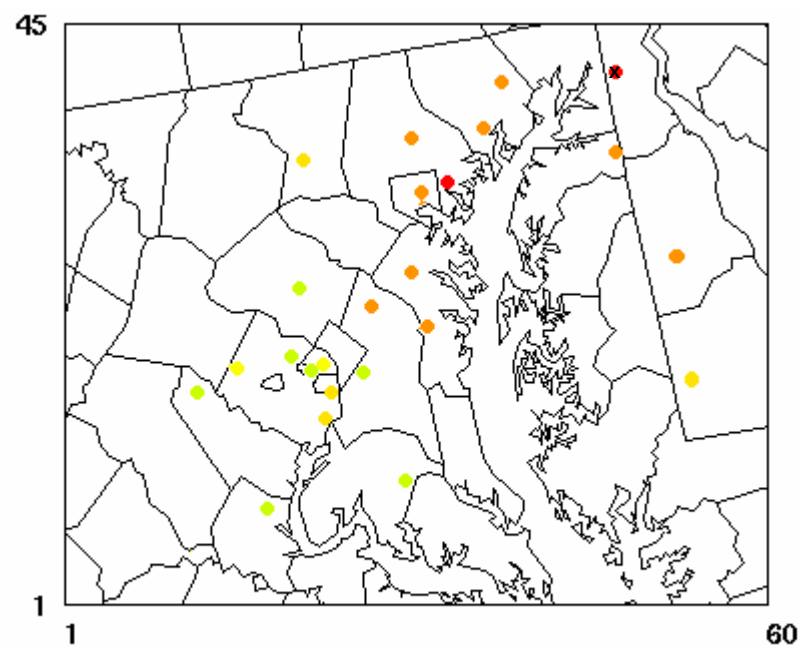
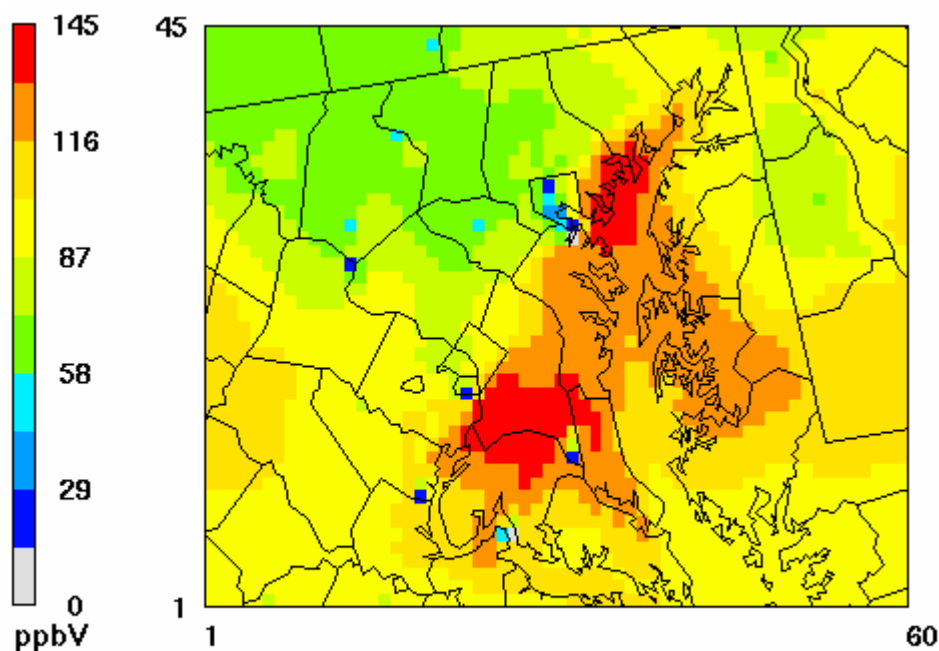
(Bell & Ellis *Atmospheric Environment* 2004)

- E.g. Mean bias = 6.2 ppb

$$D = \frac{1}{N_T} \sum_{i=1}^N \sum_{j=1}^{H_i} (c_o(i, j) - c_p(i, j))$$

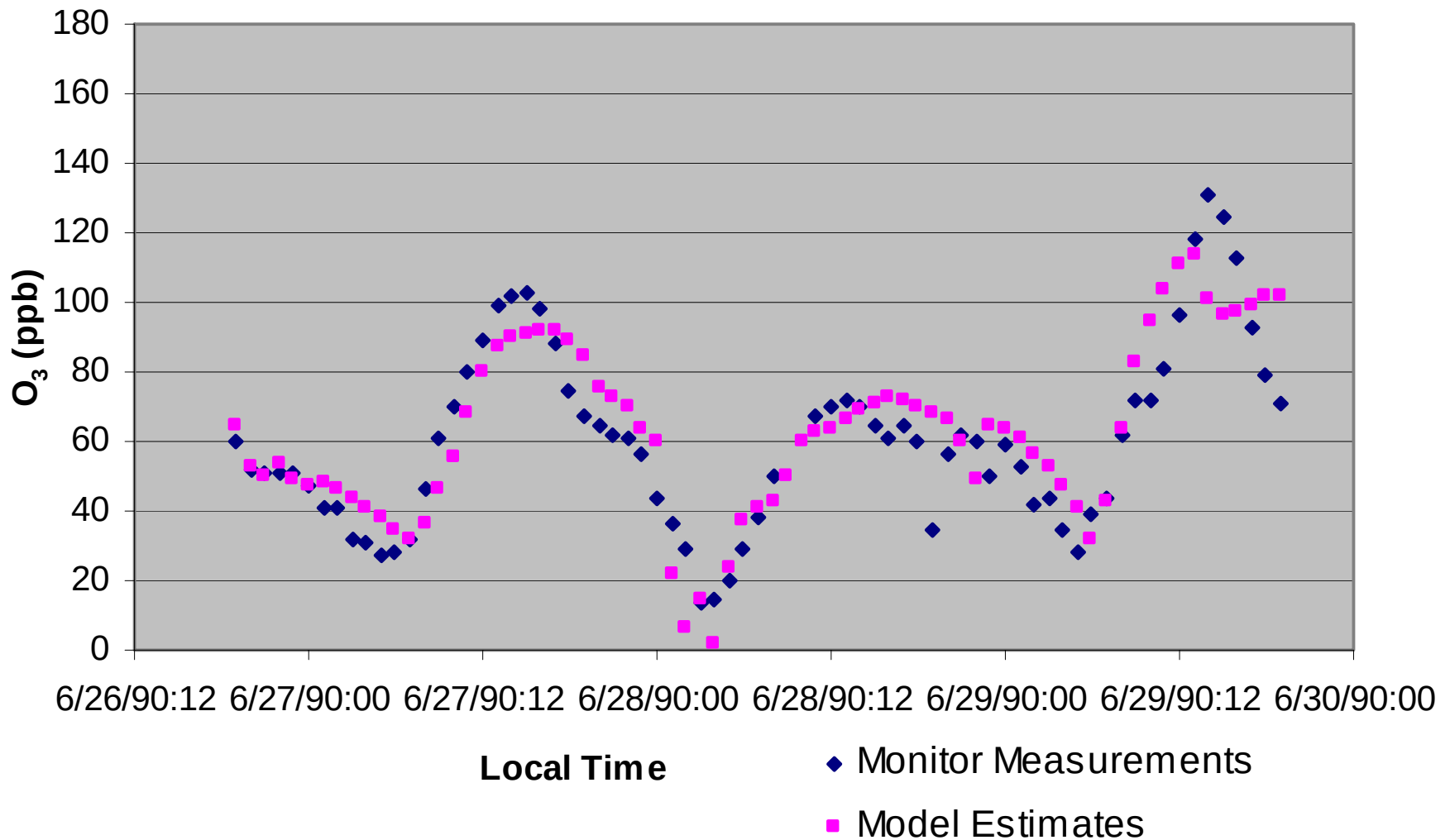
Comparison of Values at Hour of Maximum Concentration

July 13 to 15, 1995

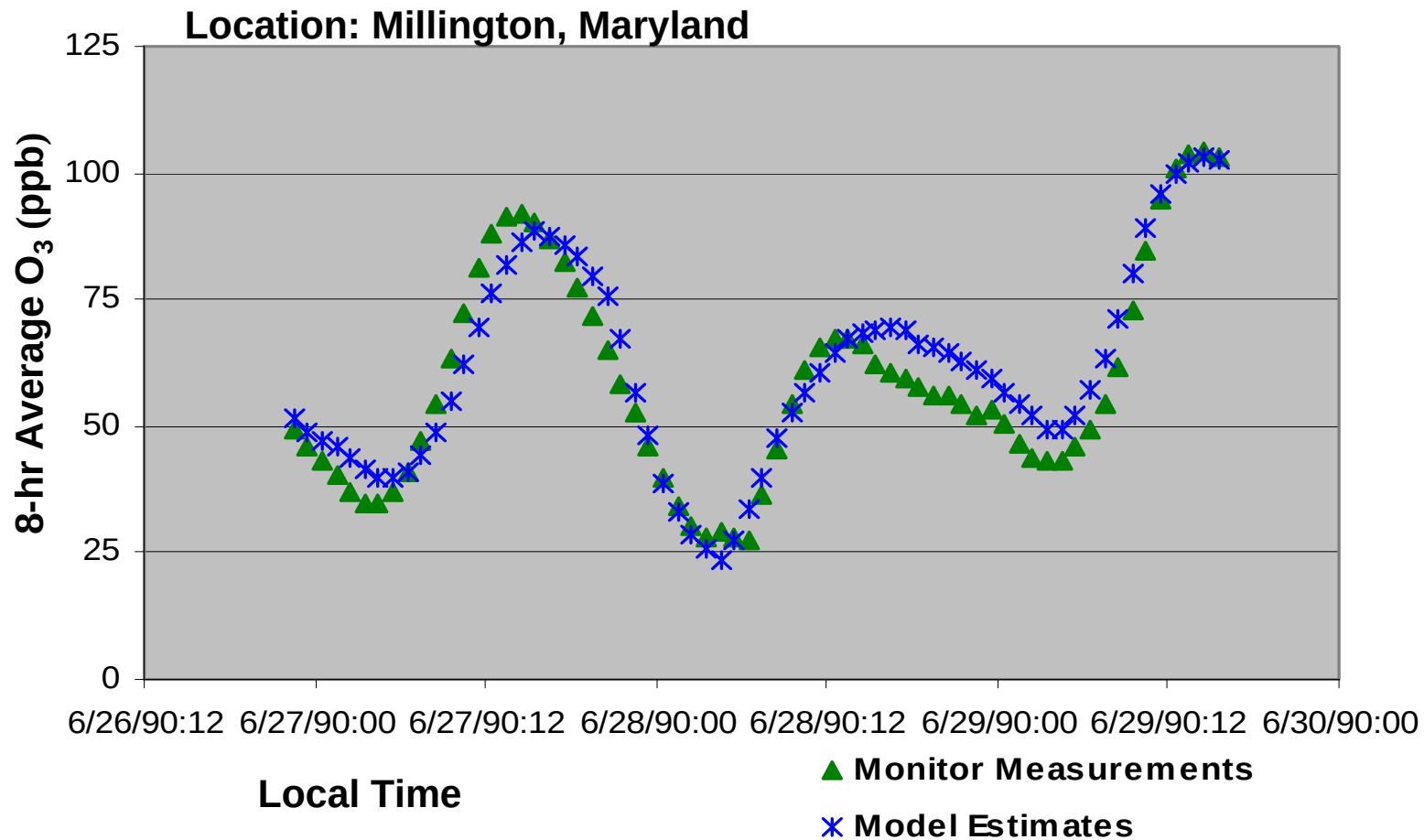


Comparison of Model Estimates and Measurements

Location: Millington, Maryland



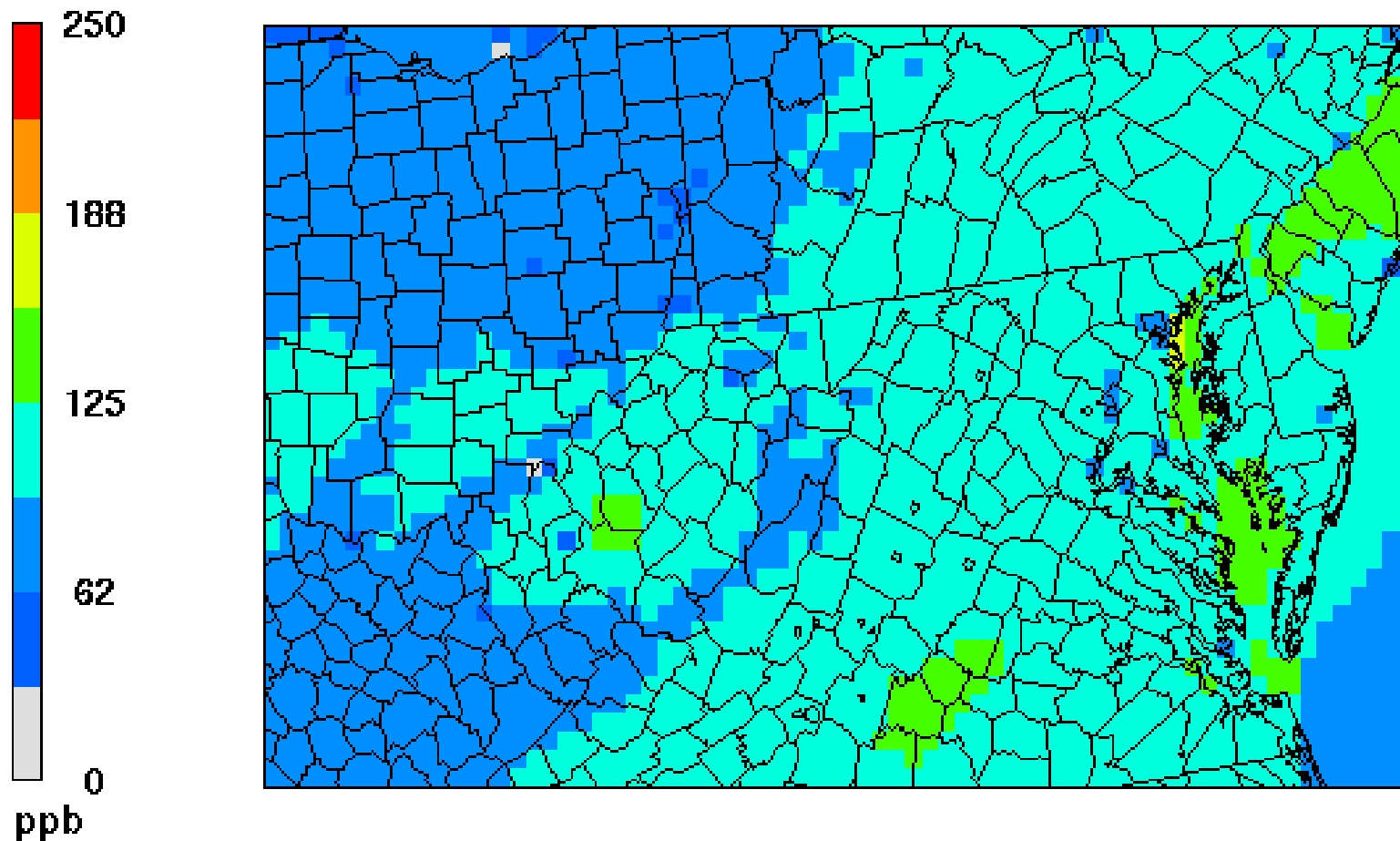
Comparison of Model Estimates and Measurements (8-hour average)



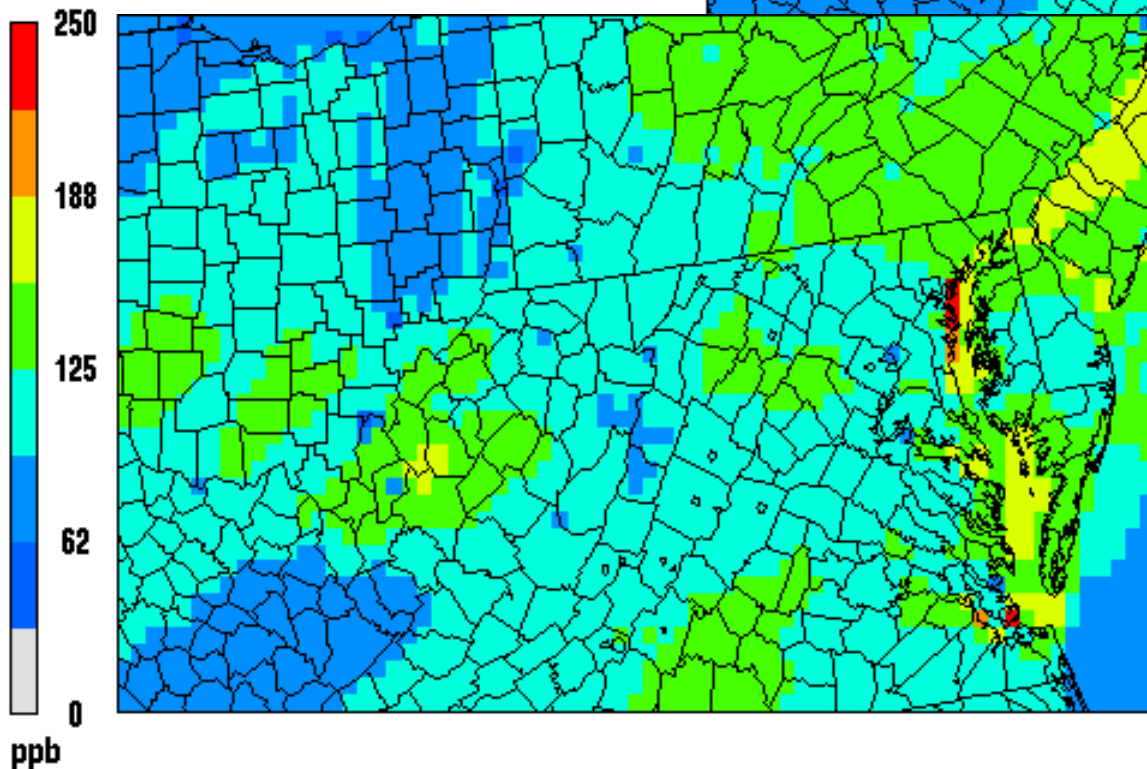
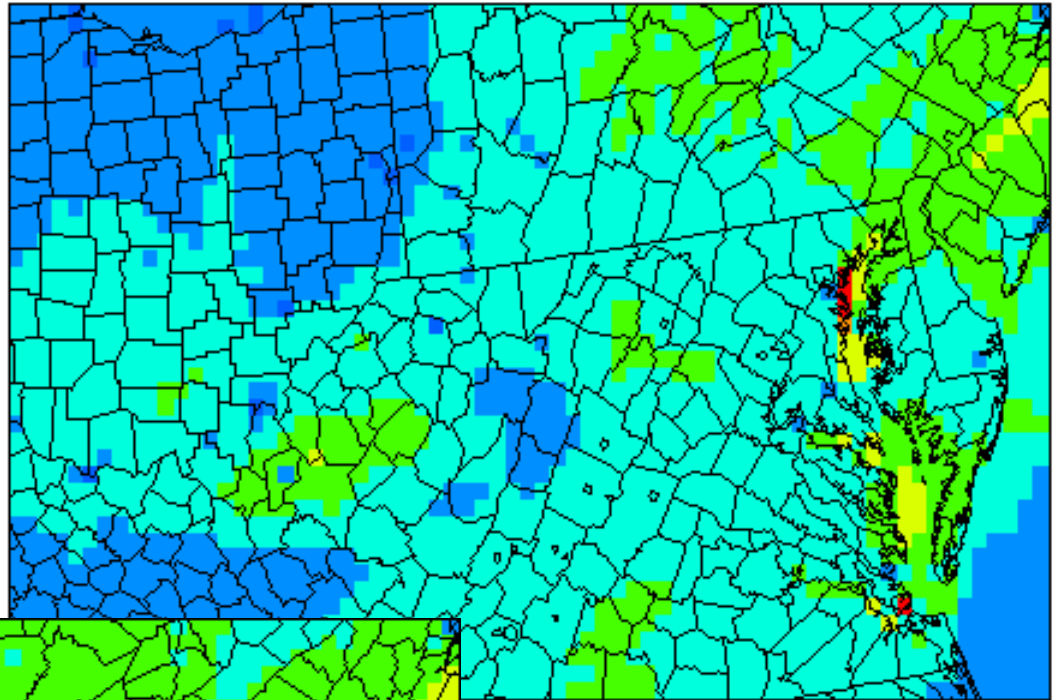
Modeling Simulations

- 27June1990 (h 00) to 30June1990 (h 00) (GMT)
 - High ozone episode
- Emissions Scenarios
 - Baseline (actual emissions)
 - 100% increase in biogenic emissions
 - 100% increase in biogenic and motor vehicle emissions

Baseline Scenario (Maximum O₃ Concentration)



Scenario B
Biogenics 100%



Scenario C
Biogenics and
Motor Vehicles
100%

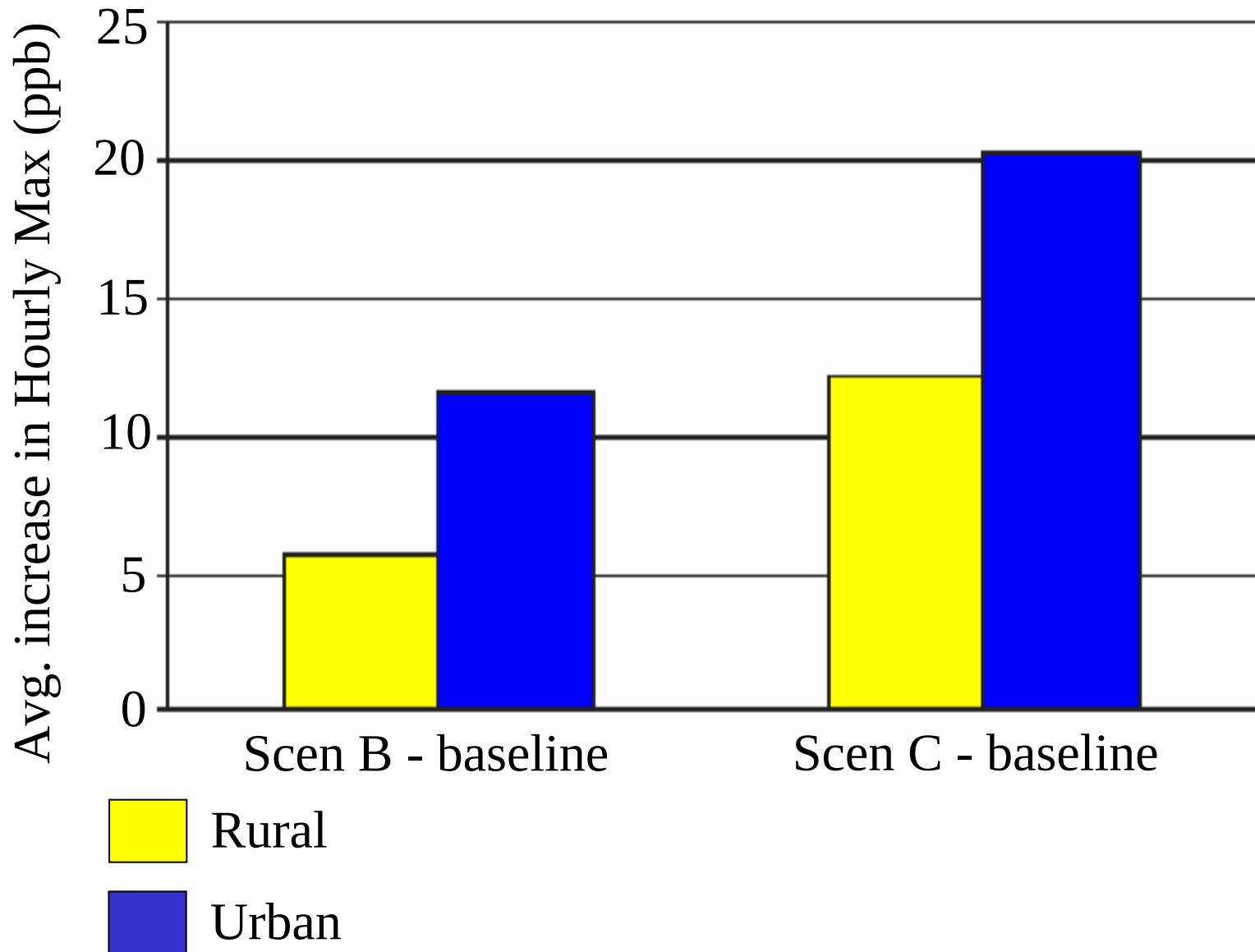
Scenario Comparisons

- Ozone Concentrations
 - Maximum hourly average, maximum 8-hour average, daily average, episode average, domain-wide average, etc.
 - Absolute values, increases, relative increases
 - Comparisons are affected by what pollution metric is used (Bell & Ellis *JAWMA* 2005)

Scenario Comparisons – Some Results

- All emissions scenarios had higher O_3 in some areas/times and lower O_3 in others
- The increase in motor vehicle emissions had less of an impact than the same relative % increase in biogenic emissions.

Rural vs. Urban Areas

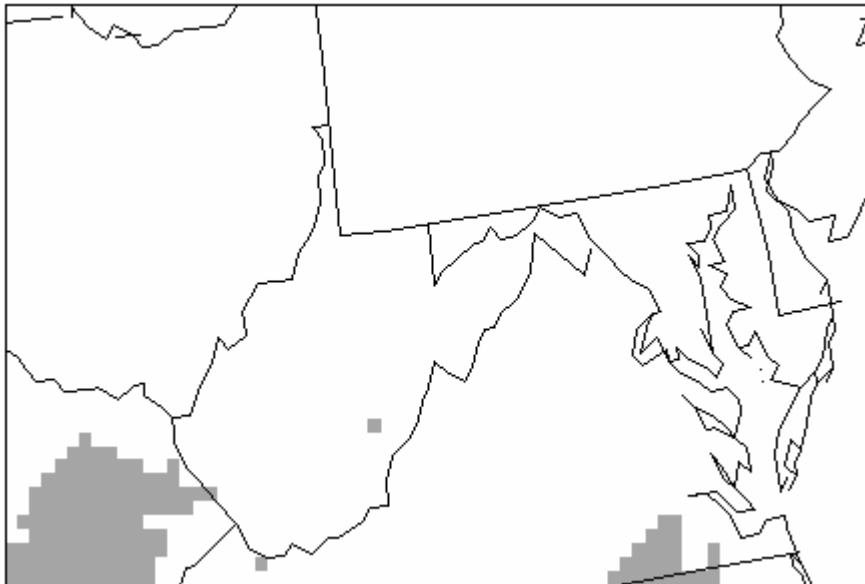


VOC vs. NO_x- sensitivity

- 13July1995 (h 00) to 15July1995 (h 00) (GMT)
- Scenarios
 - Baseline scenario (actual emissions)
 - VOCs and NO_x increased 25%
 - VOCs only increased 25%
 - NO_x only increased 25%



Areas for which the
VOC increase always
resulted in higher O₃
than the NO_x increase.



Areas for which the
NO_x increase always
resulted in higher O₃
than the VOC increase.

Concluding Thoughts

- +Air pollution modeling can be a useful tool for many purposes
 - Must believe in results (validation)

Results

- Demonstrate the importance of biogenic VOCs for the Mid-Atlantic Region of the U.S.
- Show that generalizations such as VOC-sensitivity or NO_x -sensitivity are over simplifications

Thank you