Modeling the Air Quality Impacts of Wildfires with CMAQ

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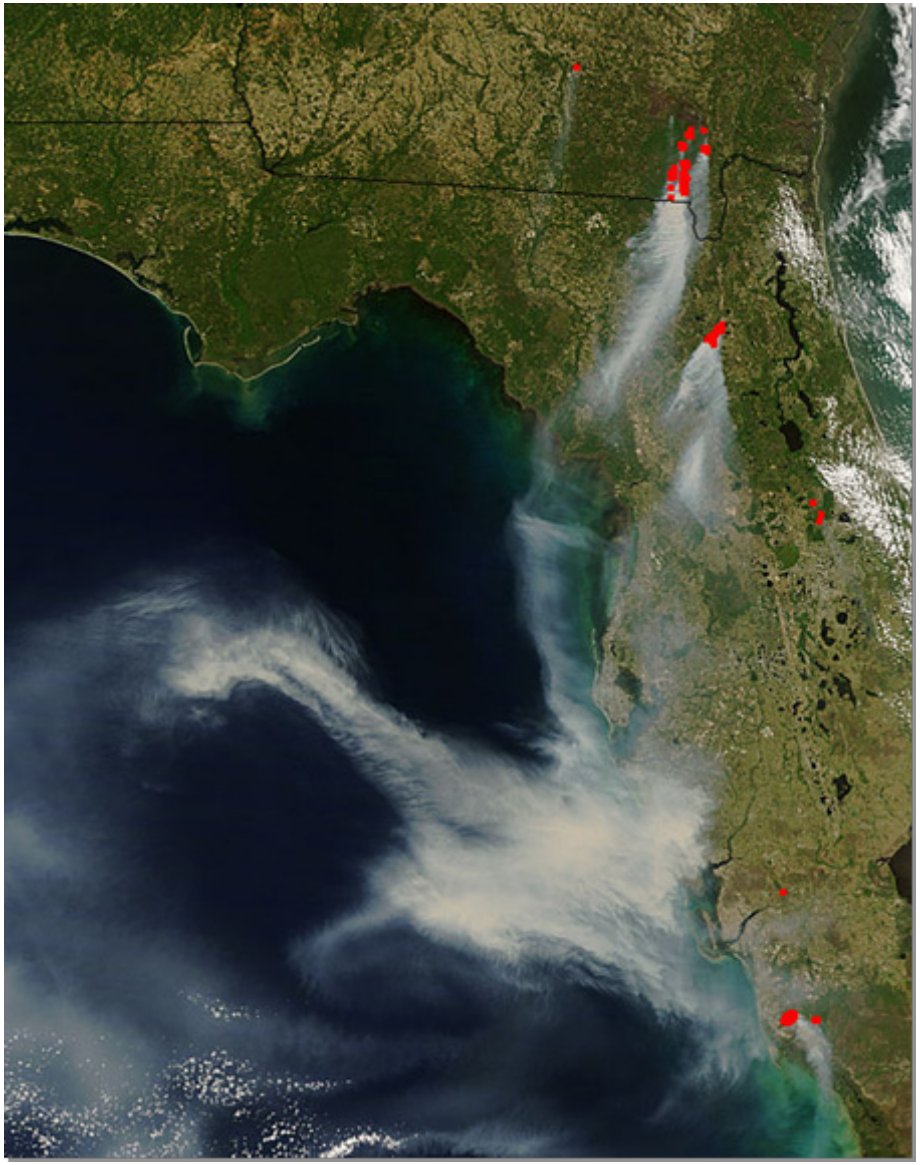
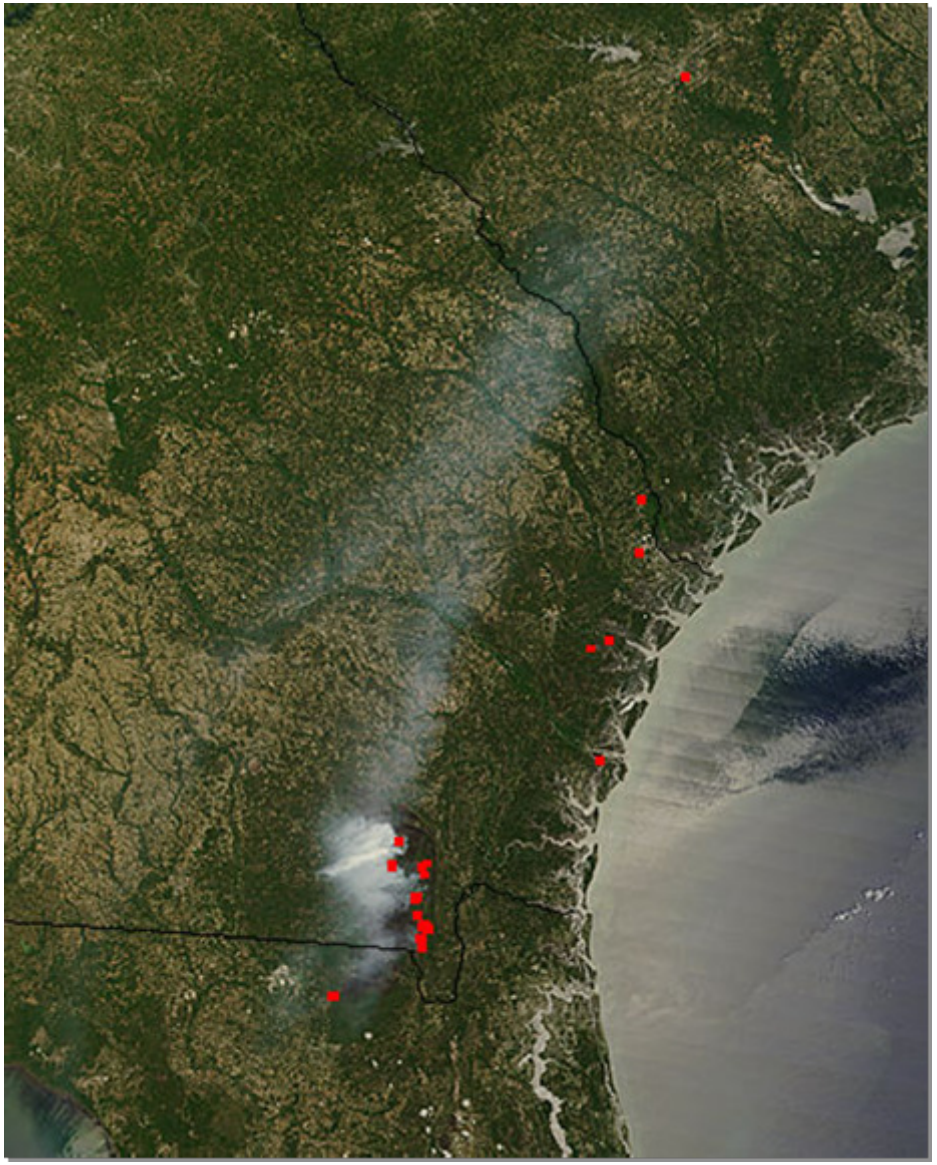
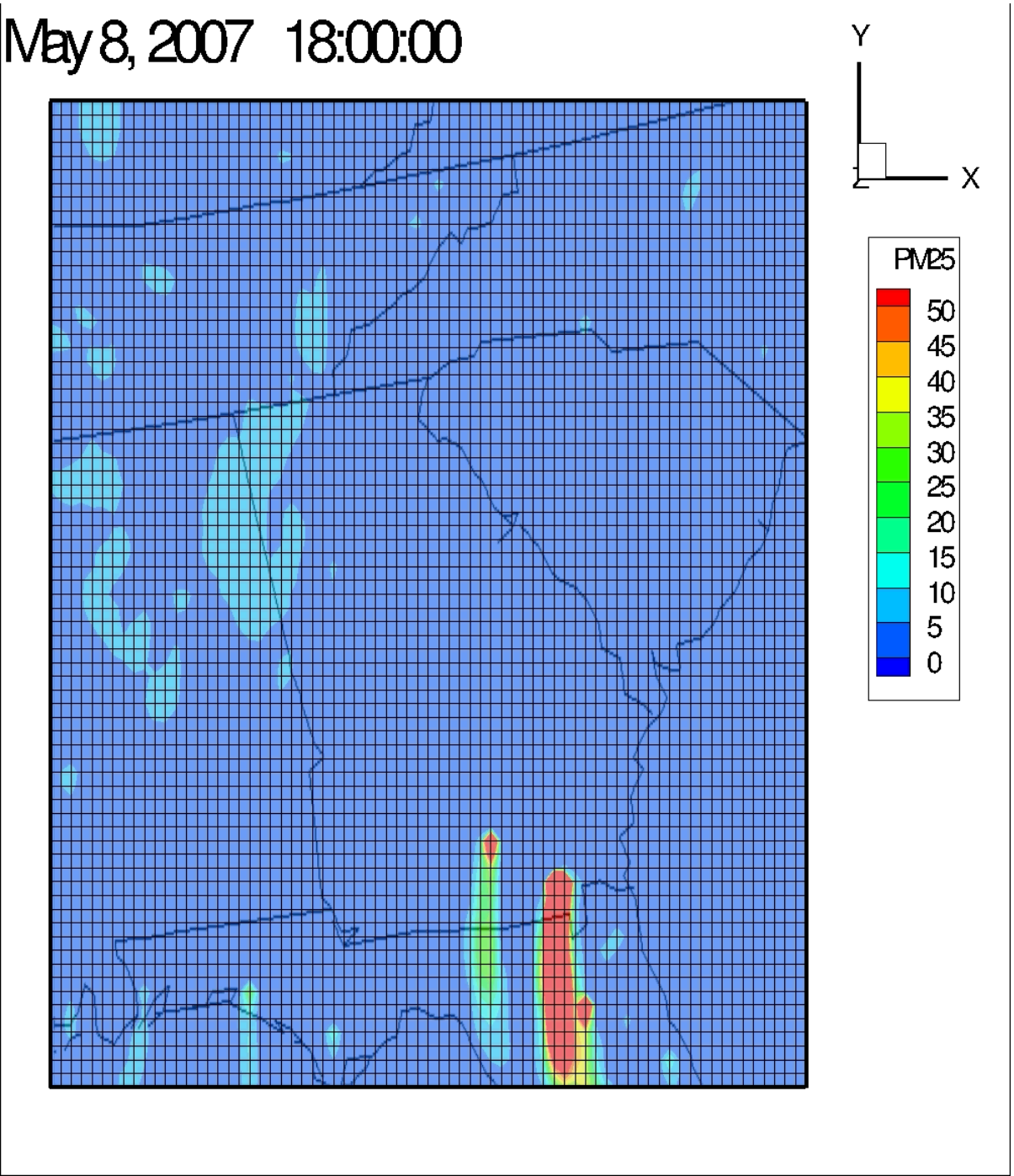
Impacts of Wildfires on Air Quality

- Wildfires may have detrimental impacts on air quality, health & visibility.
- Modeling their impact on air quality with photochemical air pollution models requires understanding the model's capabilities & uncertainties.
- Evaluations analyzing CMAQ's ability to reproduce the air quality impacts from wildfires are necessary to achieve successful simulations.

Georgia-Florida Spring 2007 Wildfires



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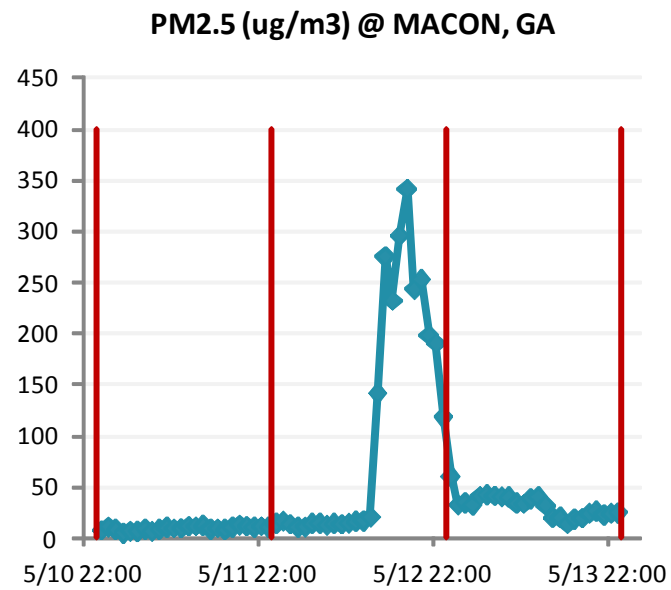
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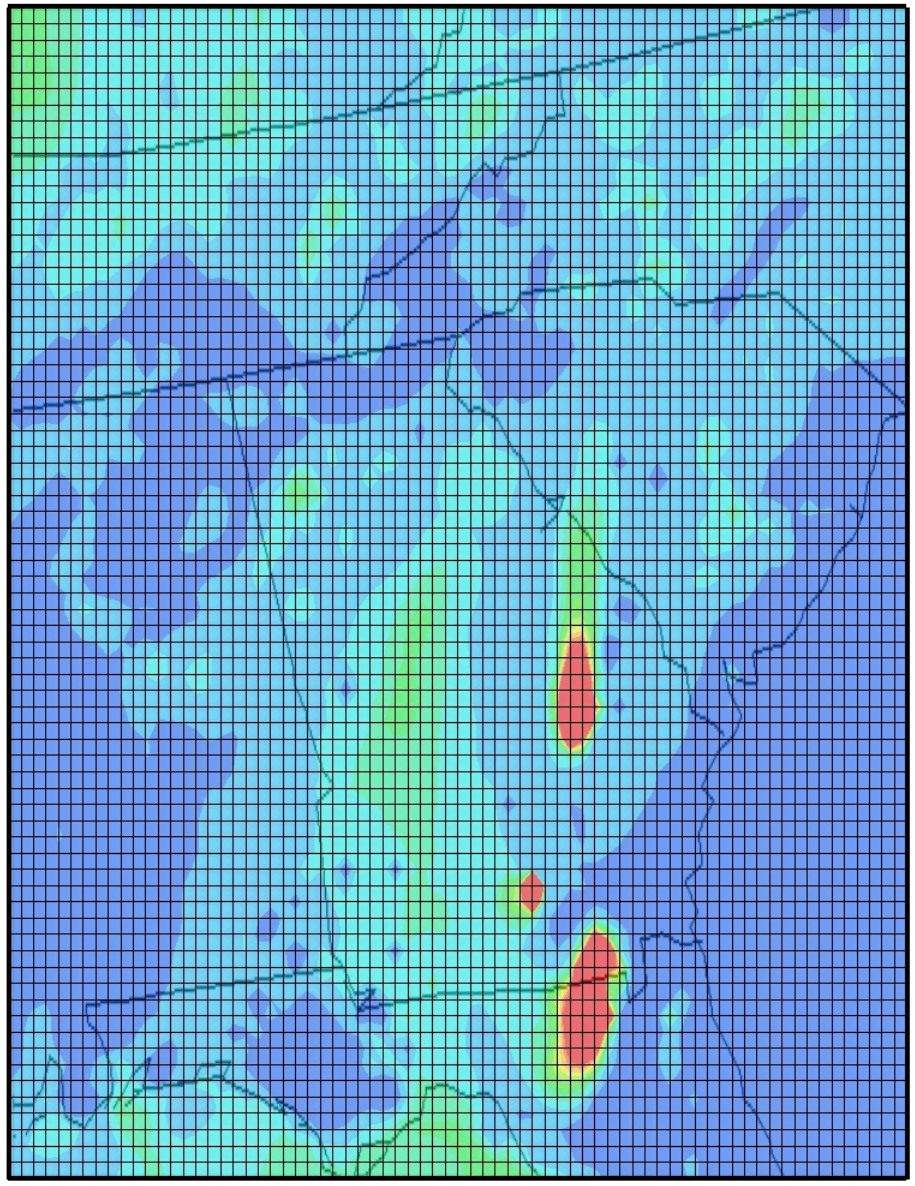

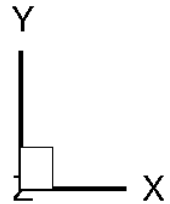

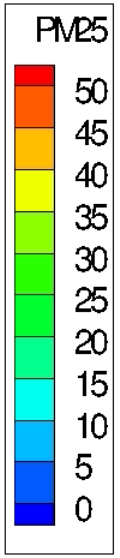

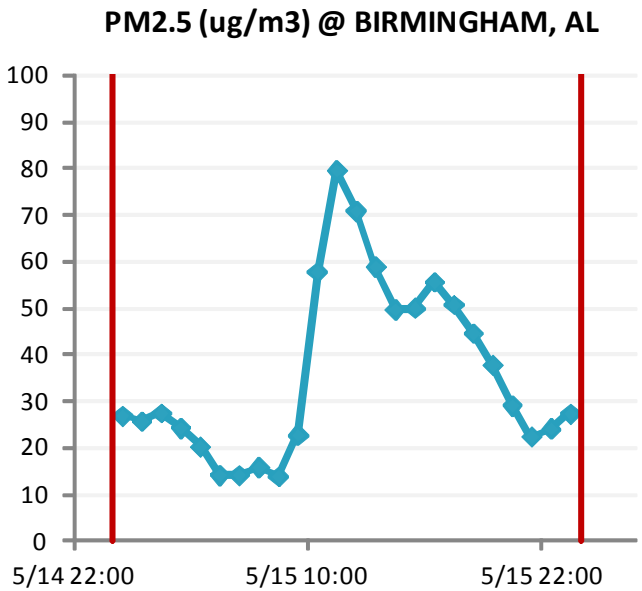

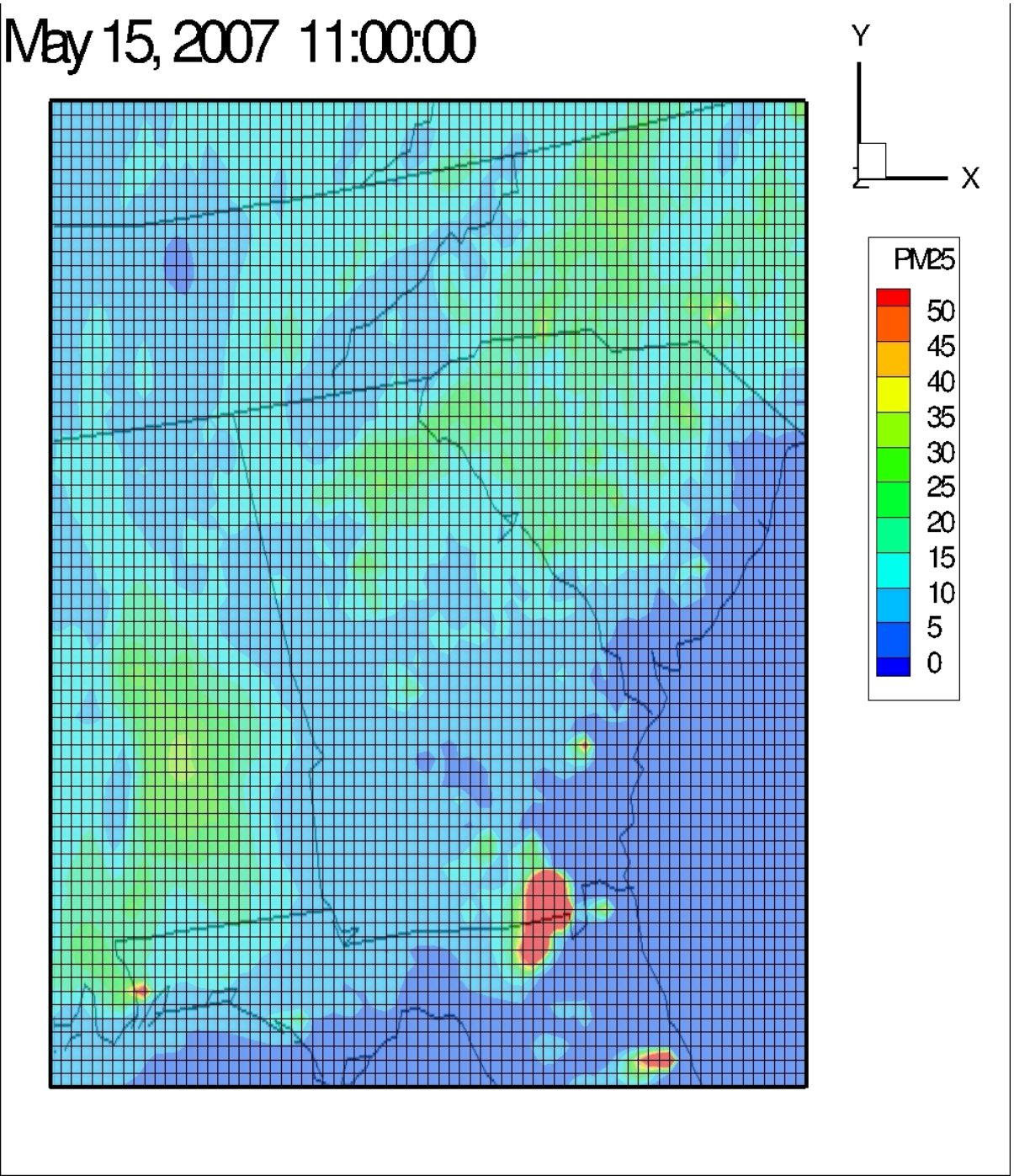
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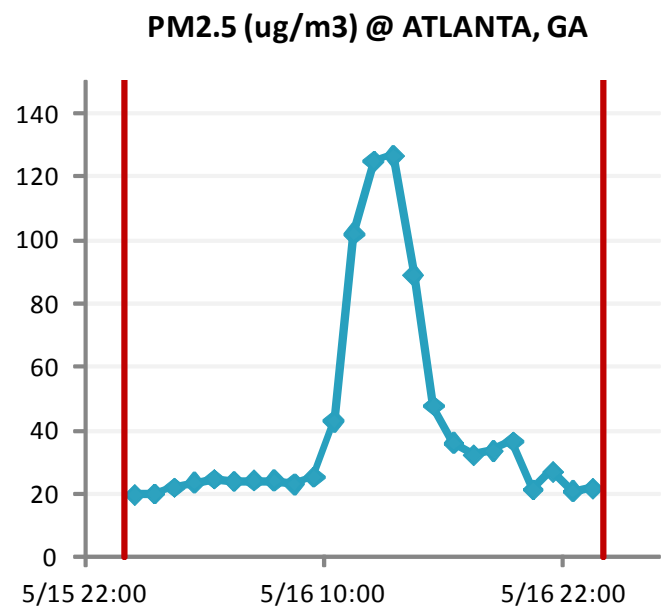
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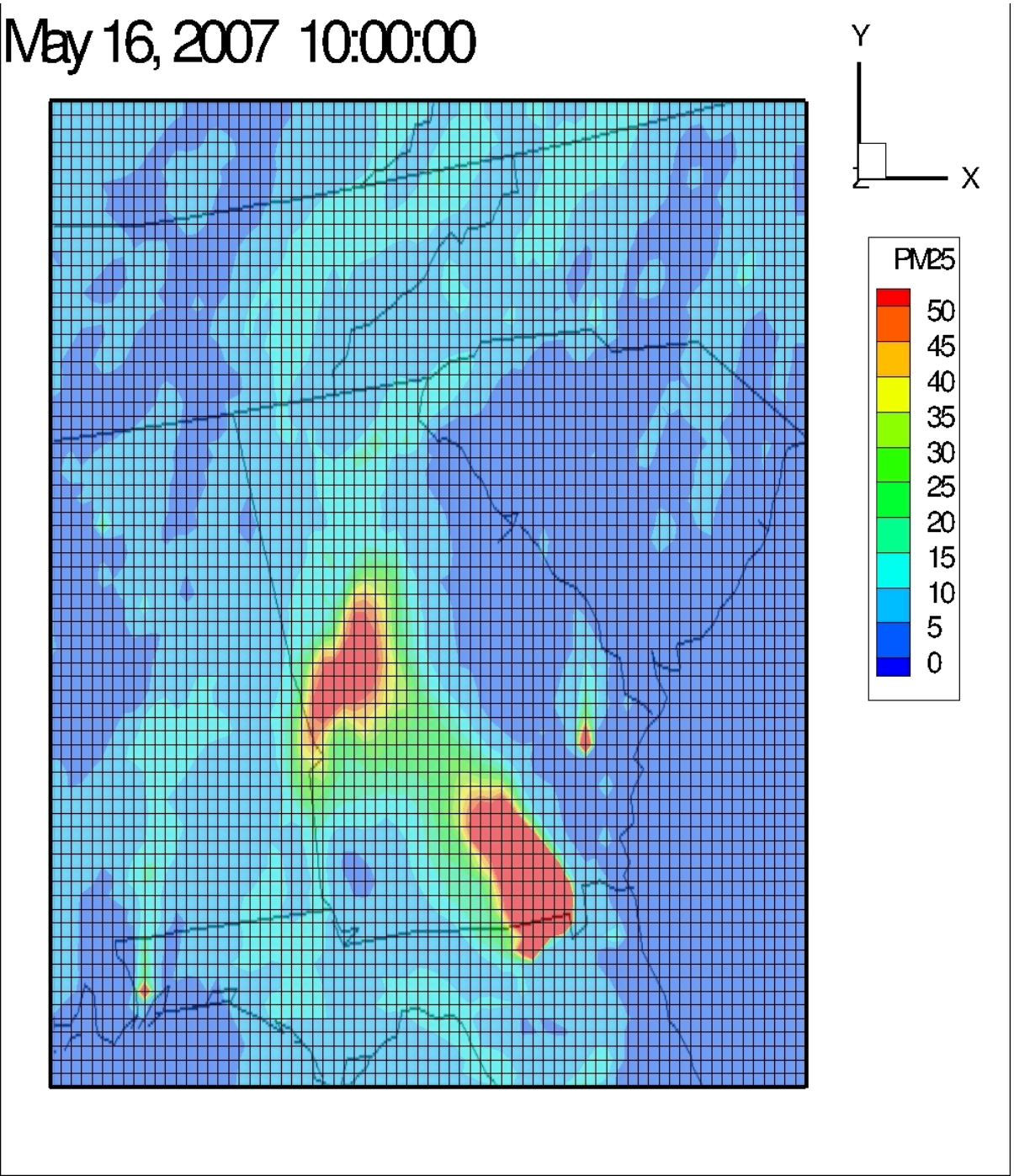
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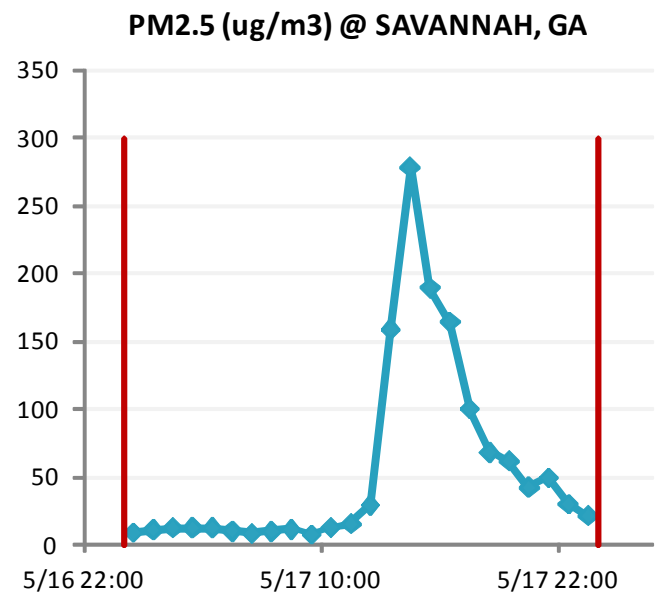
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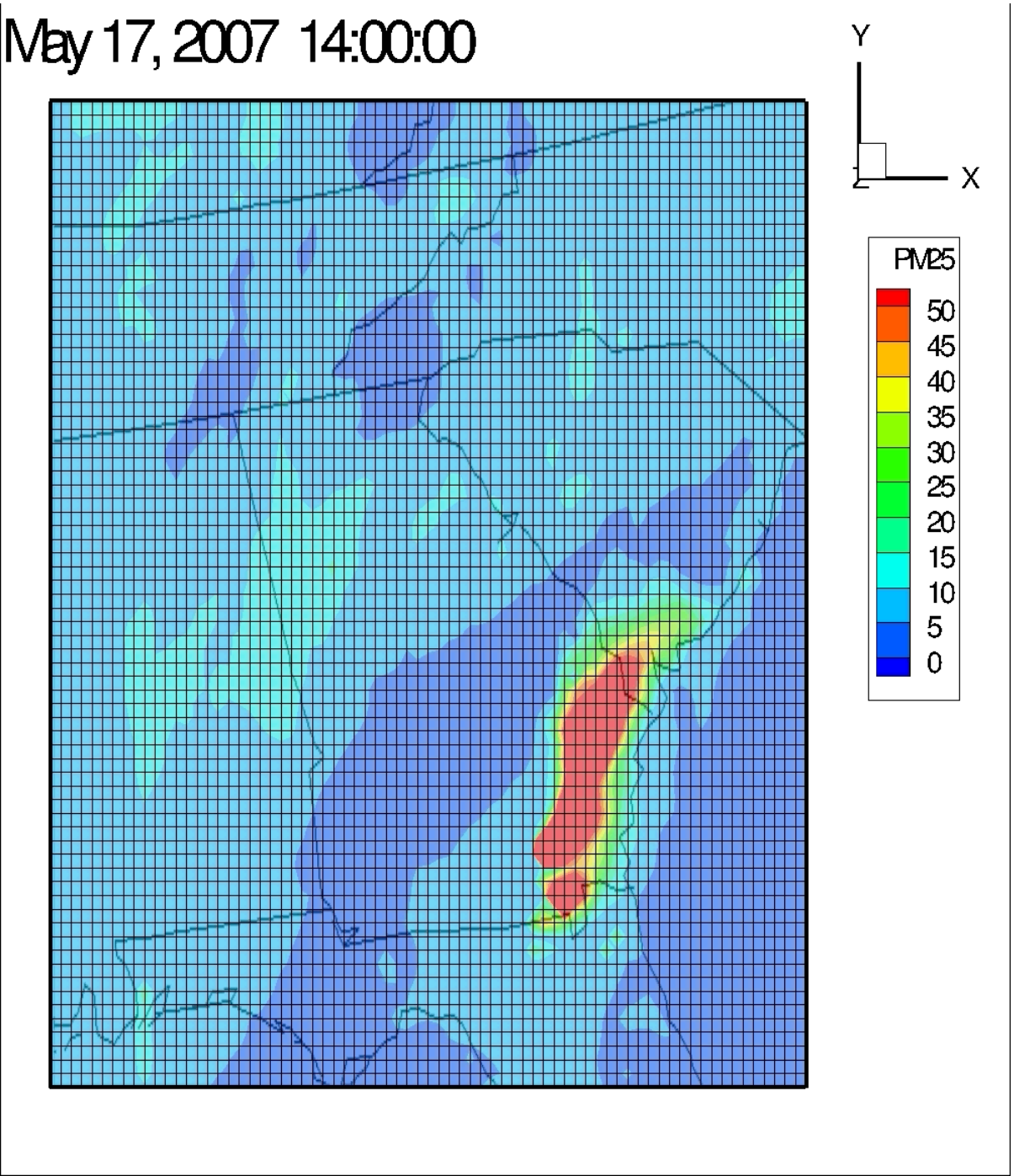
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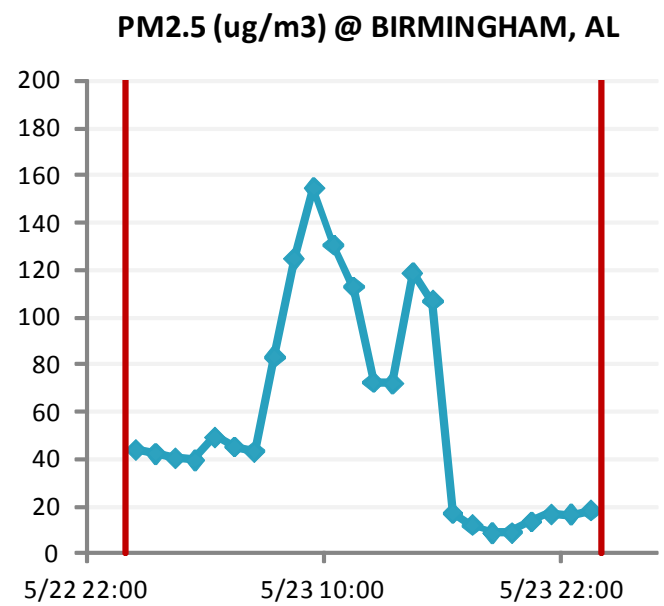
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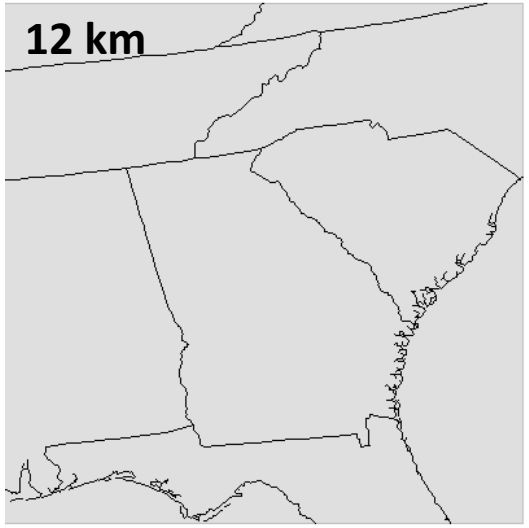
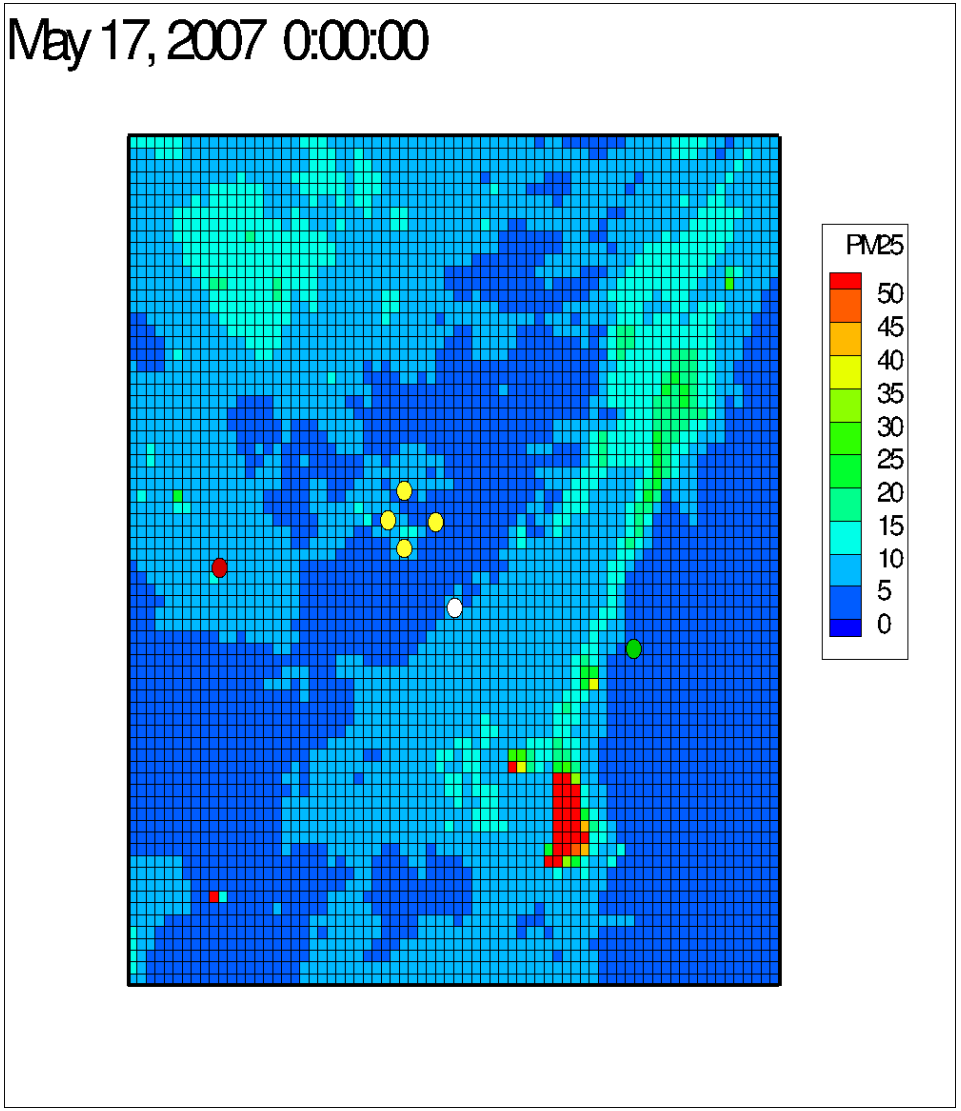
CMAQ Simulation



- **34** vertical CMAQ layers
- **<u>Fire Emissions</u>**: Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) and BlueSky modeling framework
- **<u>Background Emissions</u>**: Sparse Matrix Operator Kernel Emissions (SMOKE)
- **<u>Meteorology</u>:** Weather Research & Forecasting model (WRF)

Savannah, GA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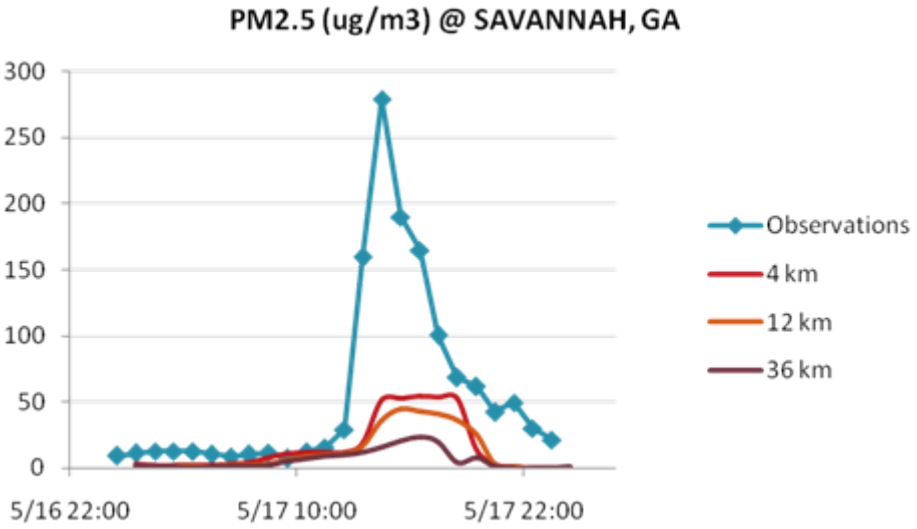
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Observations
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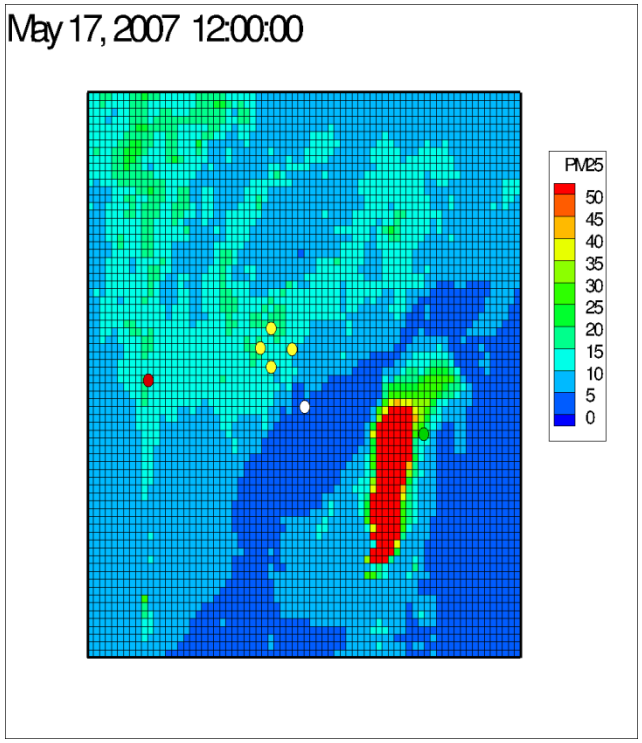
12 km
36 km

Savannah, GA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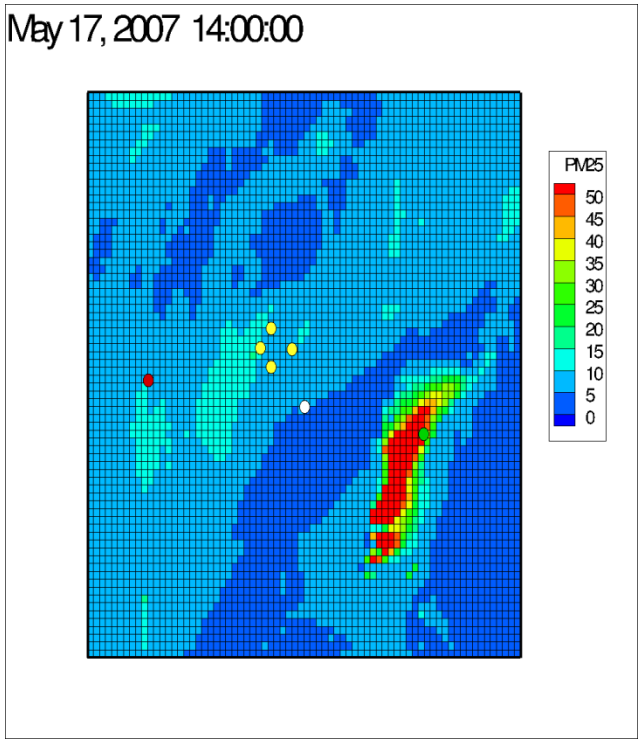
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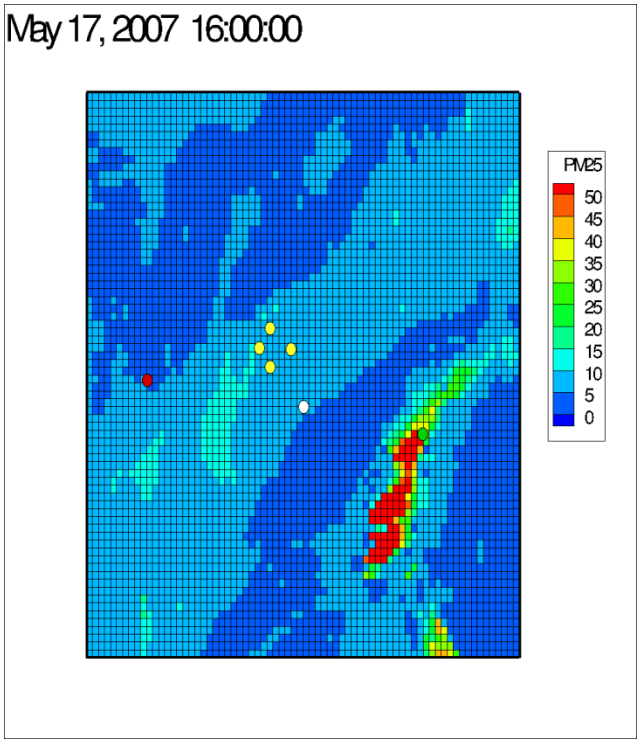
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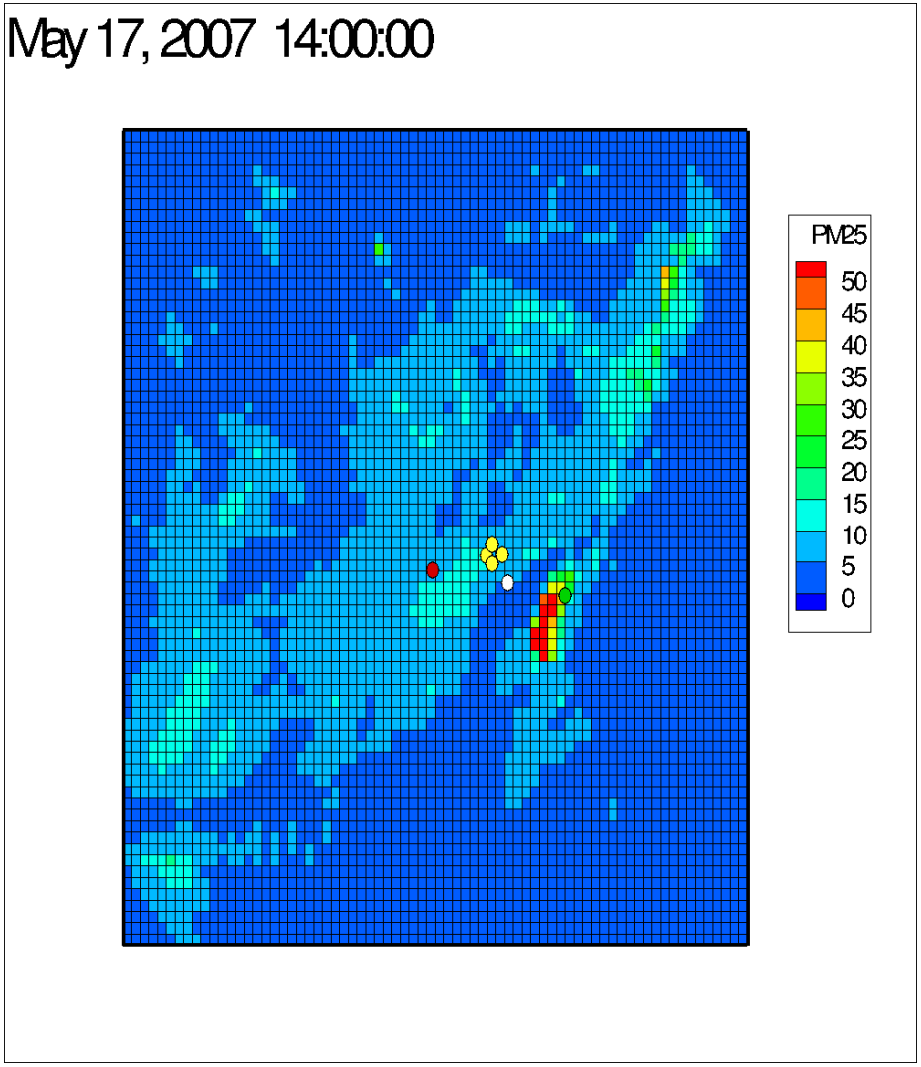
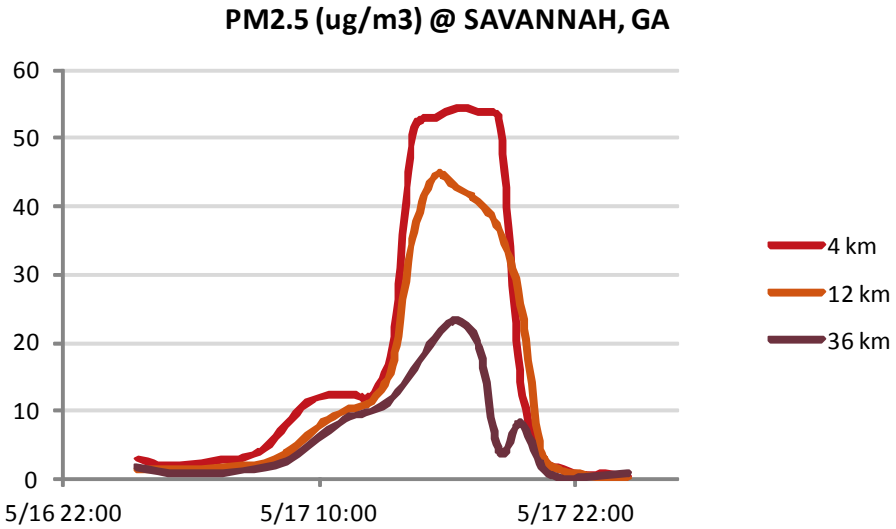
Savannah, GA: 36km Simulation





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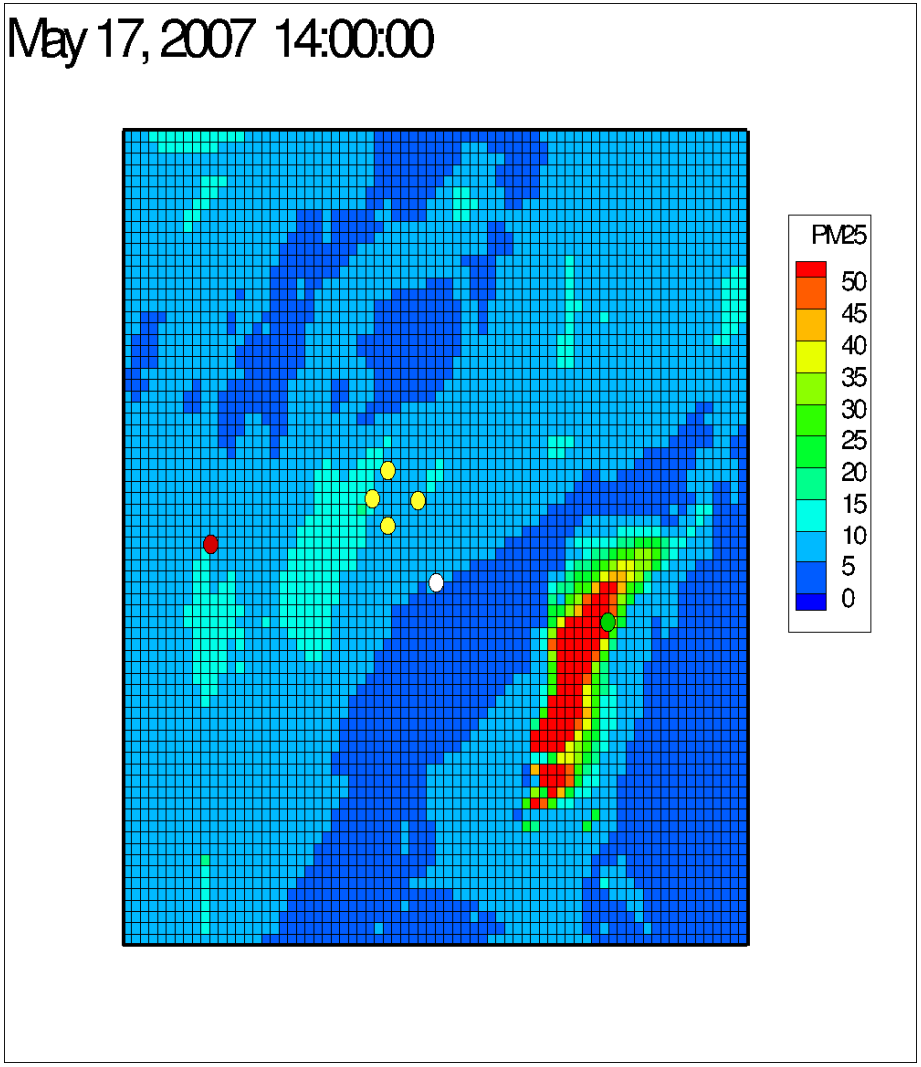
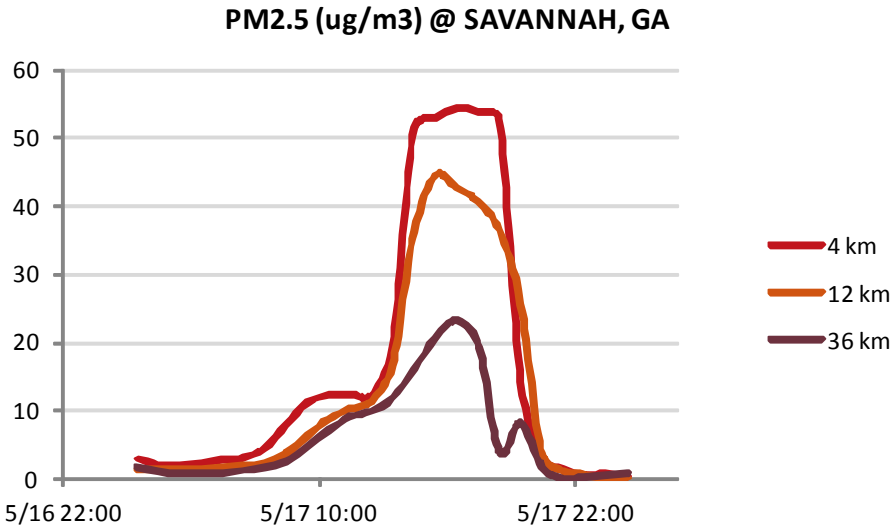
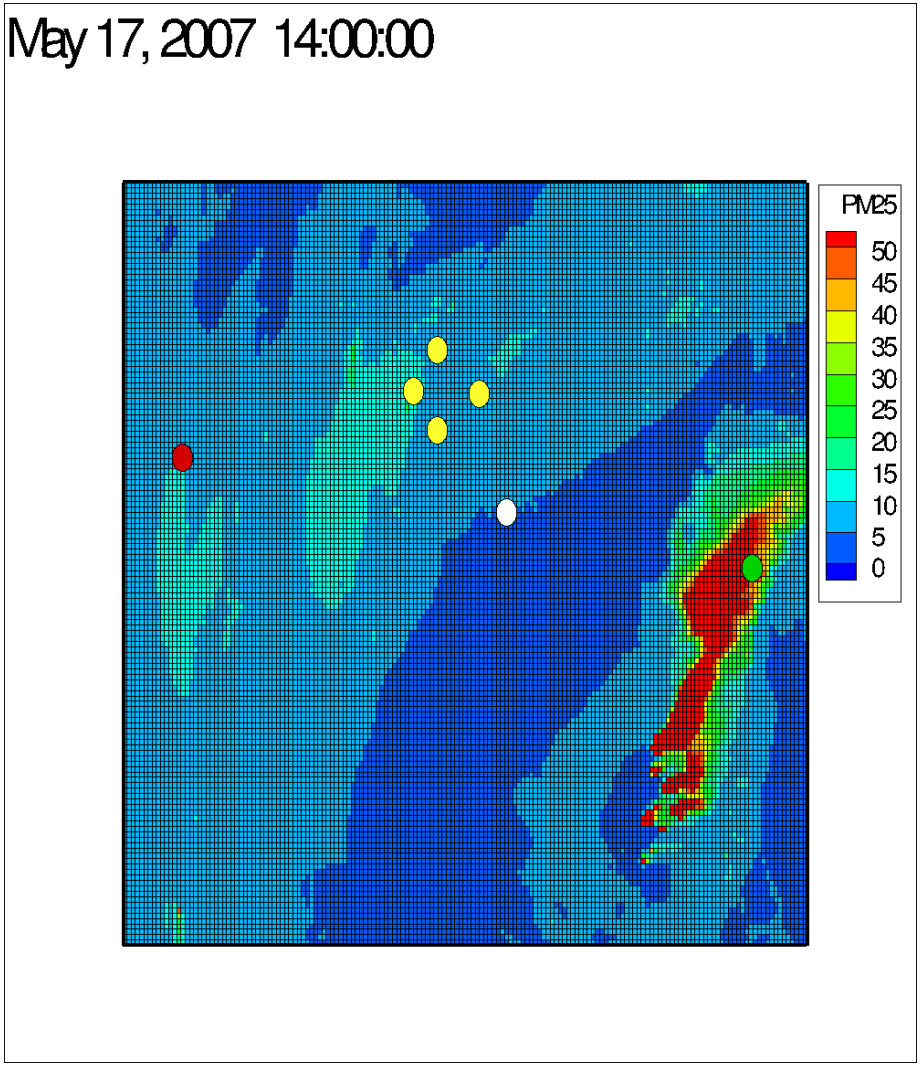
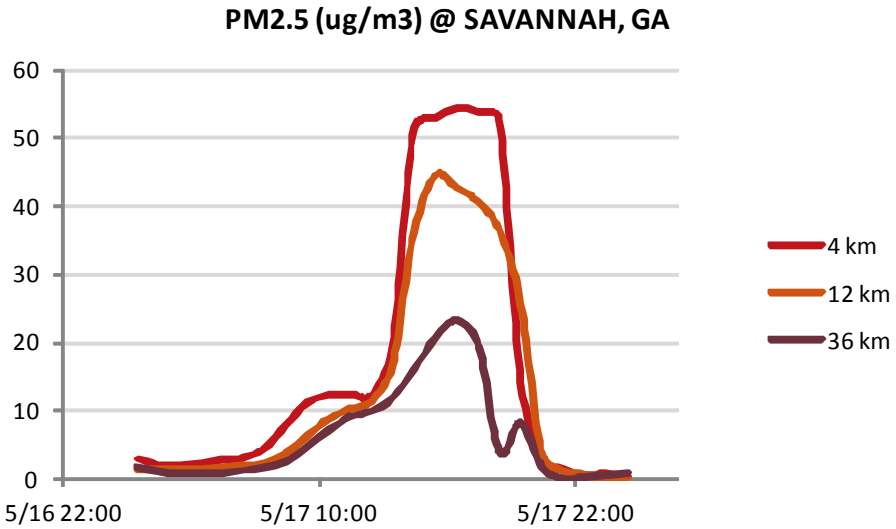




Savannah, GA: 4km Simulation





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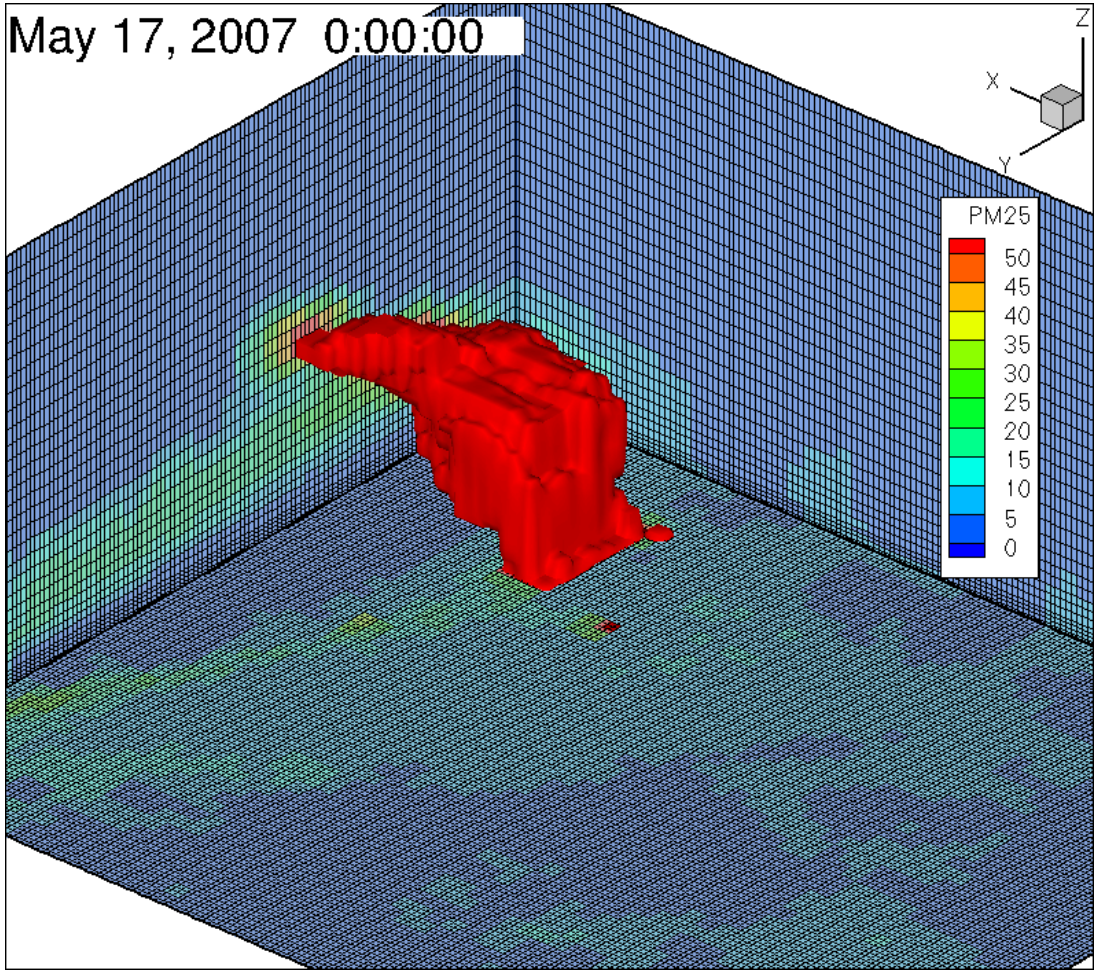

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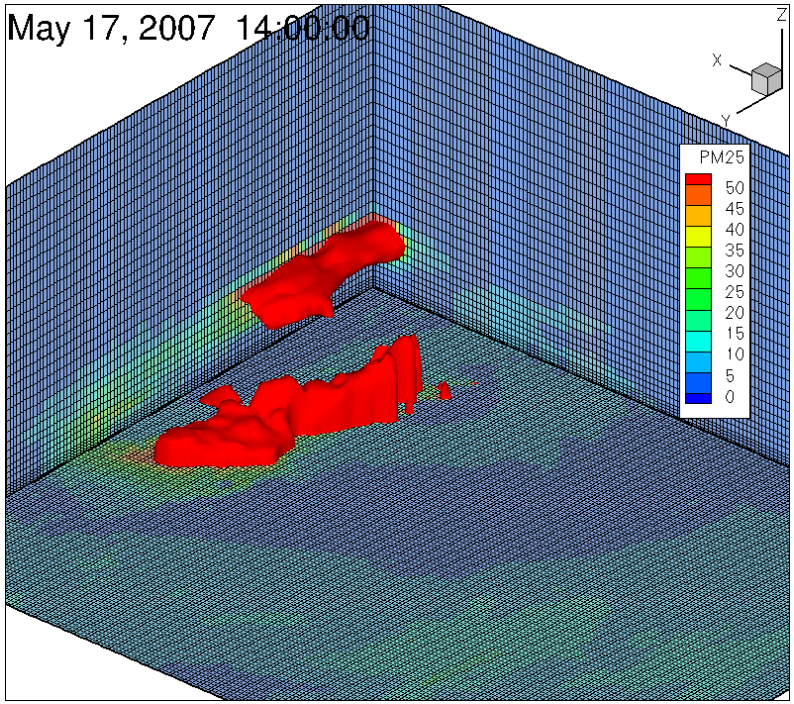
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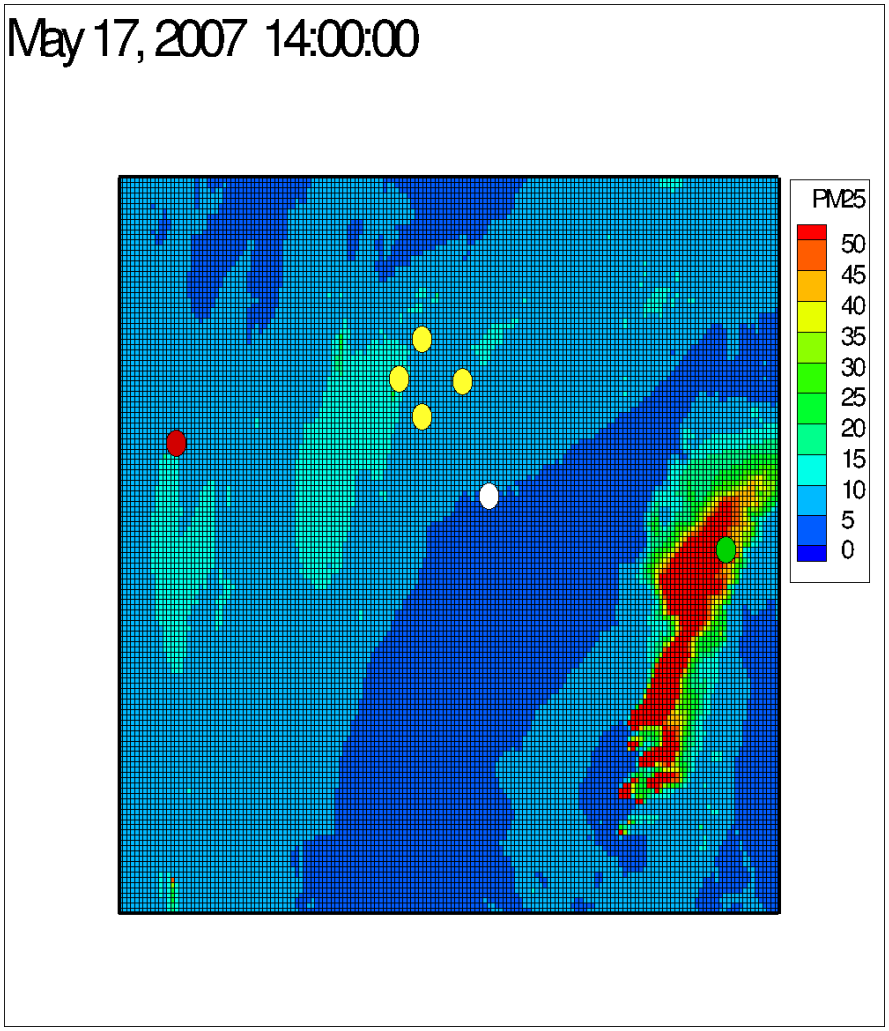
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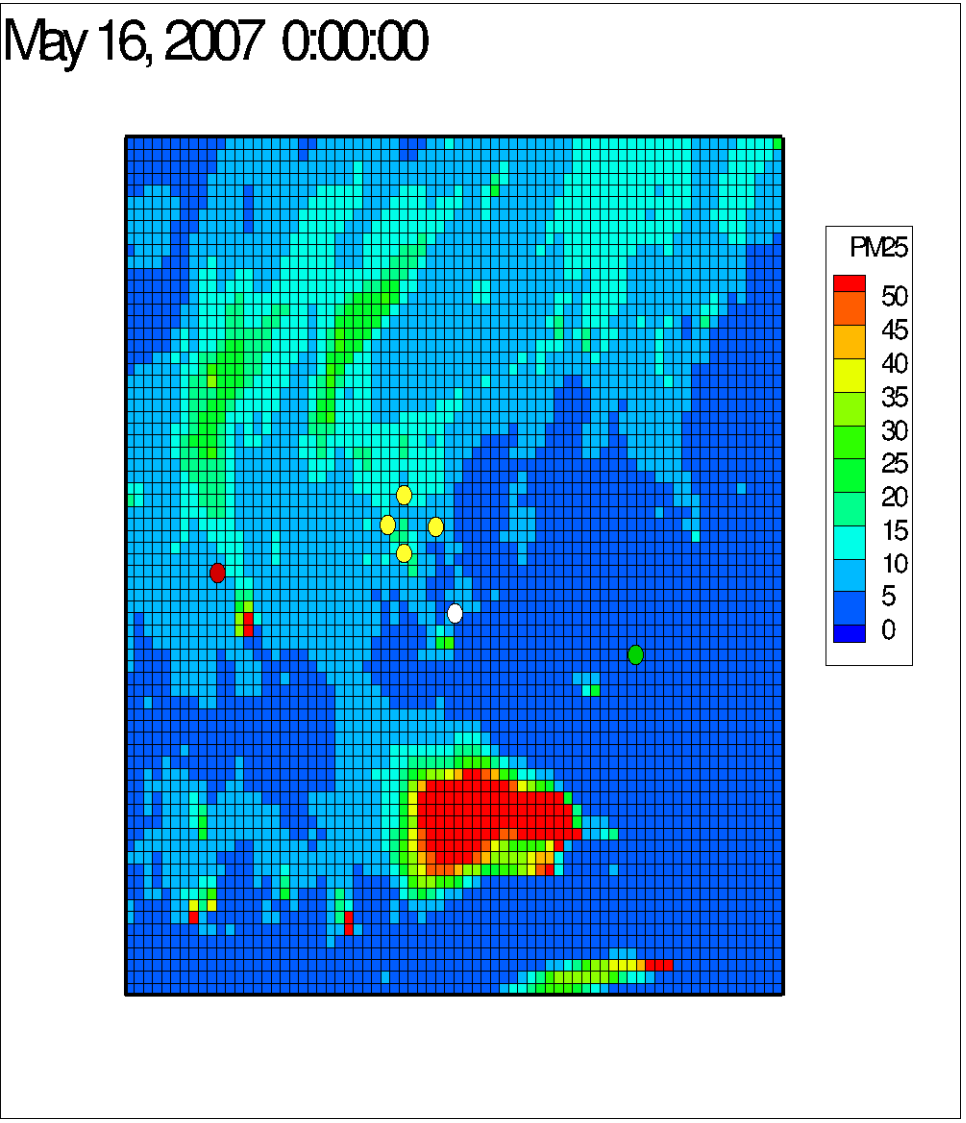
Atlanta, GA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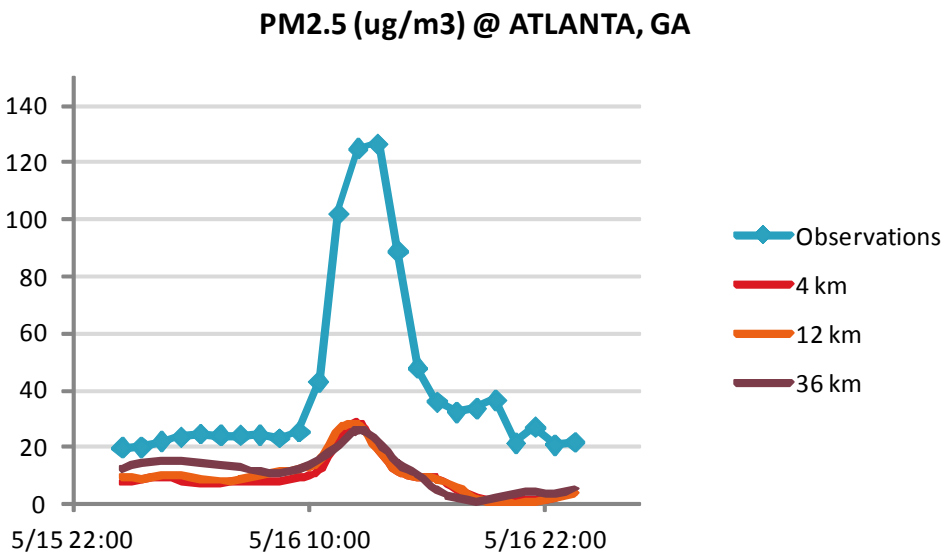
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Observations
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12 km
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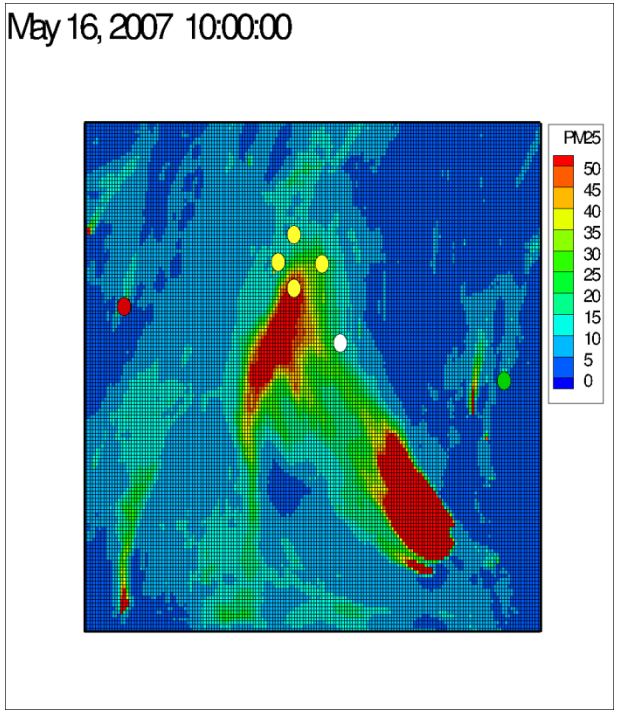
Atlanta, GA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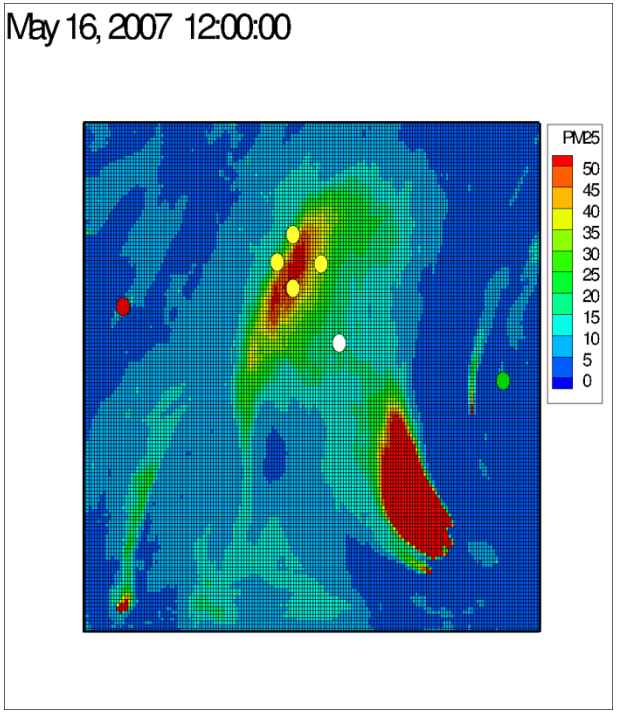
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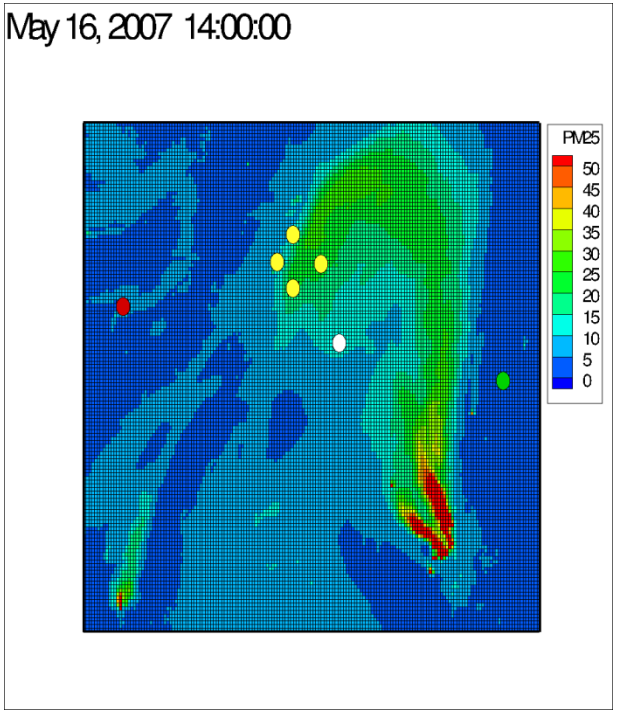
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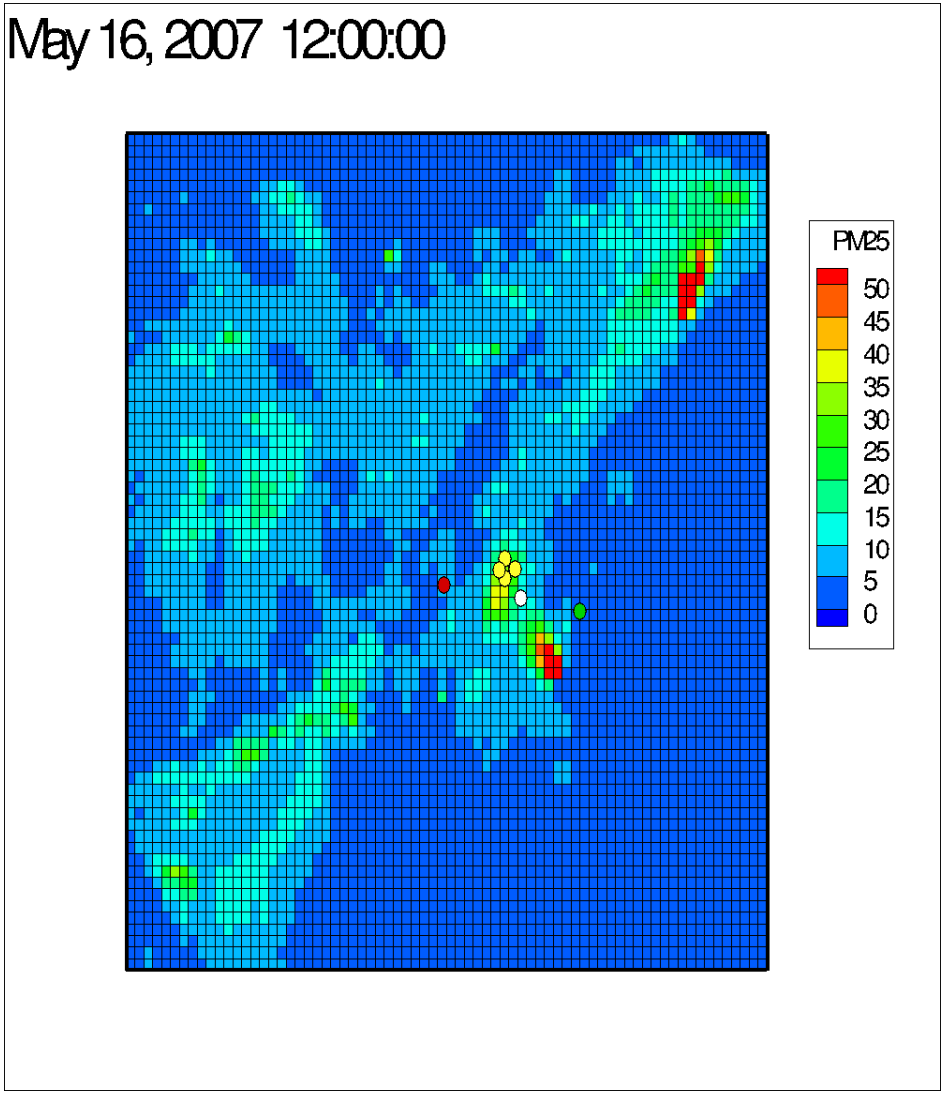
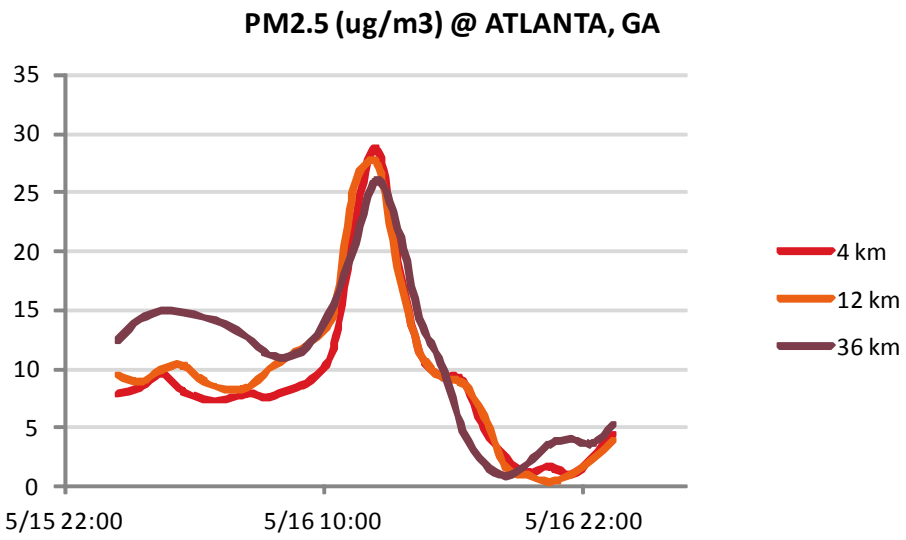
Atlanta, GA: 36km Simulation





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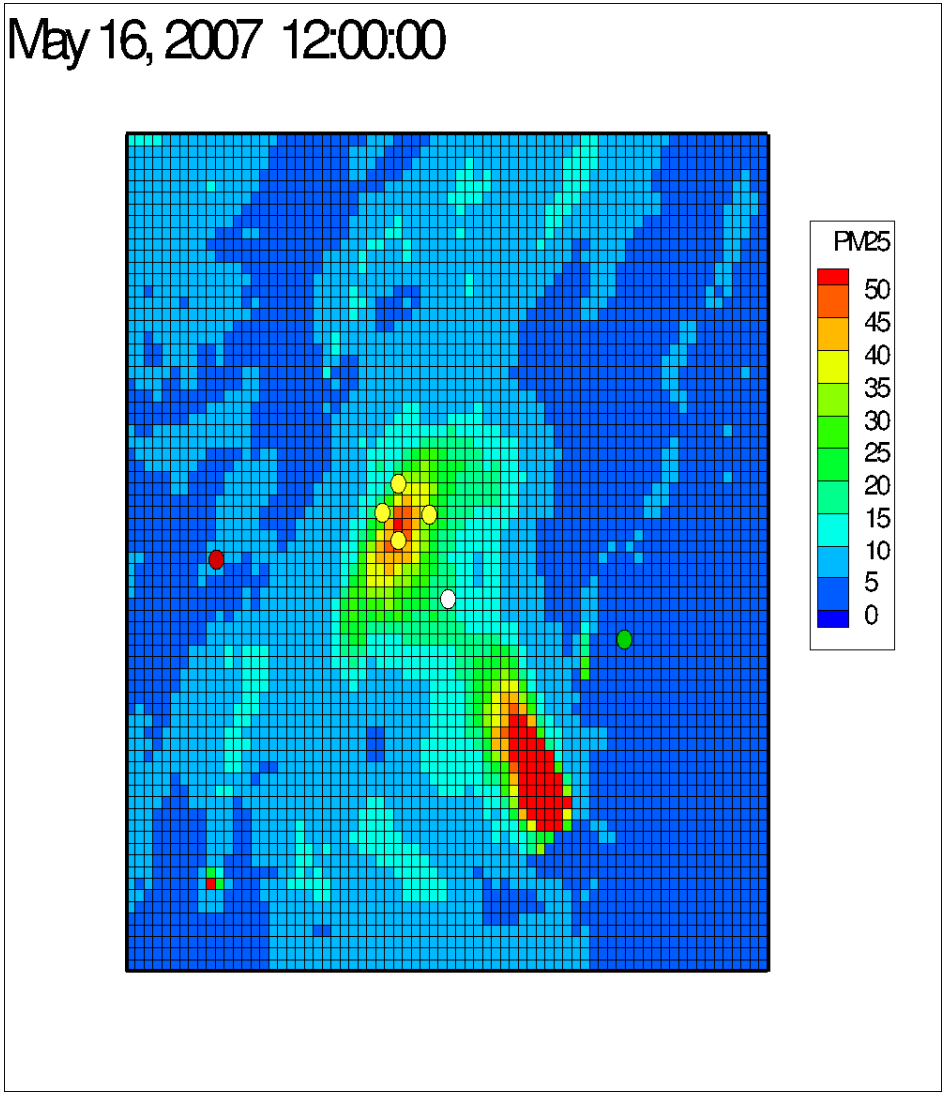

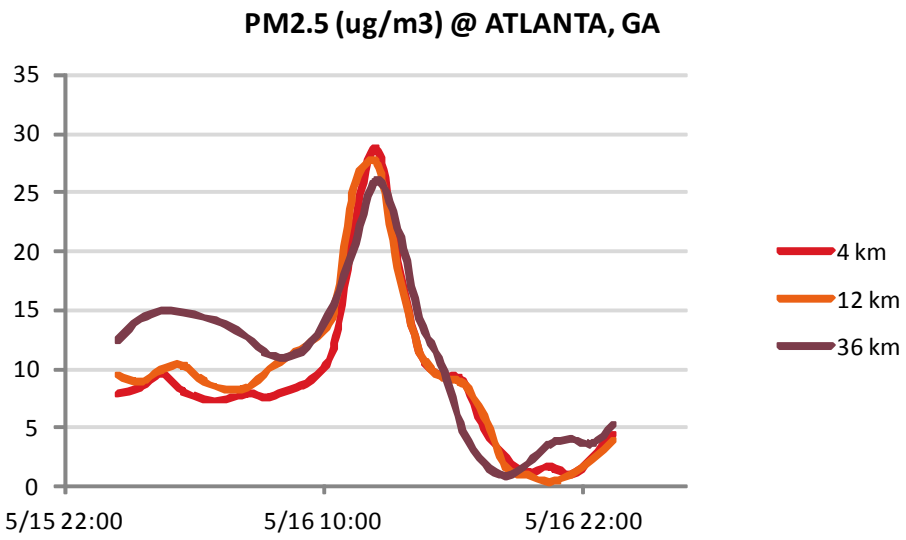

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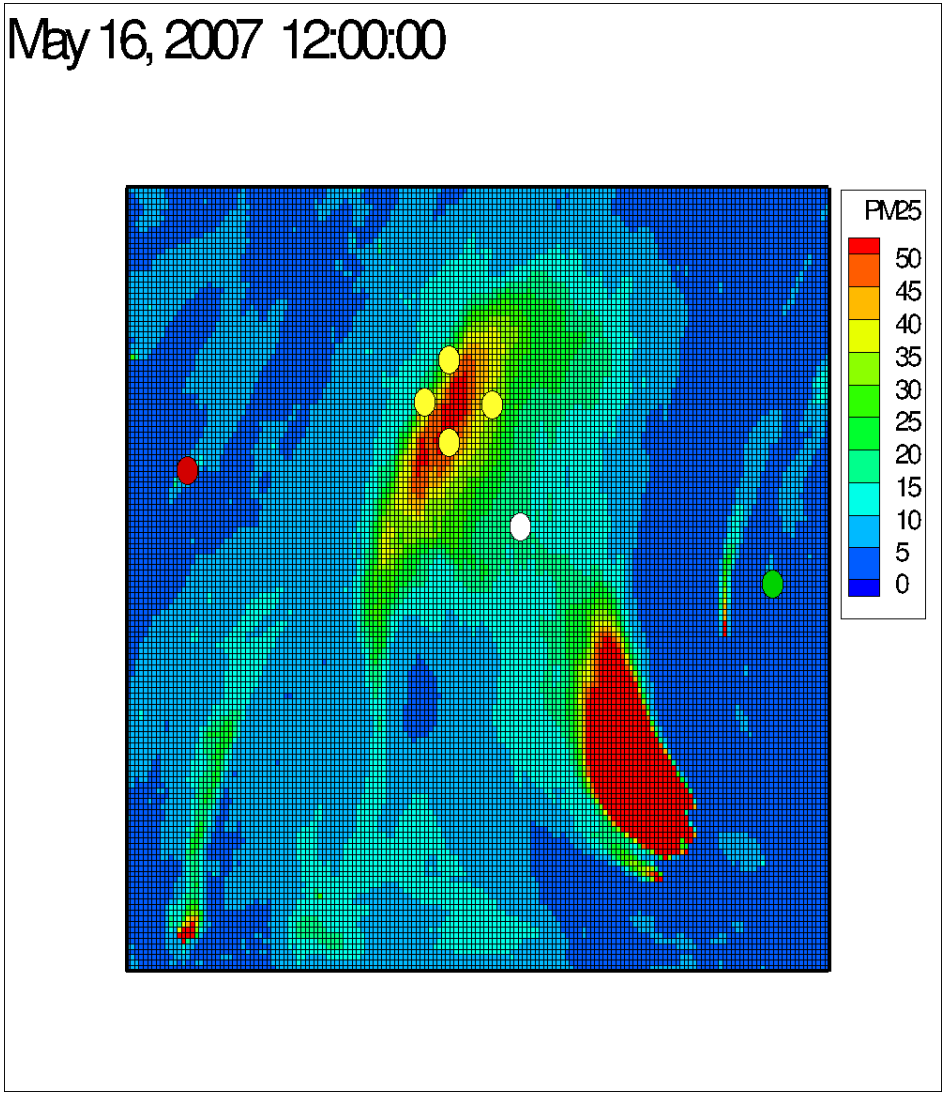

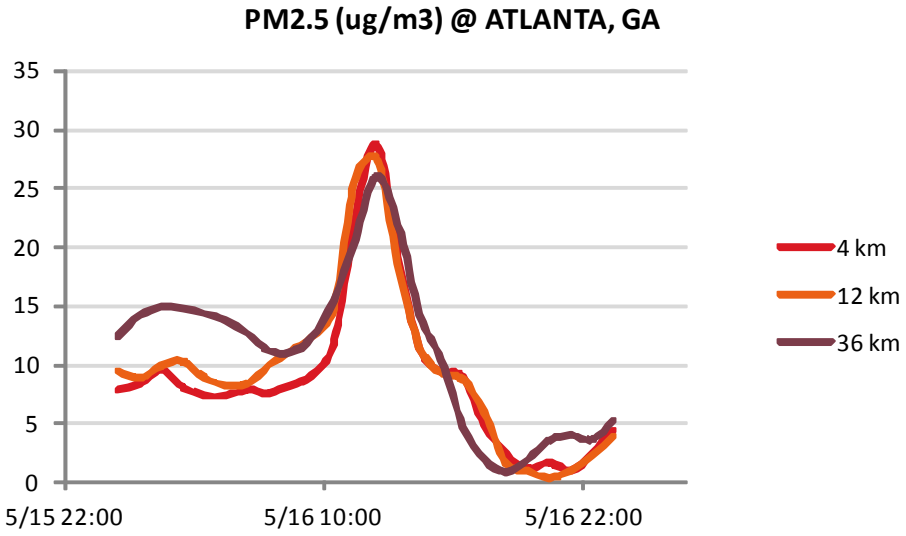

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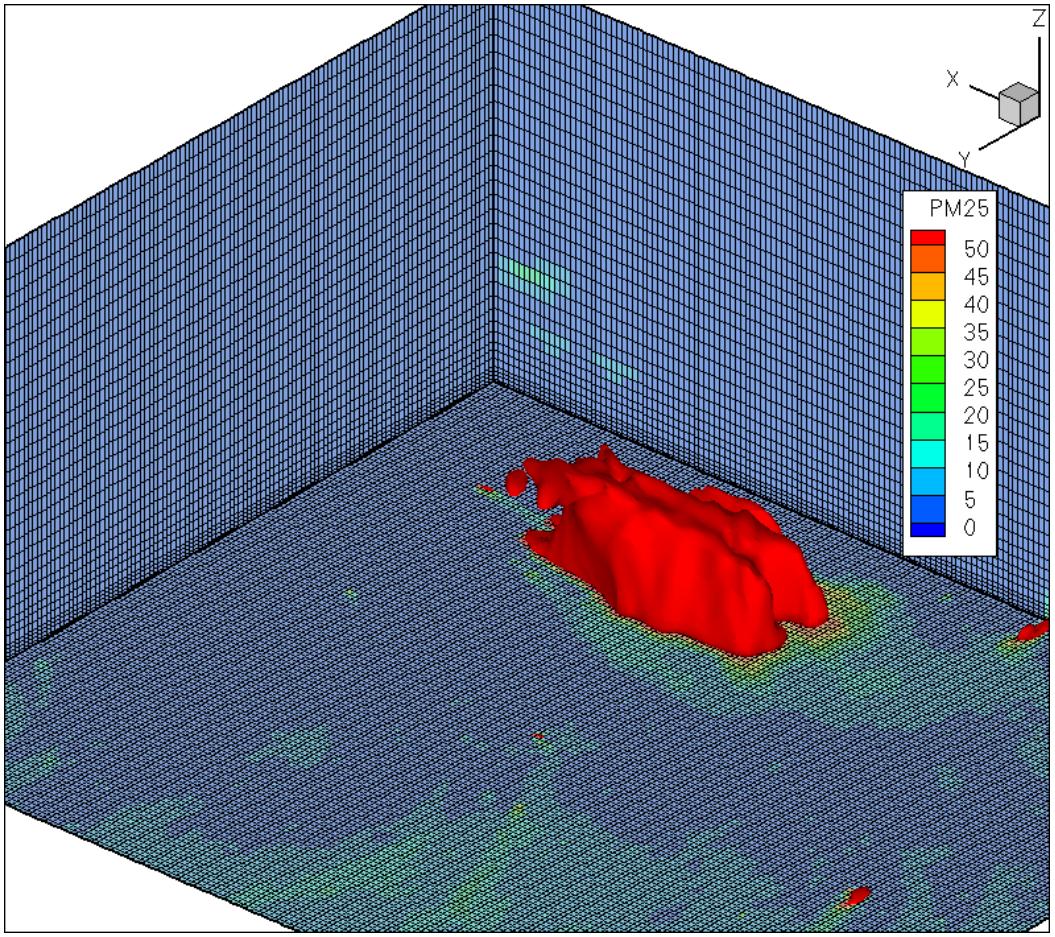

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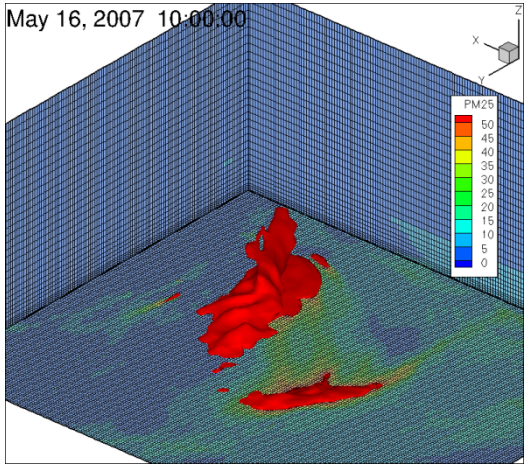
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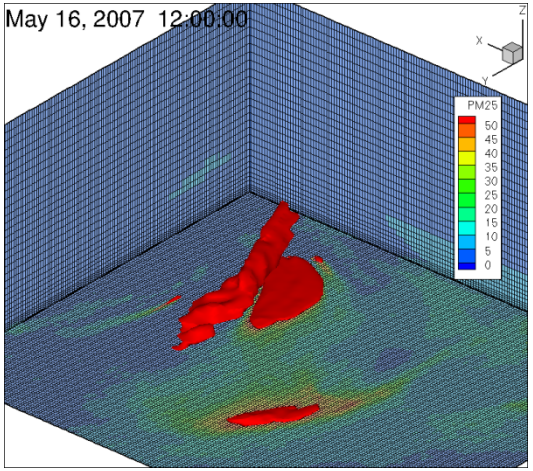
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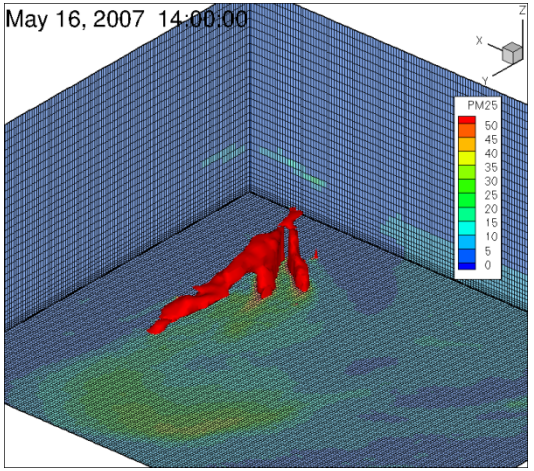
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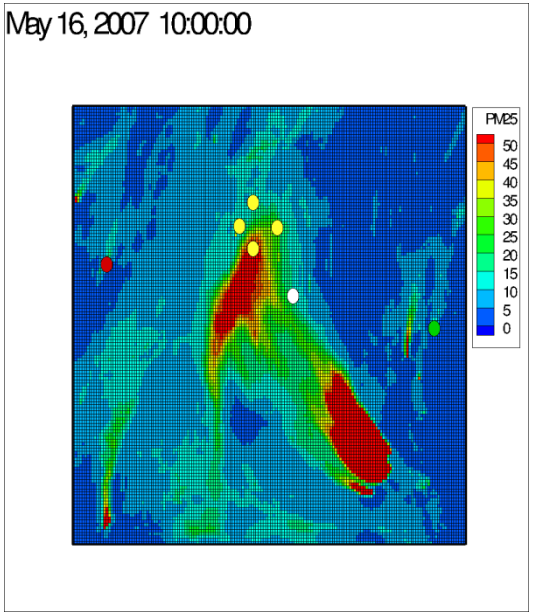
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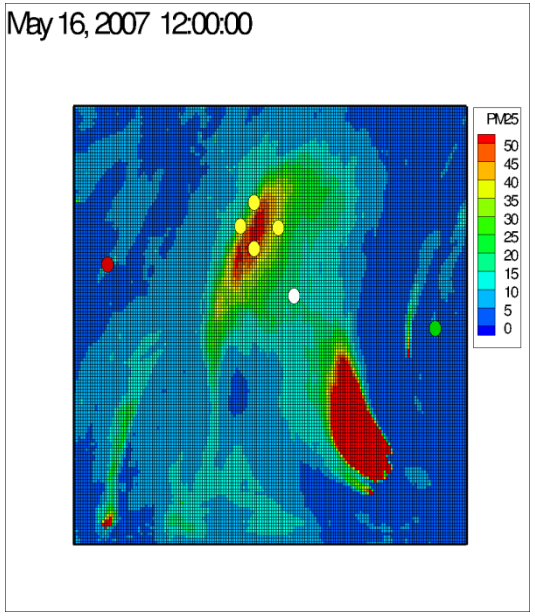
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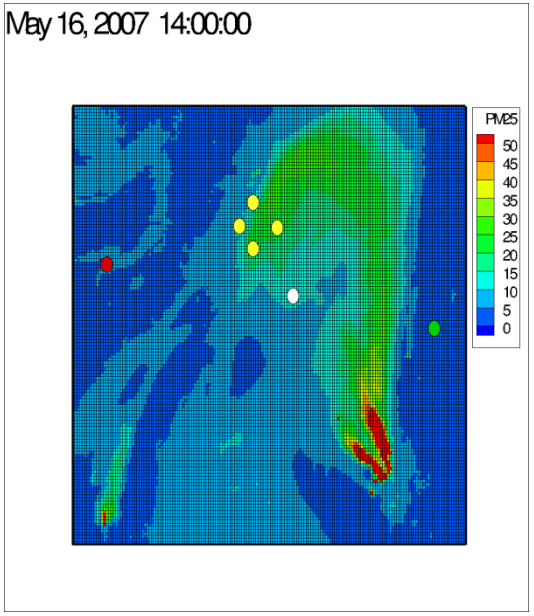
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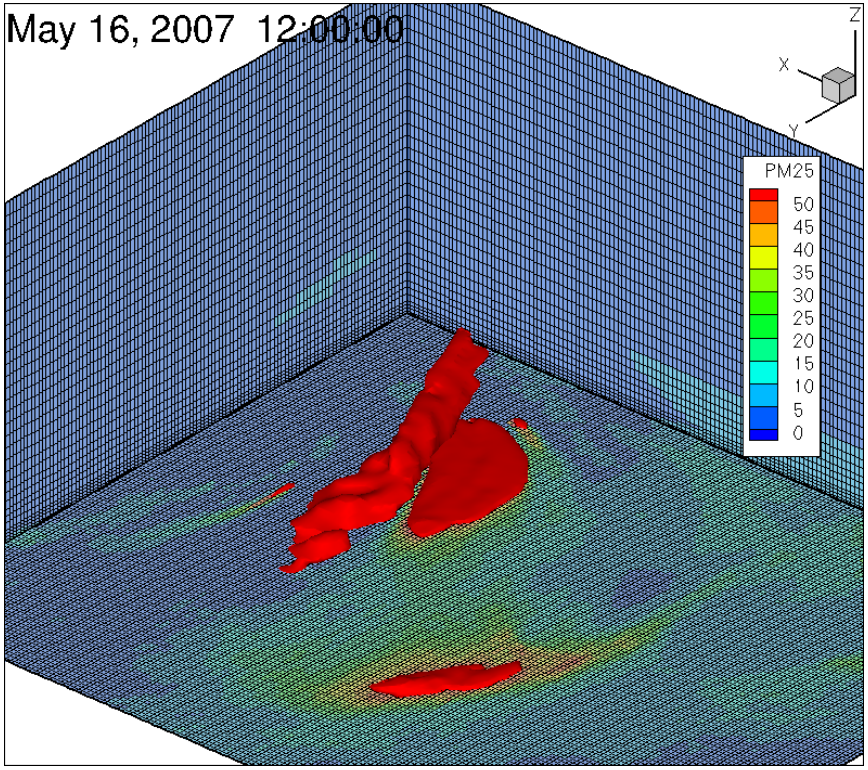
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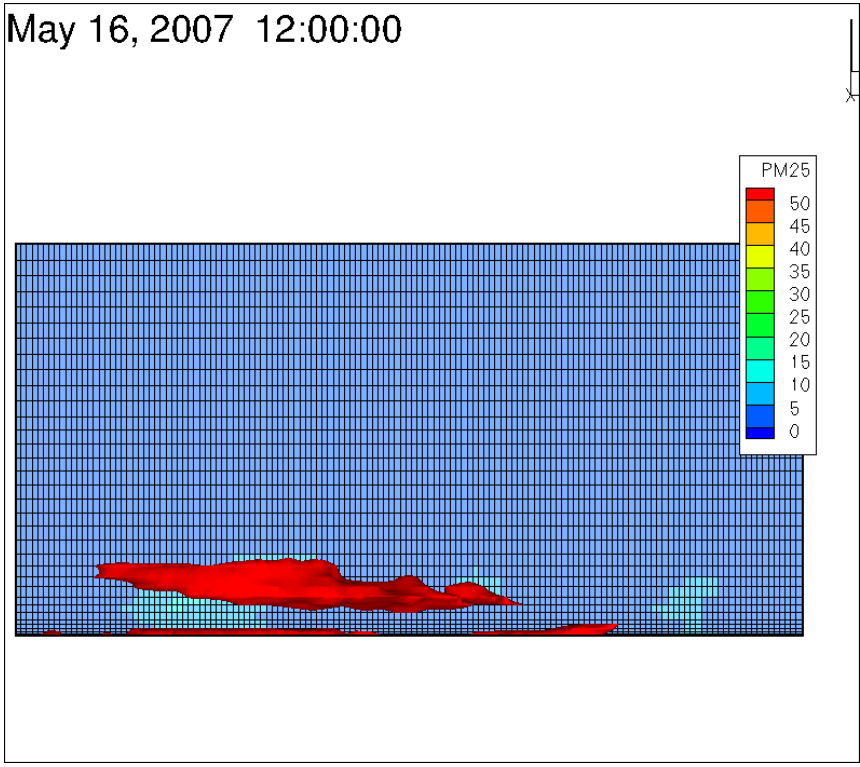
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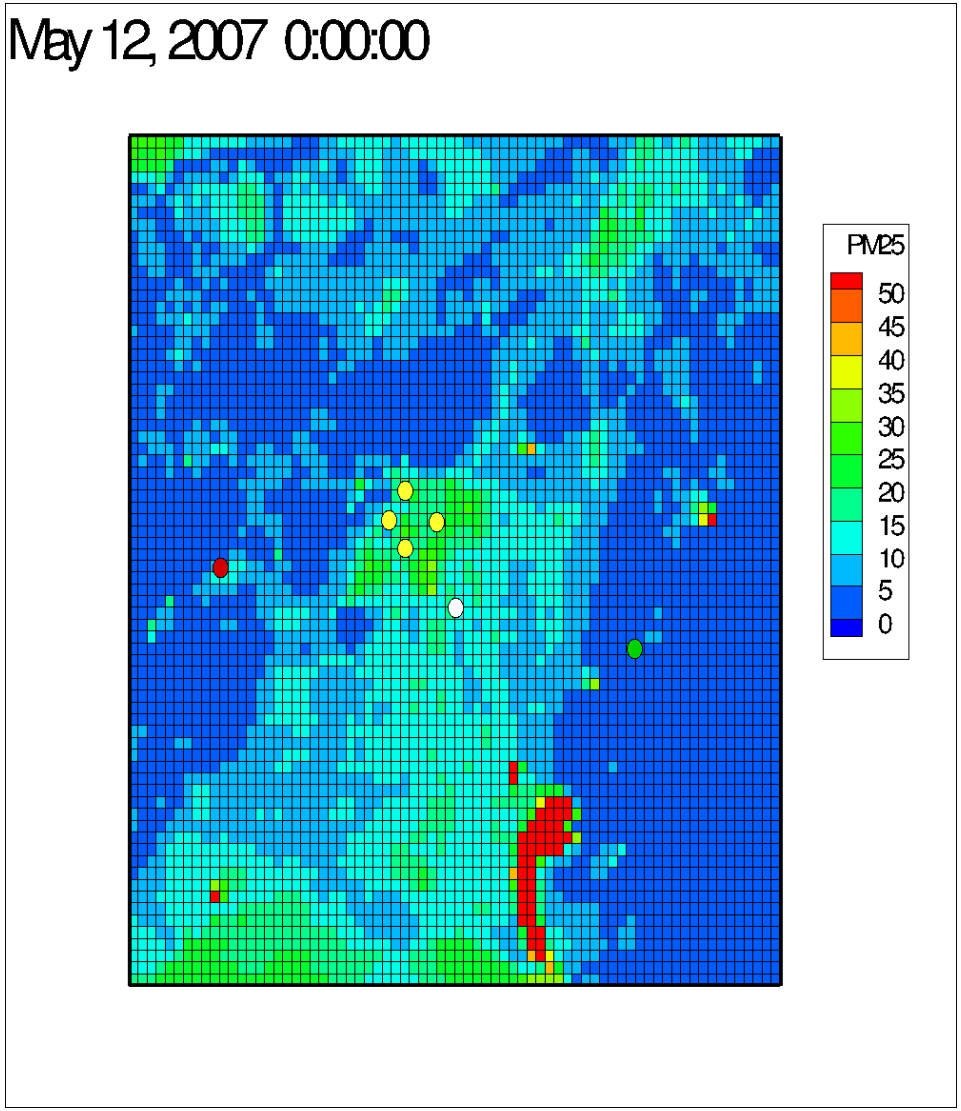
Macon, GA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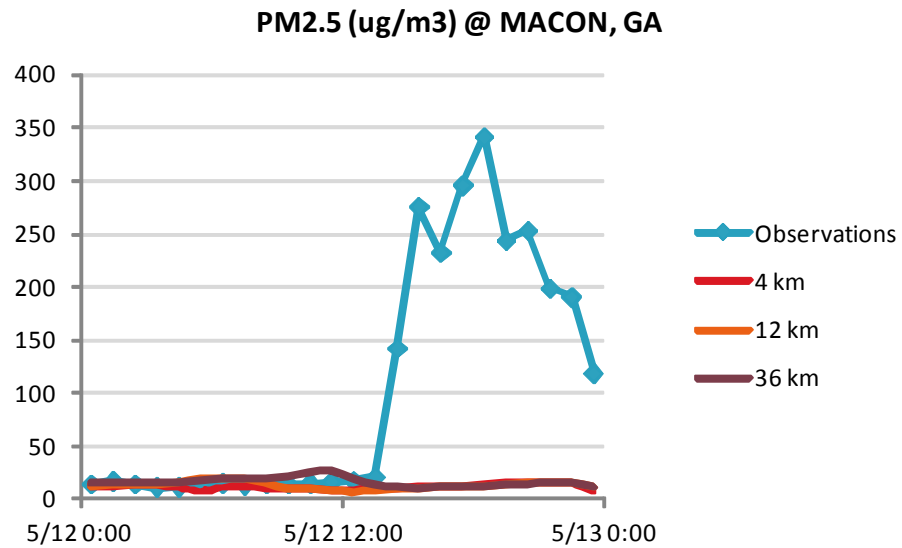
PM2.5 (ug/m3) @ MACON, GA
400
350
300
250
200
150
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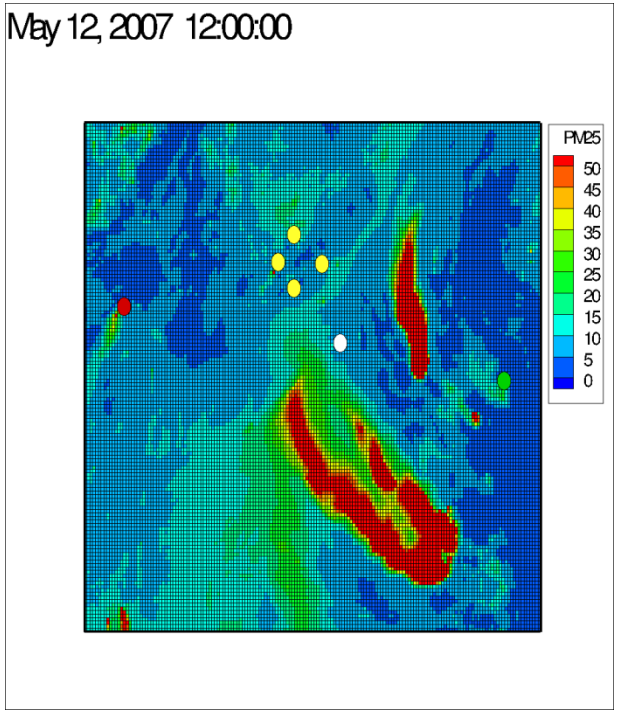
5/12 0:00
5/12 12:00
5/13 0:00
Observations
4 km
12 km
36 km

Macon, GA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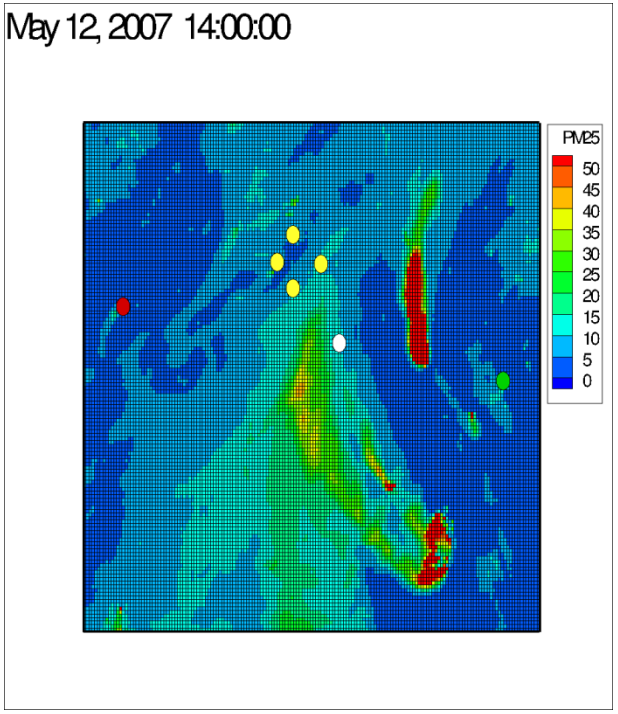
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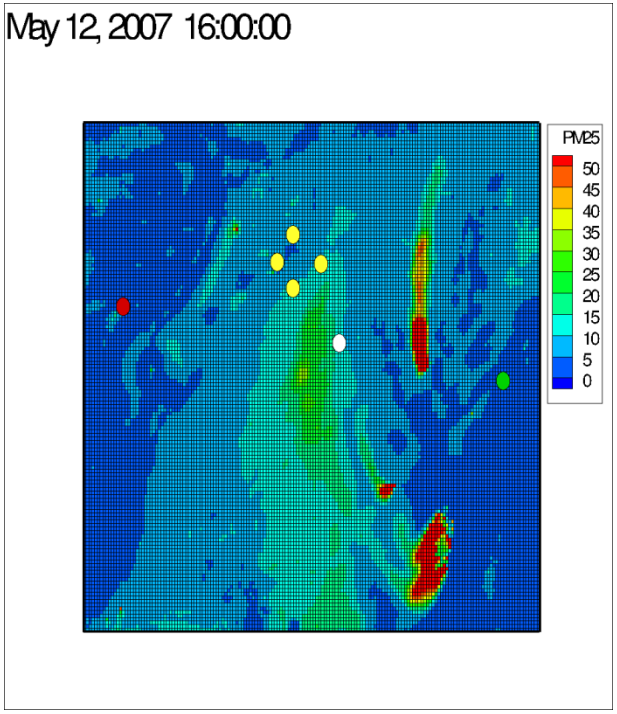
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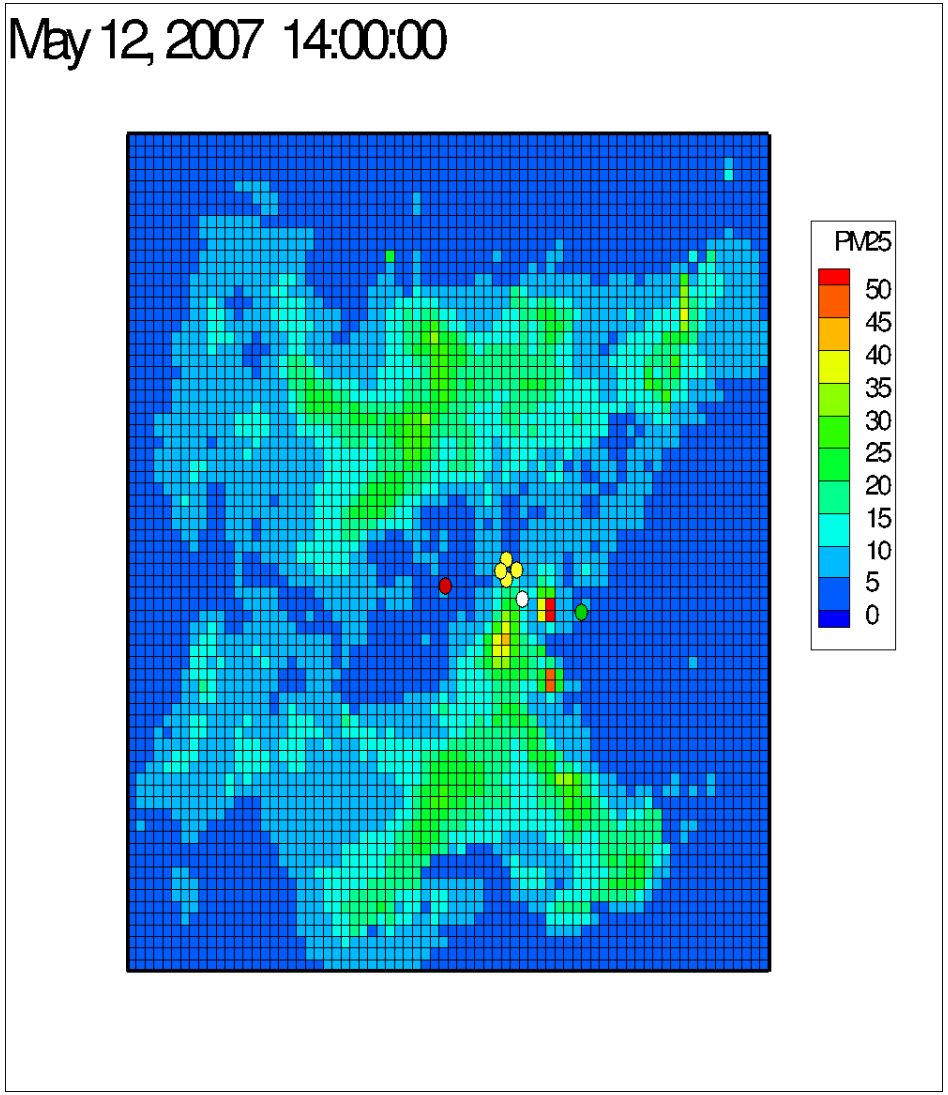
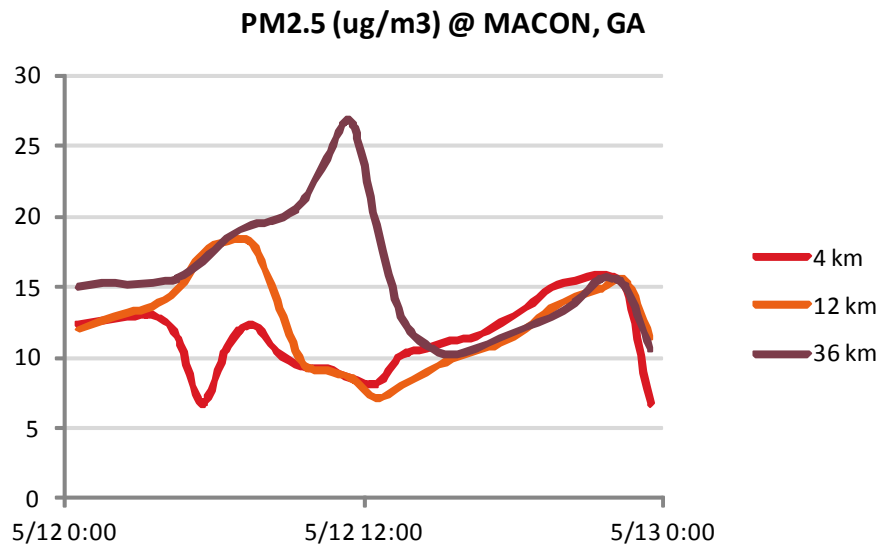
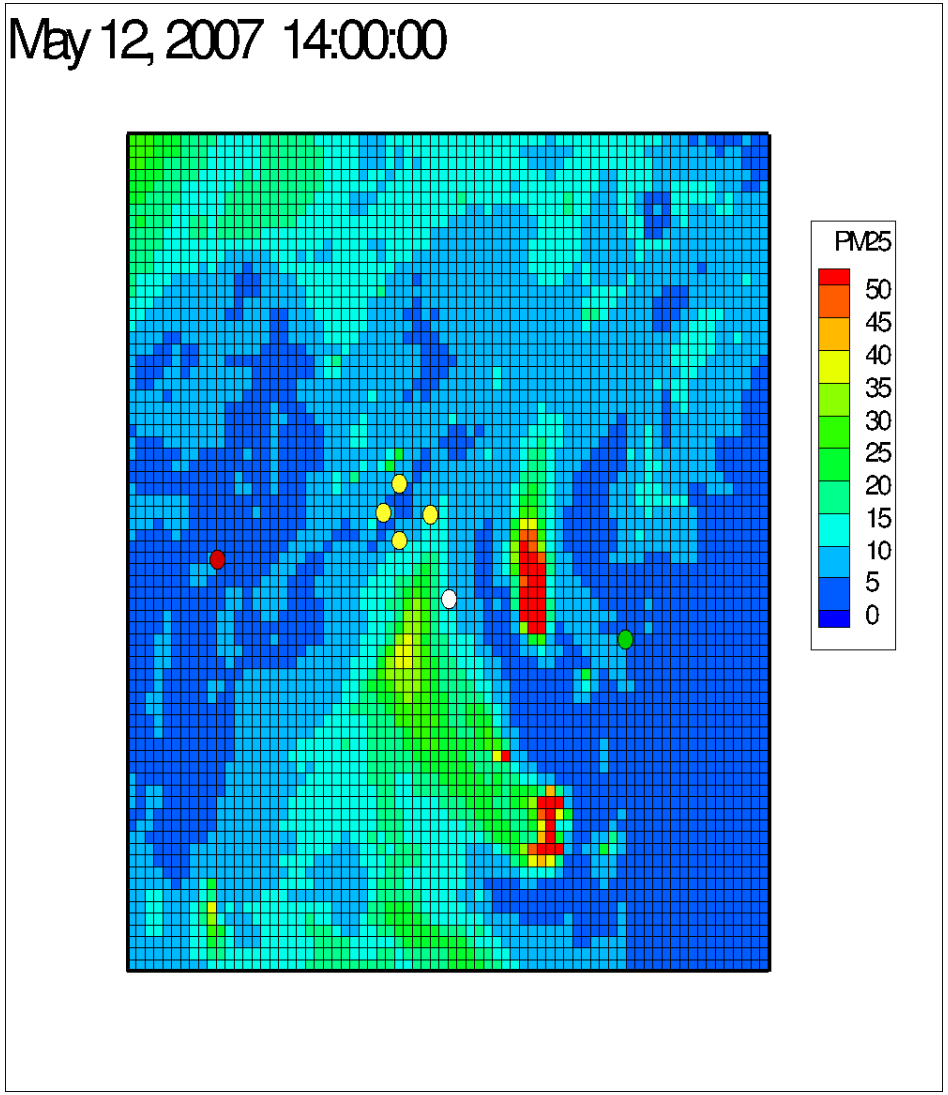
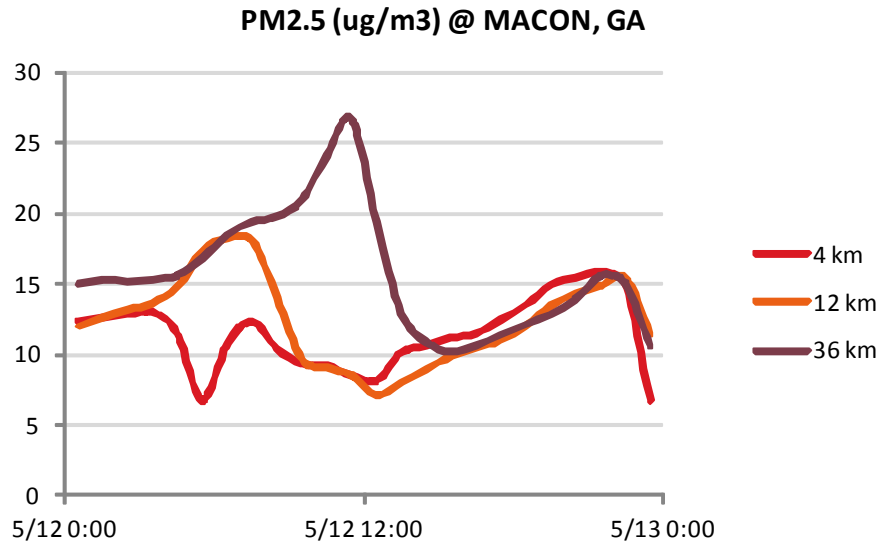
Macon, GA: 36km Simulation



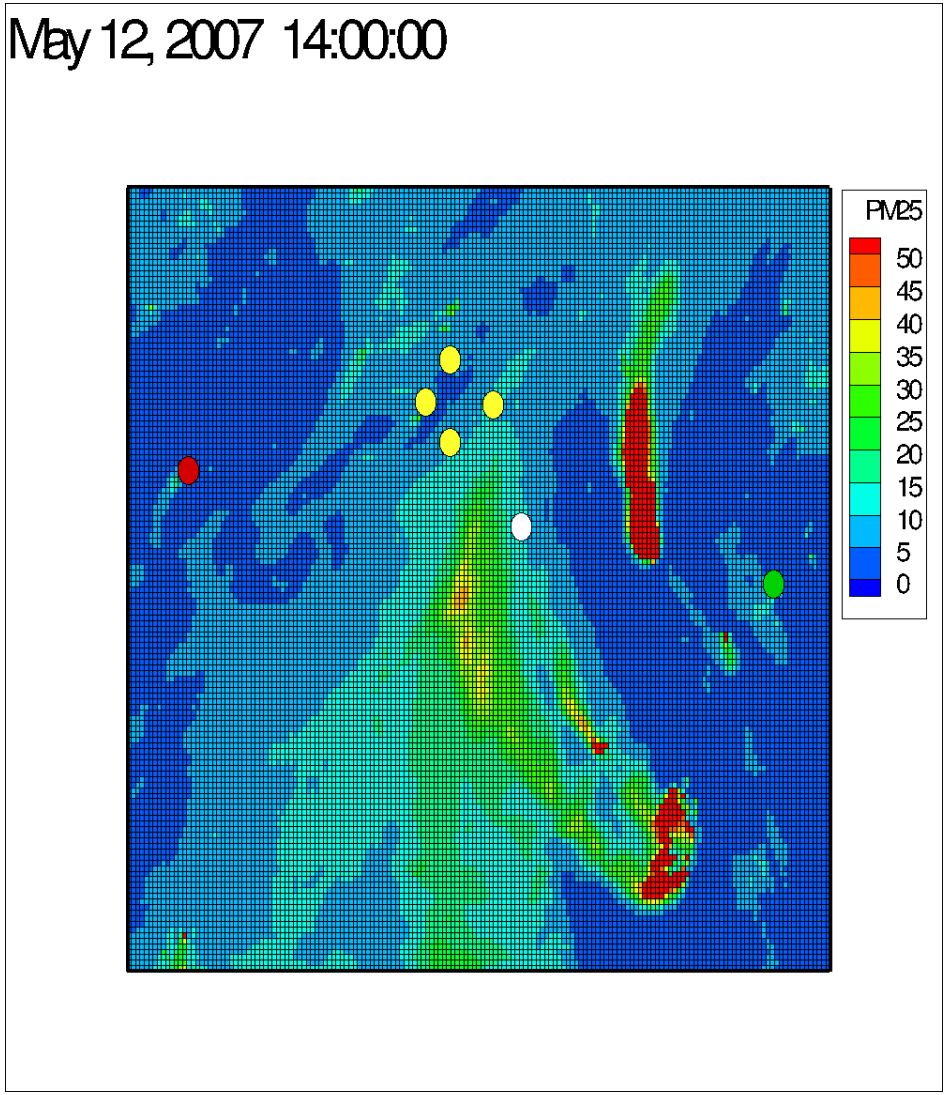


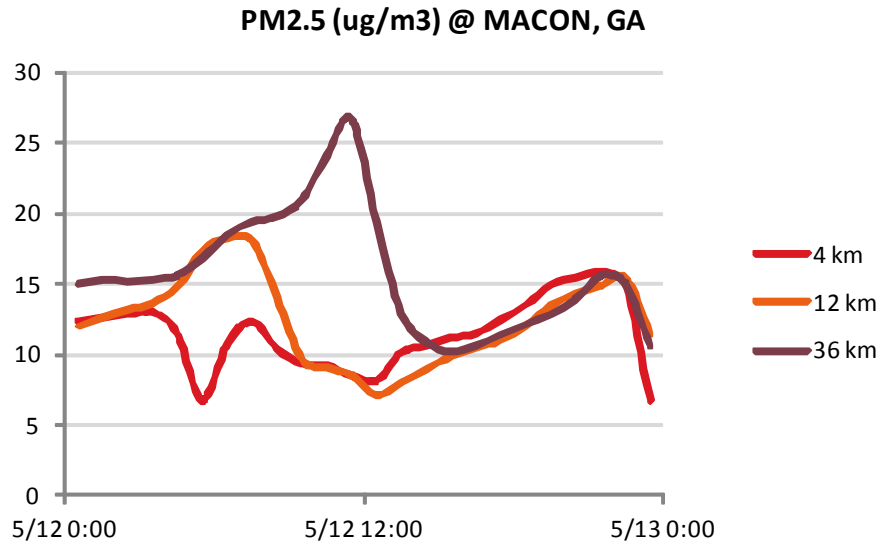
Macon, GA: 12km Simulation



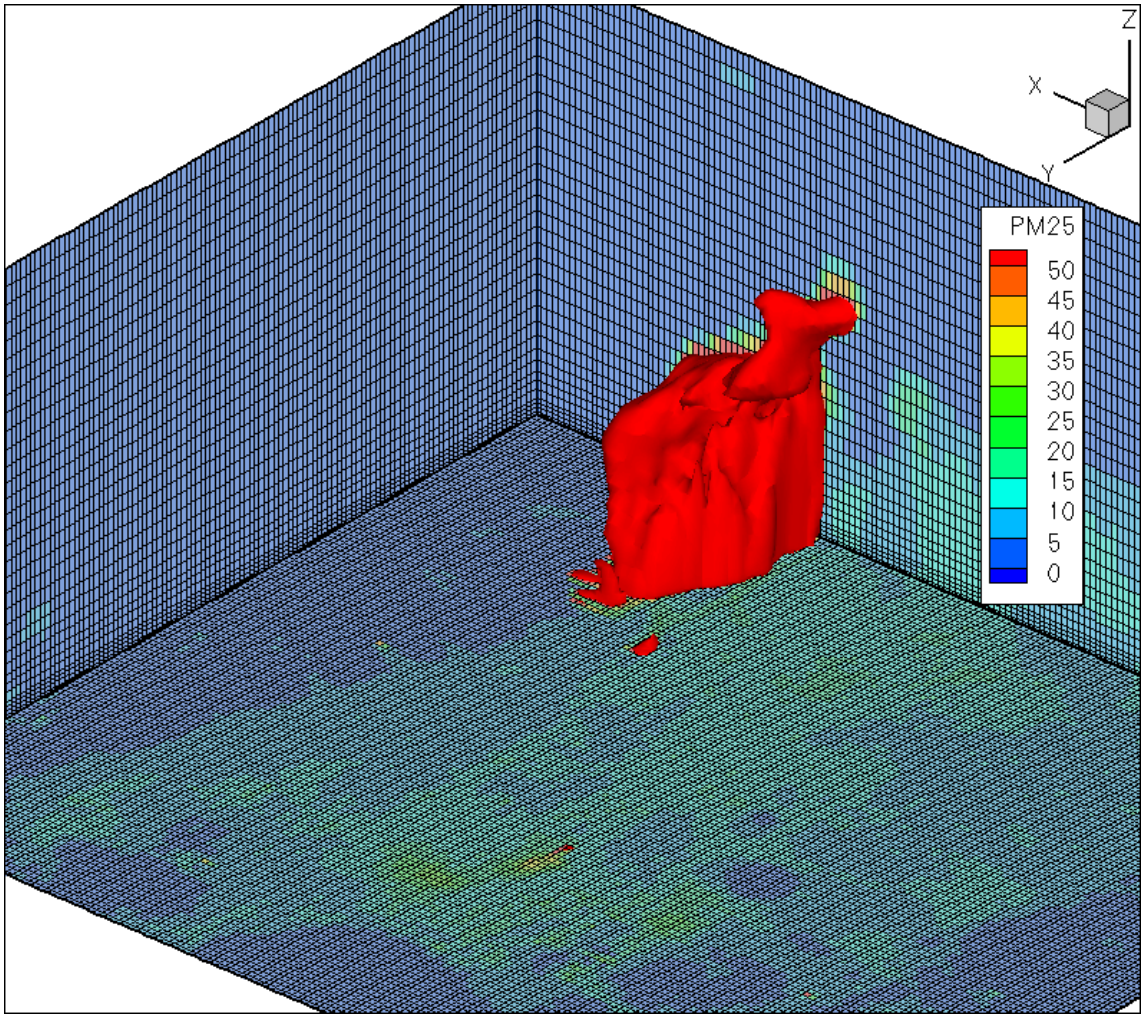


Macon, GA: 4km Simulation

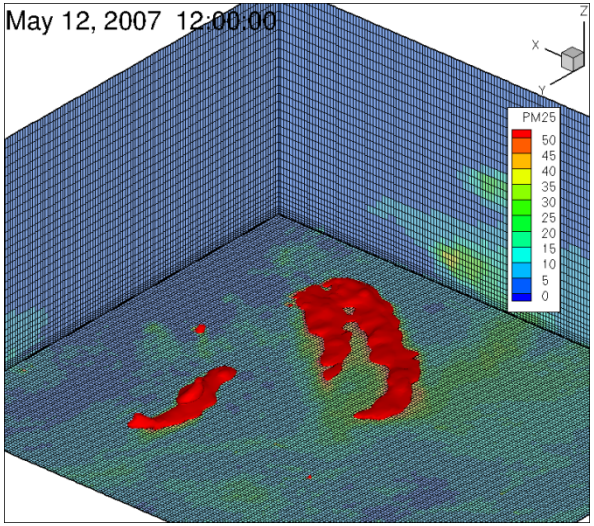




Macon, GA



Macon, GA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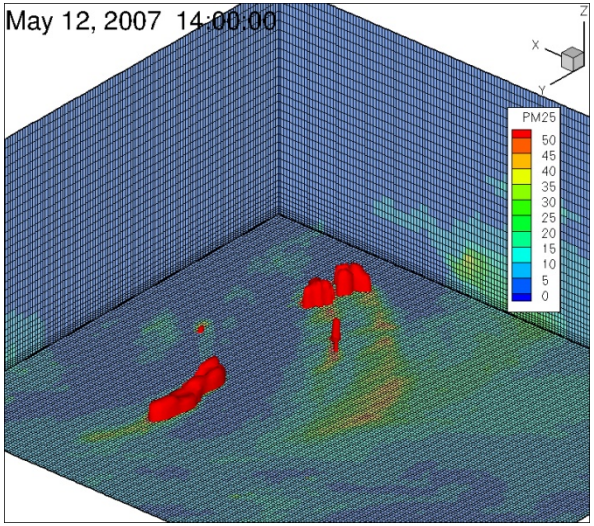
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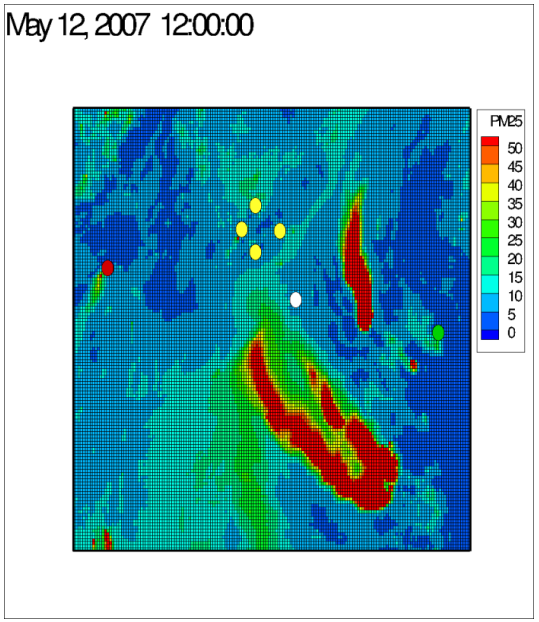
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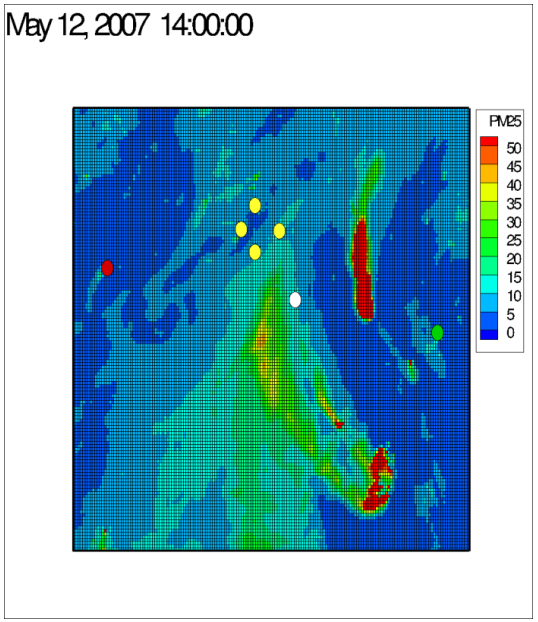
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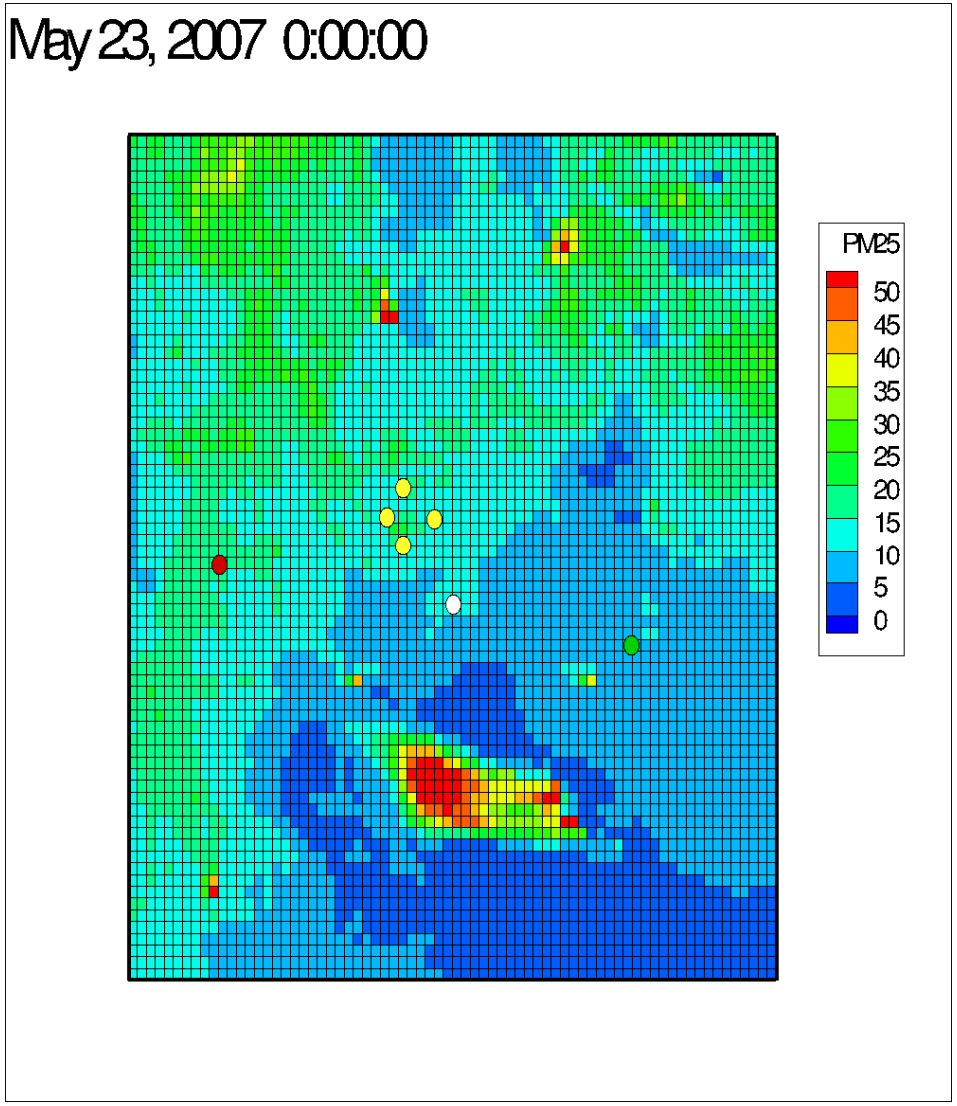
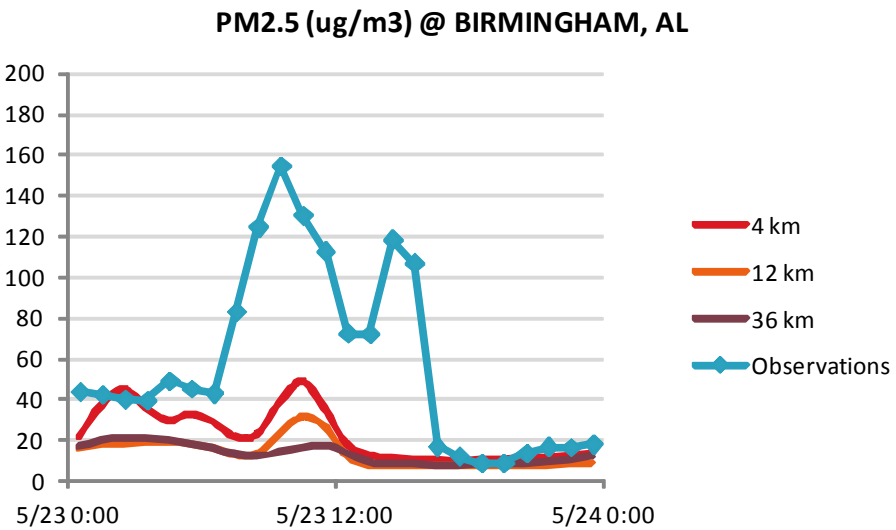
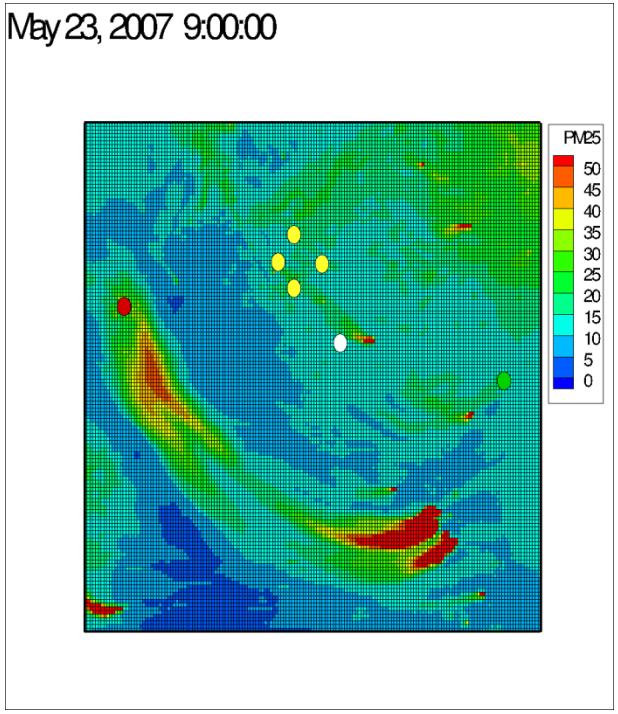
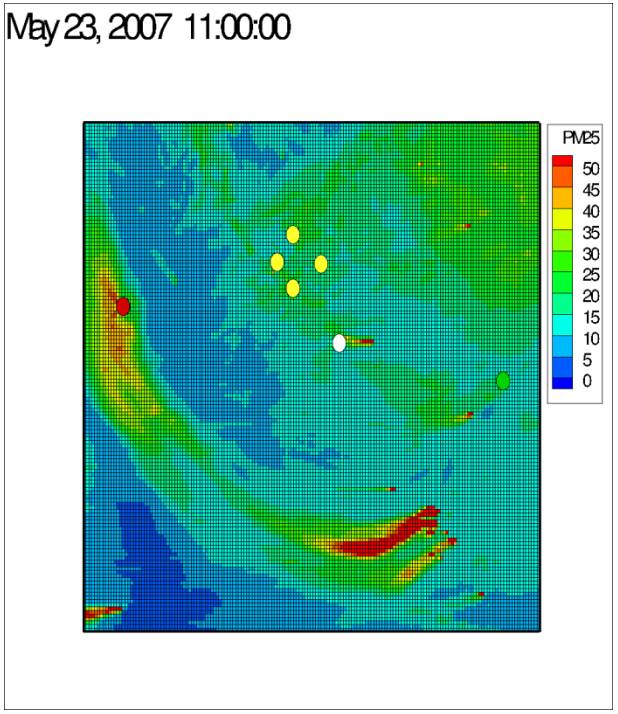
Birmingham, AL (5/23)

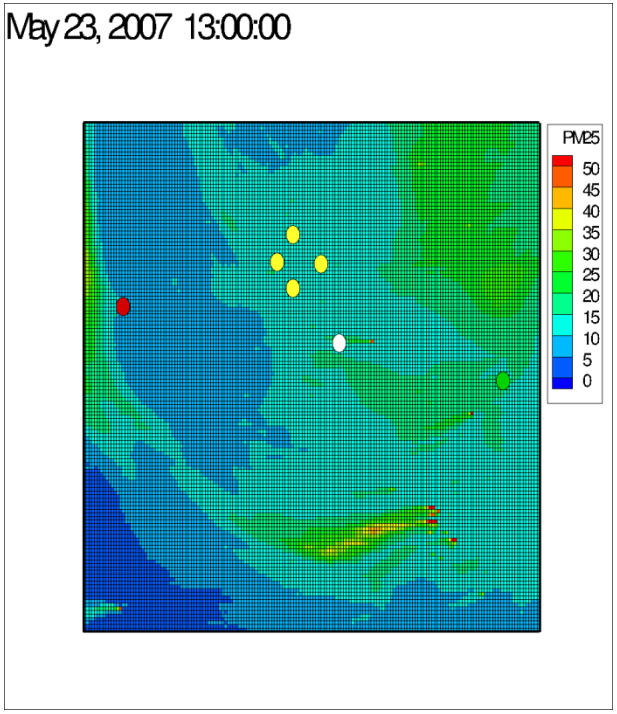




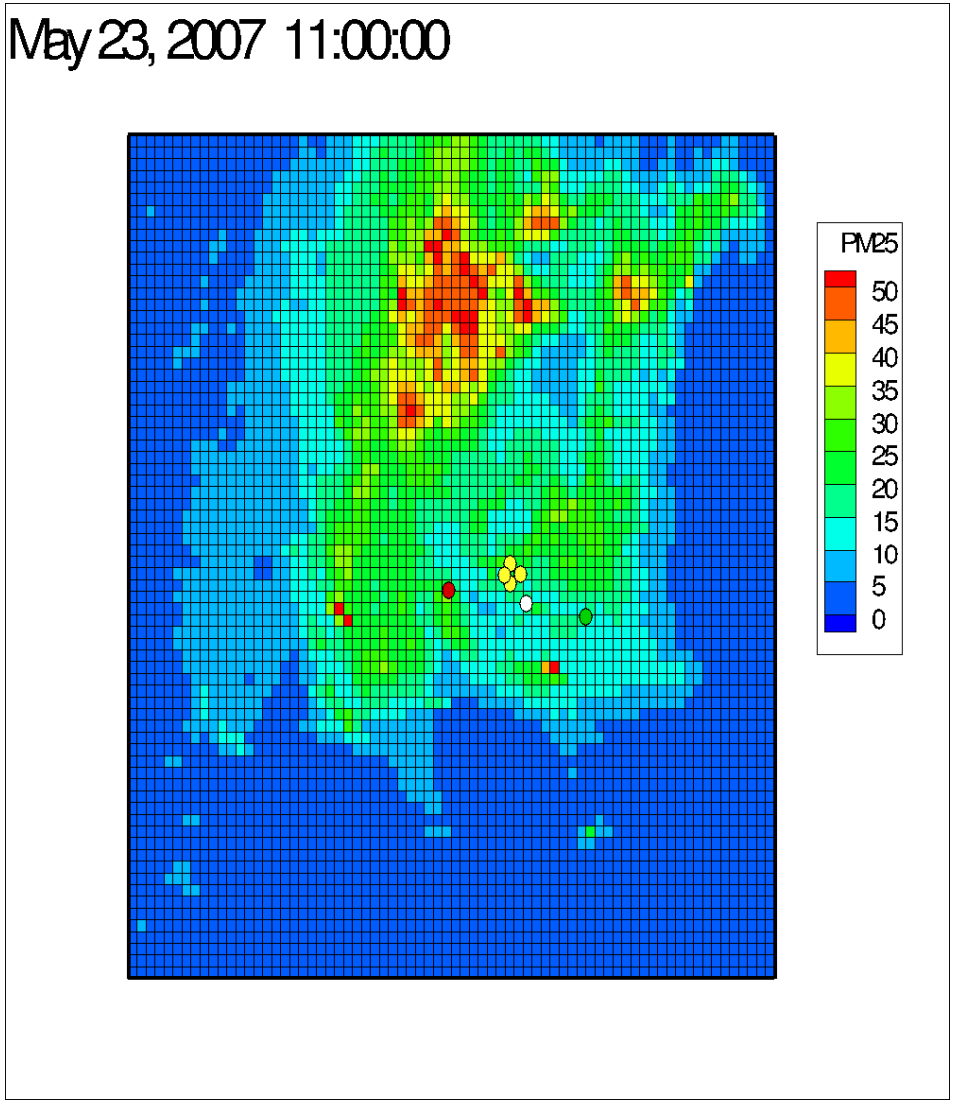
Birmingham, AL (5/23)

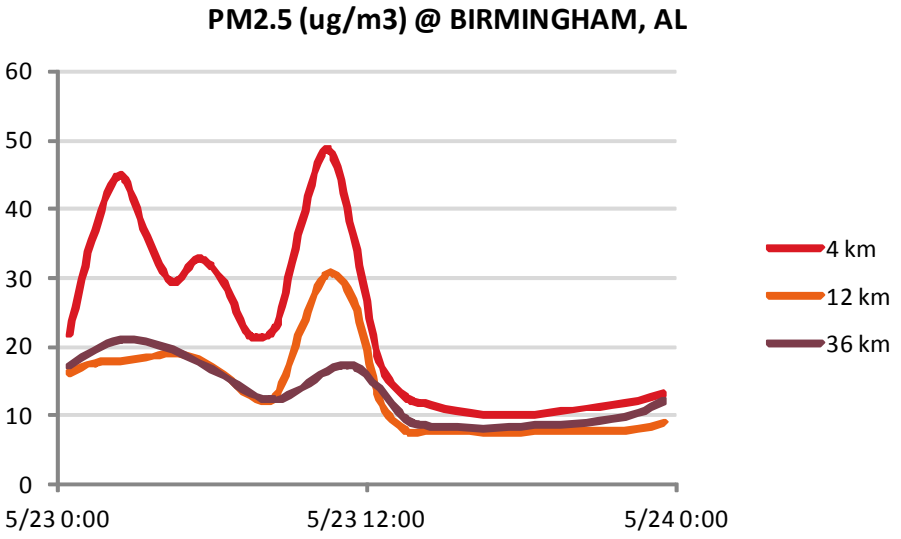




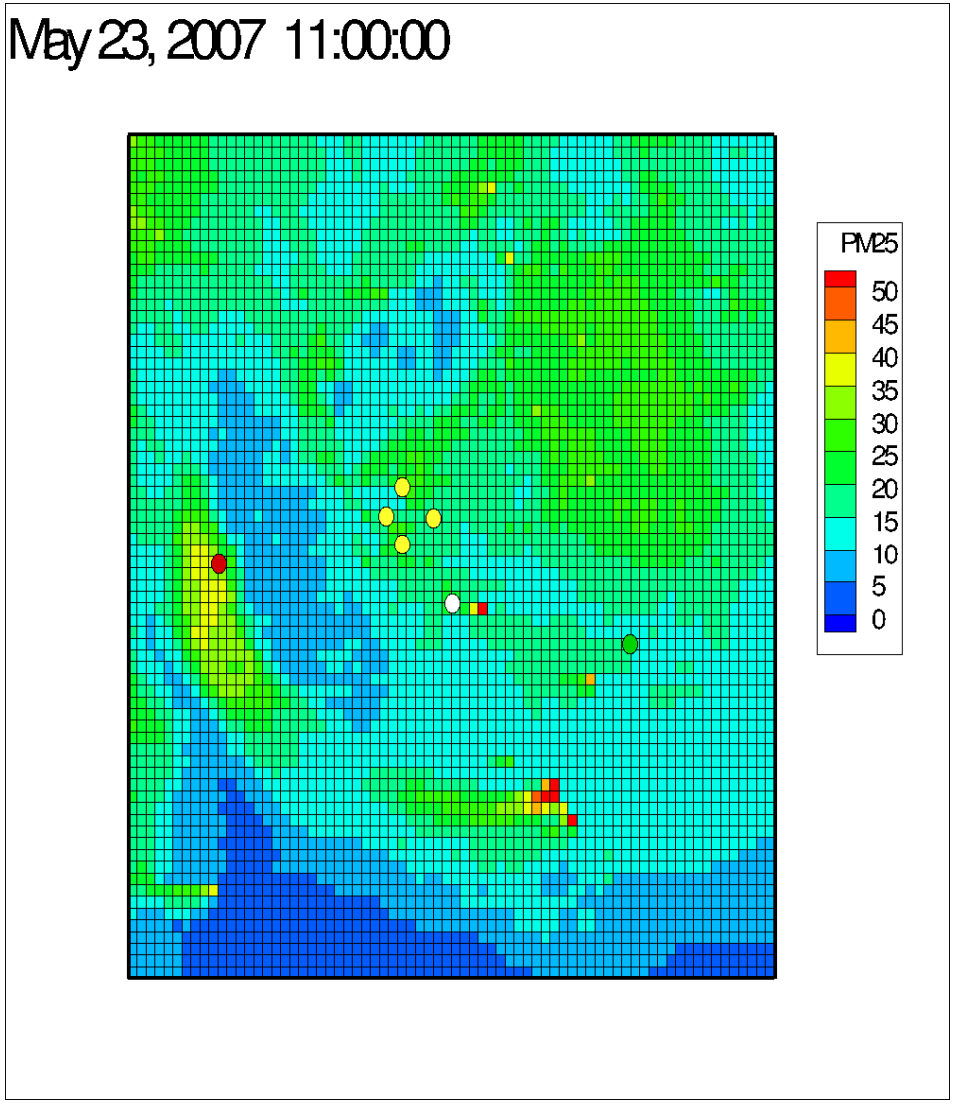


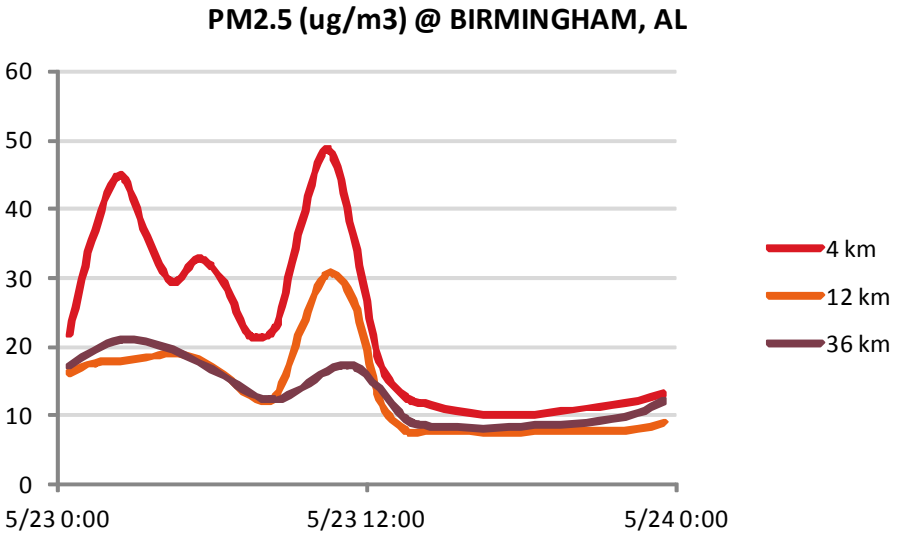
Birmingham, AL (5/23): 36 KM



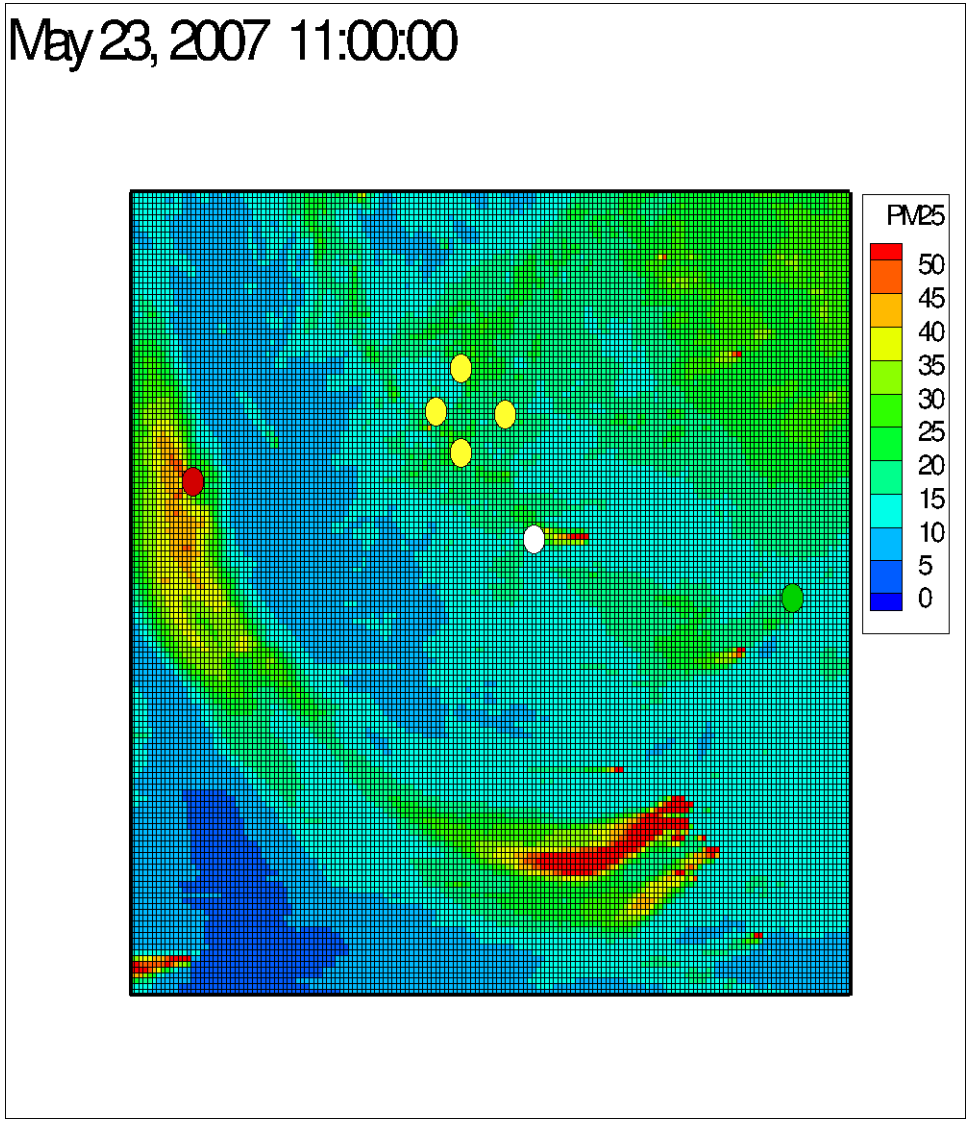


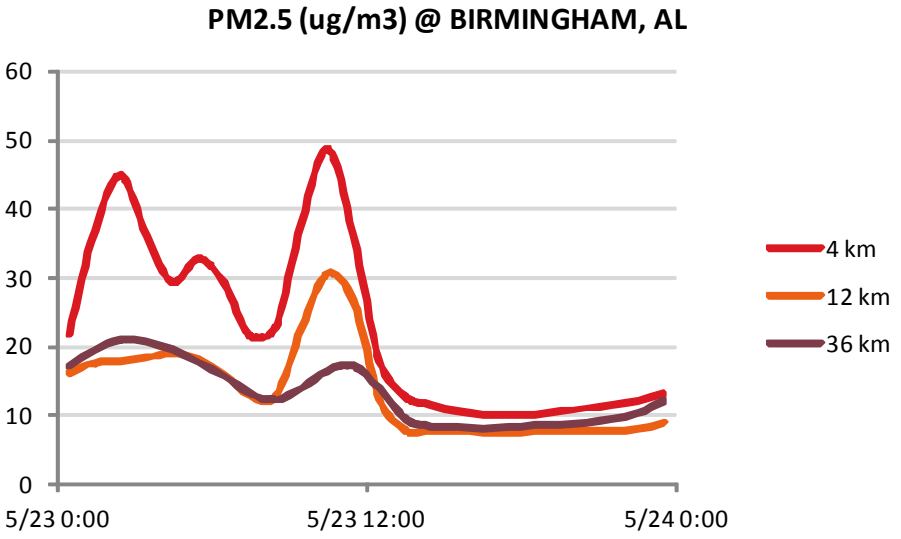
Birmingham, AL (5/23): 12 KM



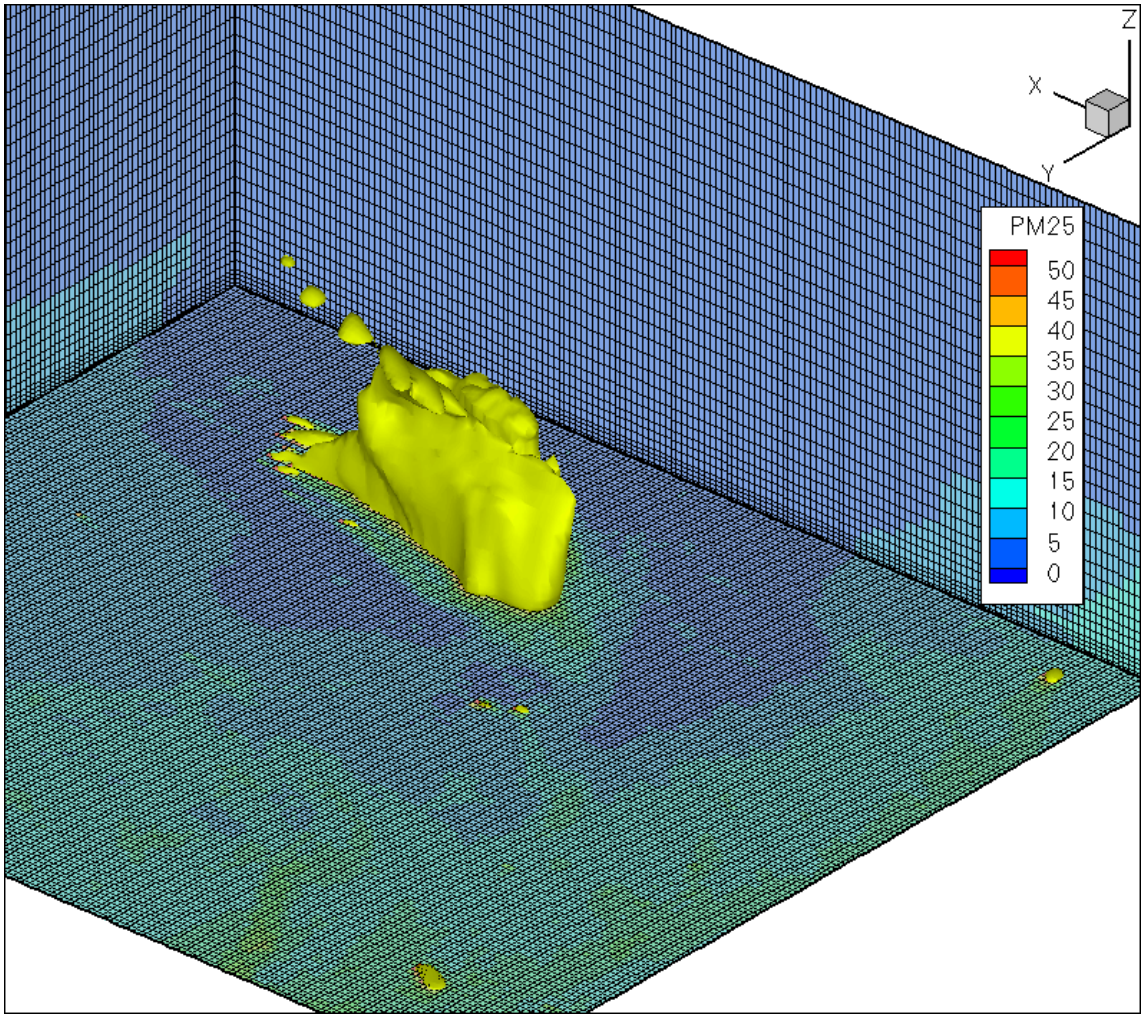


Birmingham, AL (5/23): 4 KM

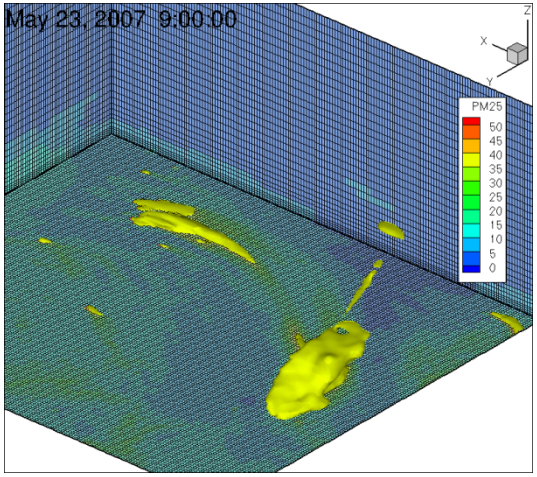


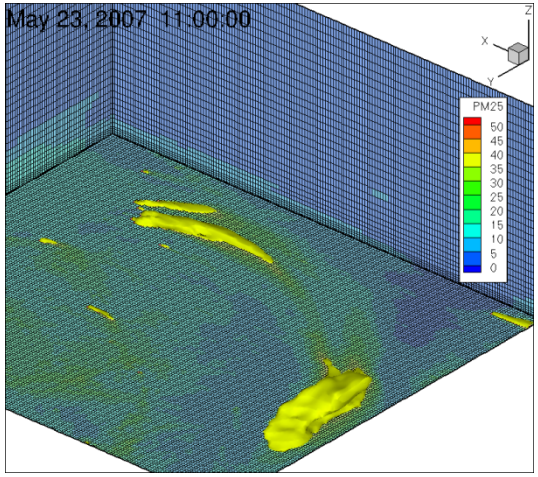


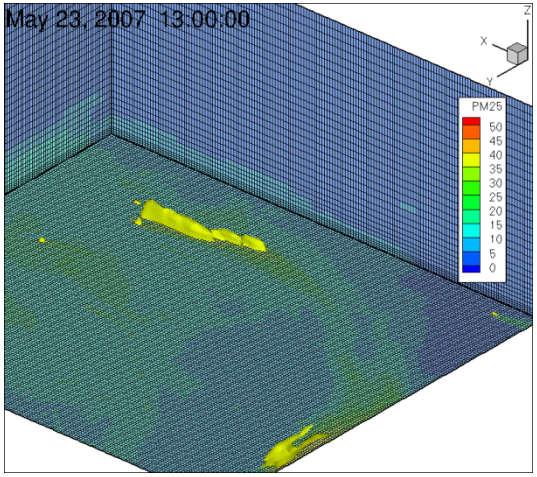
Birmingham, AL (5/23)

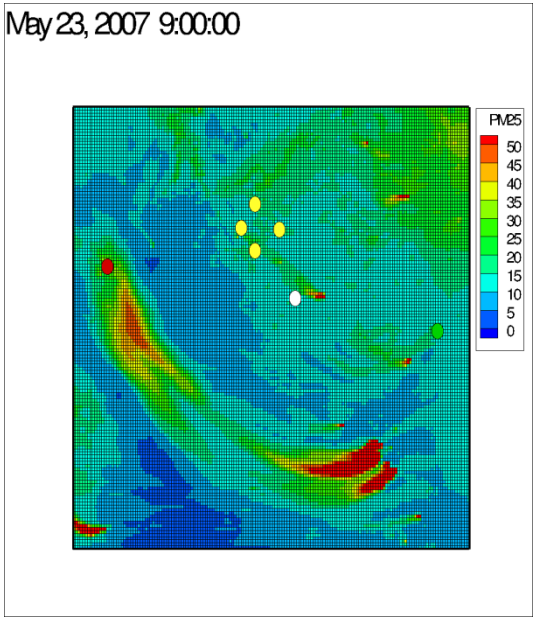


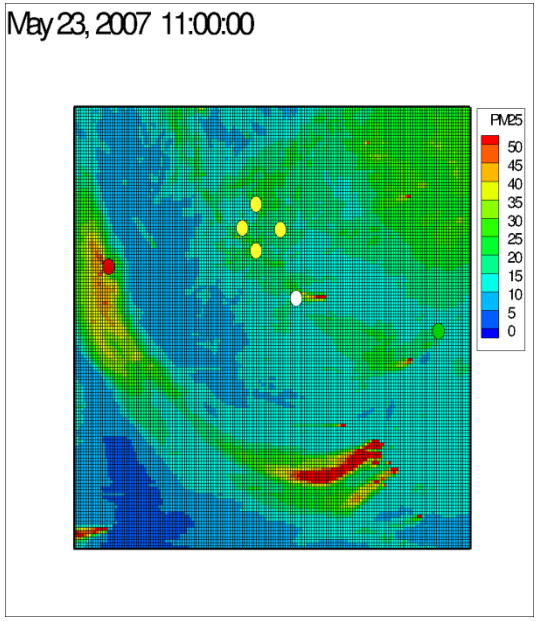
Birmingham, AL (5/23)

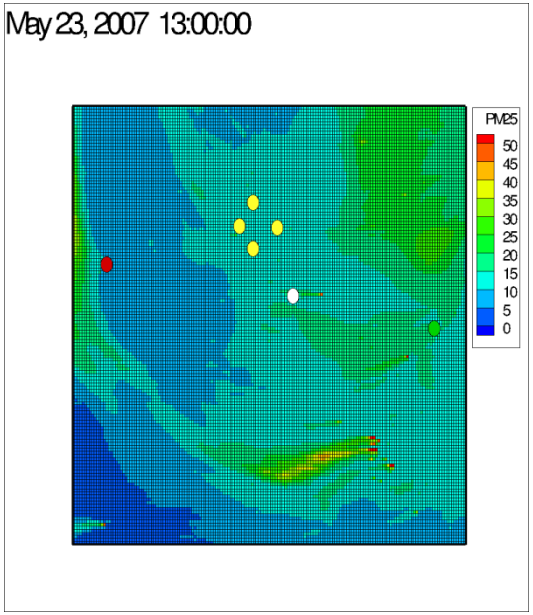




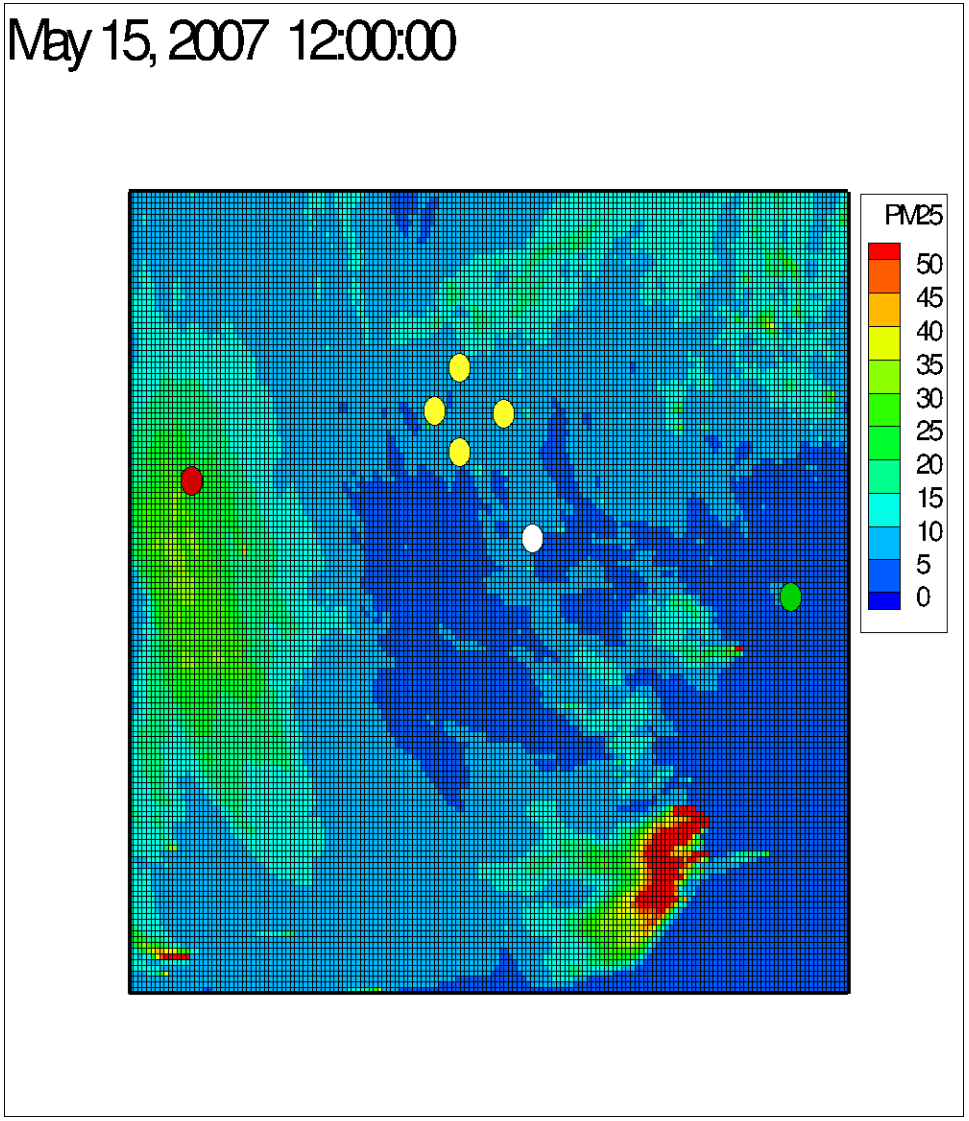


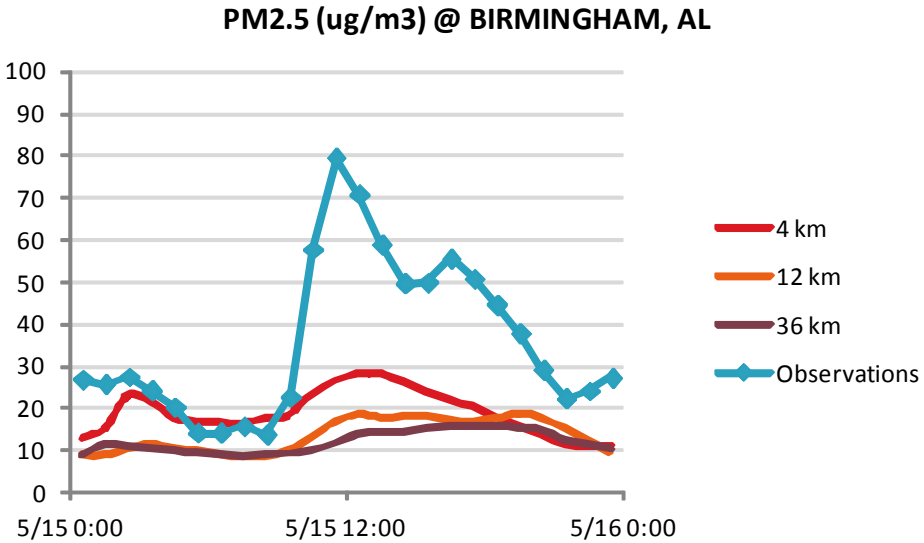


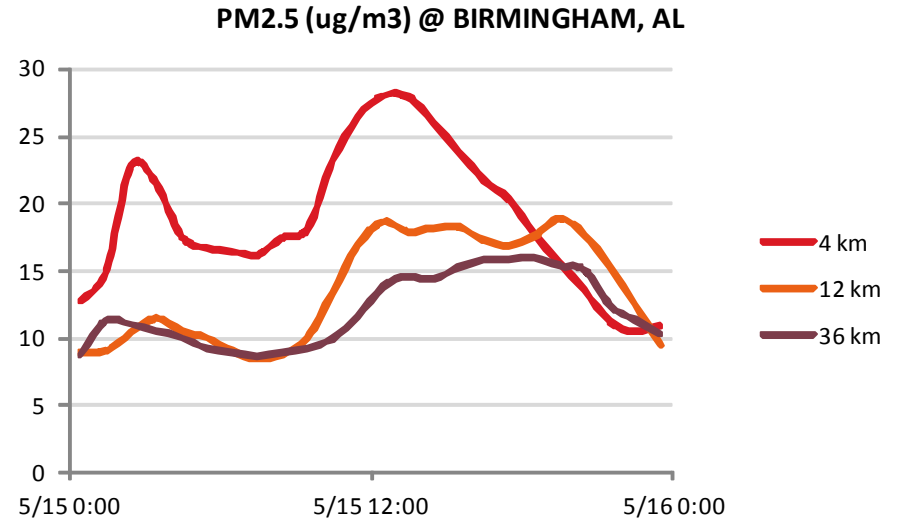




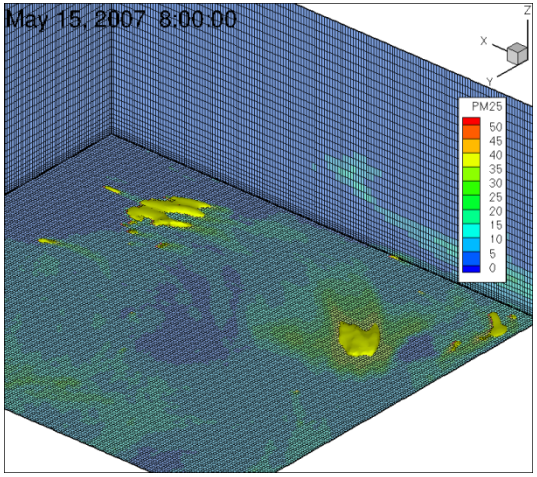
Birmingham, AL (5/15): 4 KM

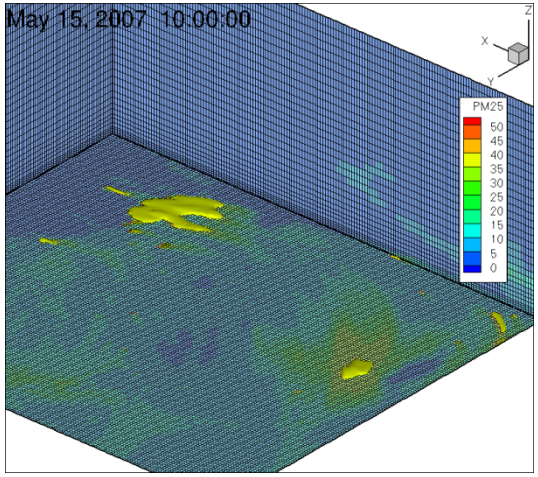


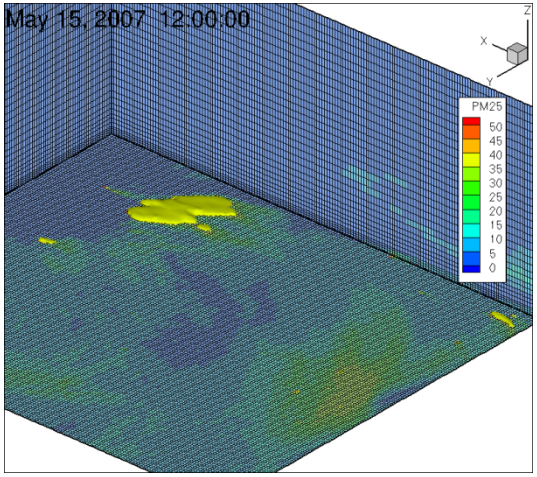


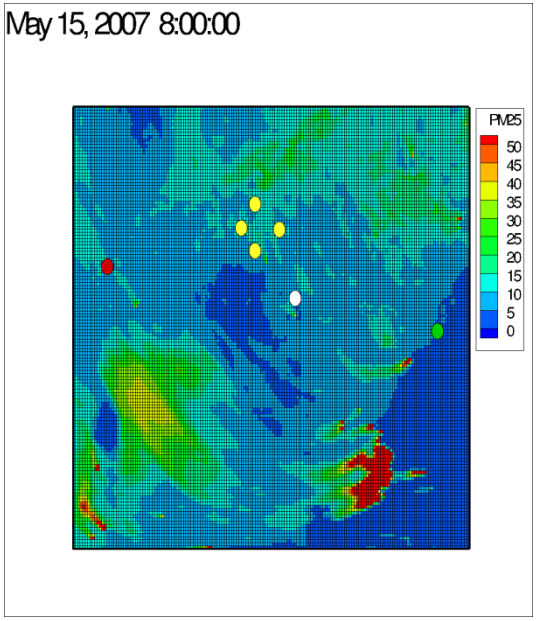


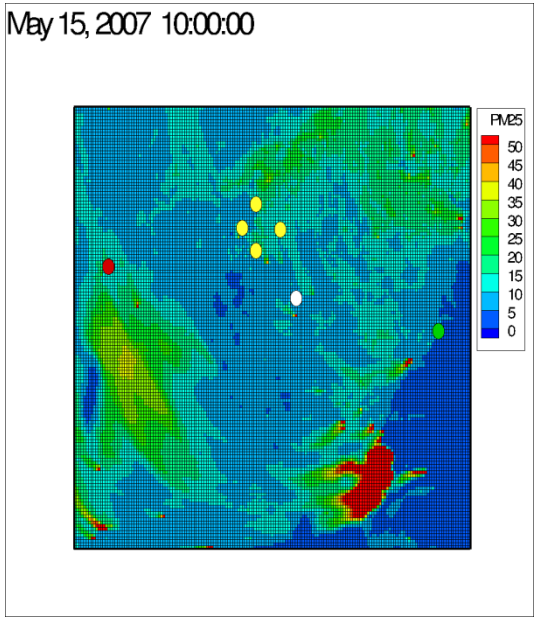
Birmingham, AL (5/15)

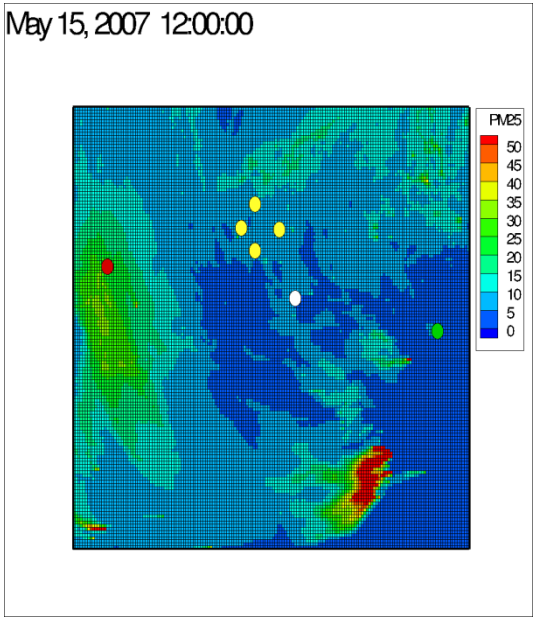




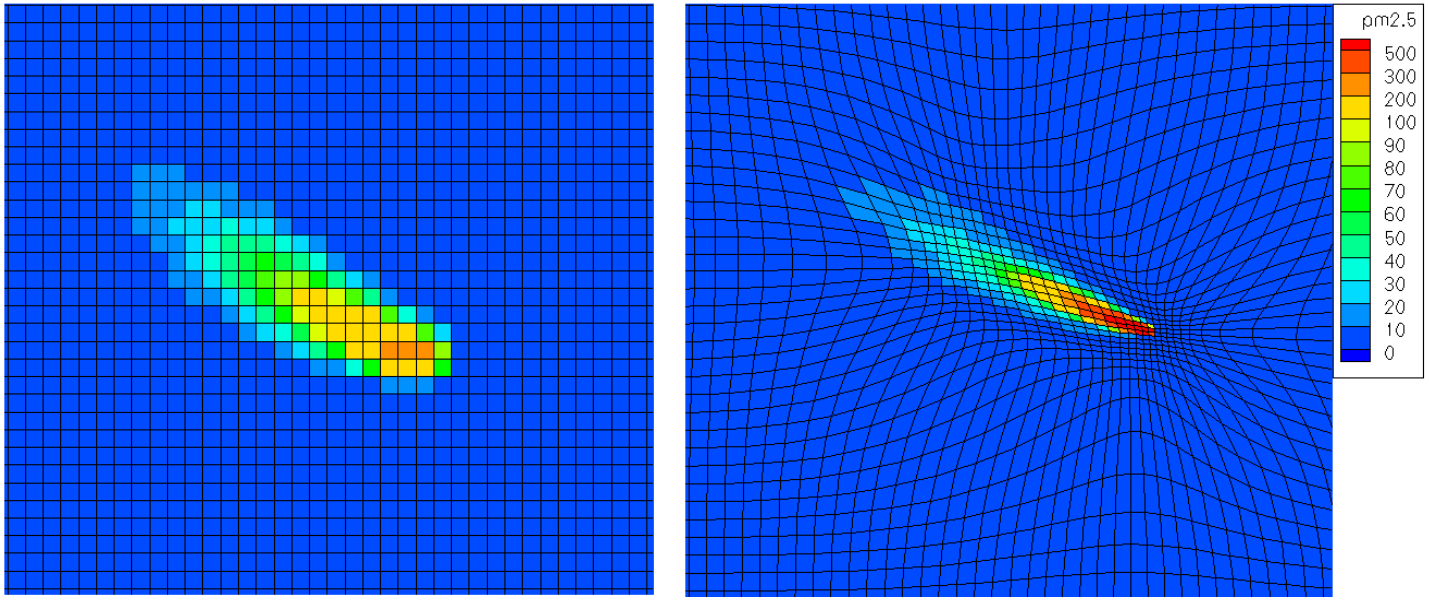








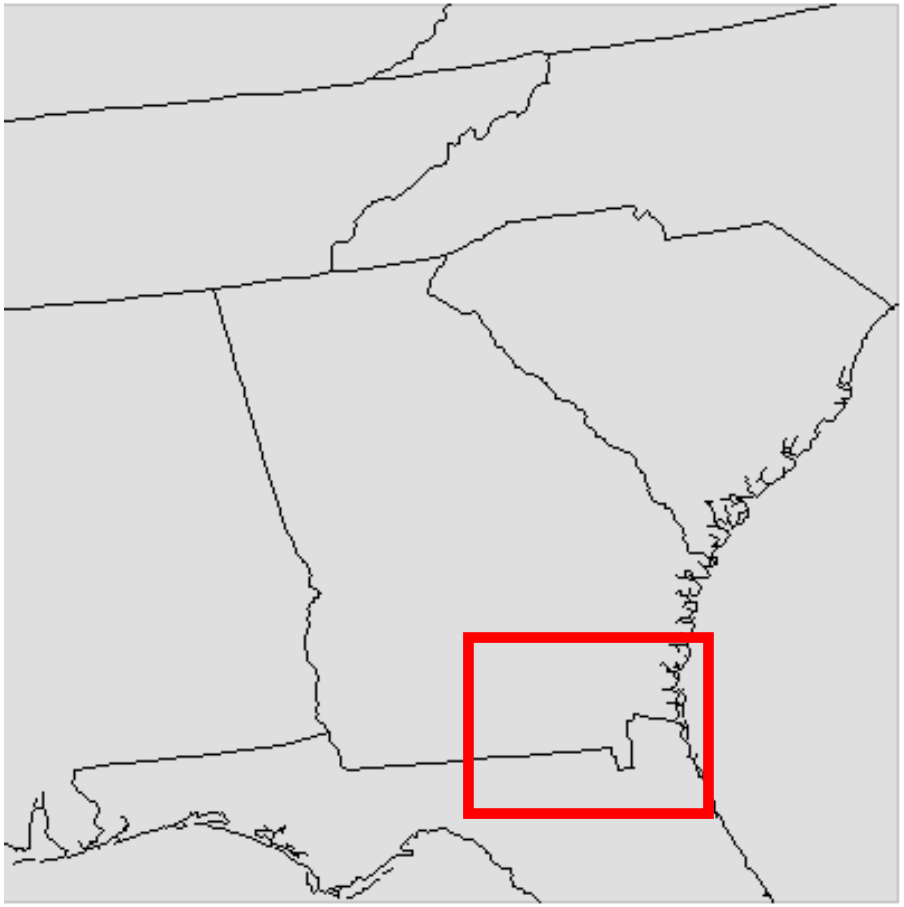
Adaptive Grid CMAQ



CMAQ AG-CMAQ

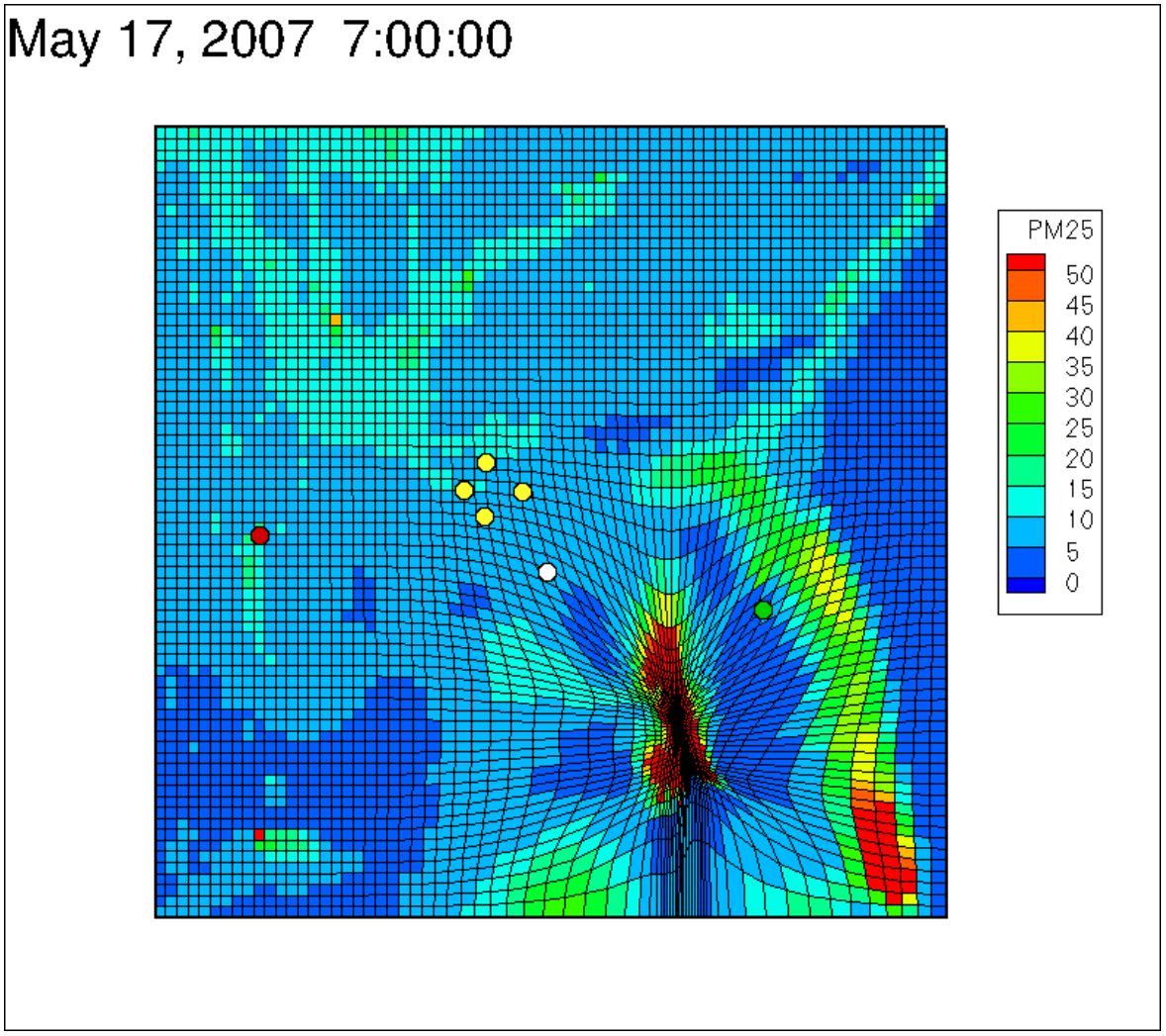
- Dynamic, solution-adaptive grid algorithm model
- $PM_{2.5}$ concentration curvature driven refinement

Adaptive Grid CMAQ Simulation

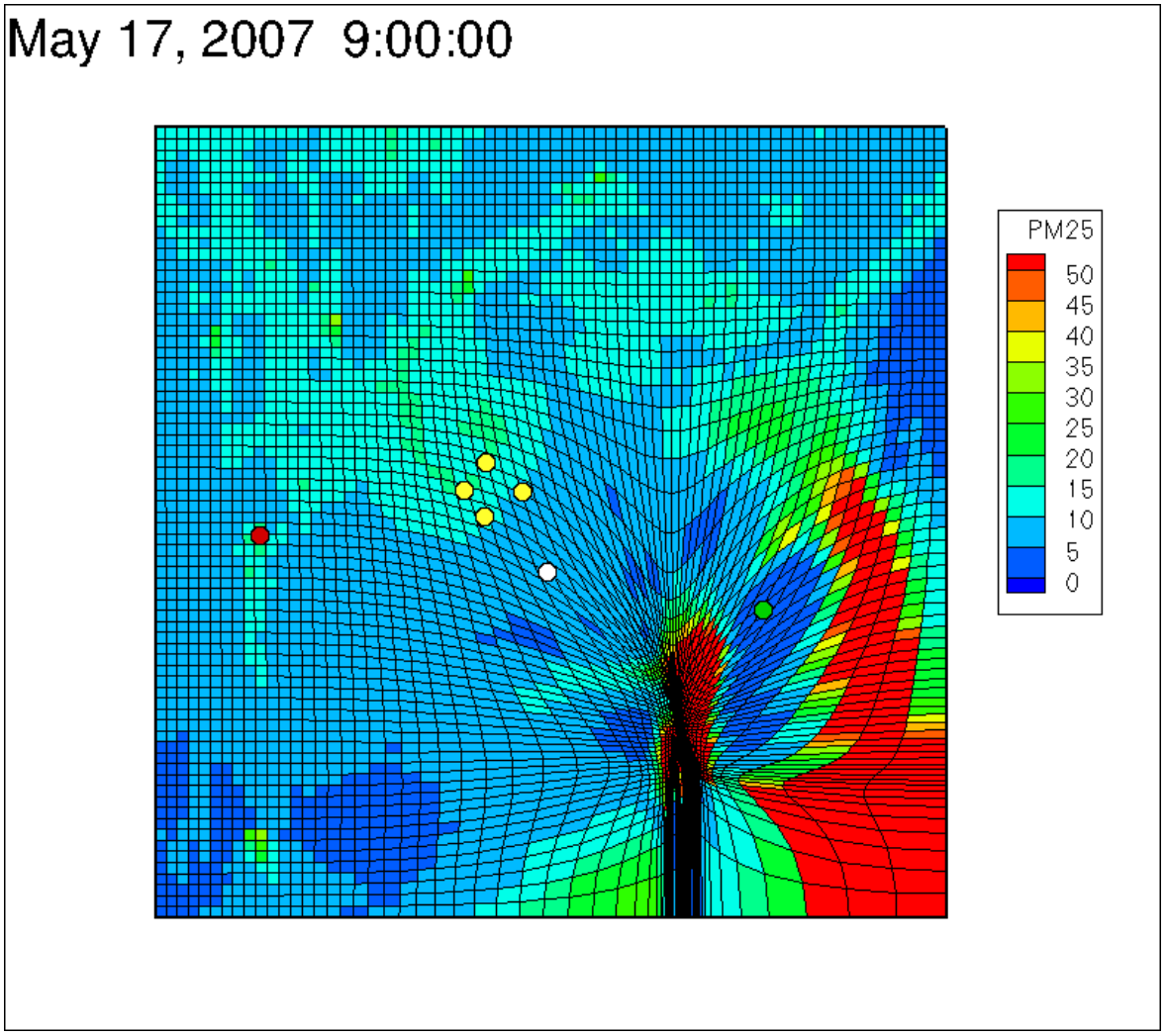


- Initial 12 km resolution
- Adaptation to wildfire emitted $PM_{2.5}$ within a selected subdomain
- Shorter (1-5 day) AG-CMAQ simulations

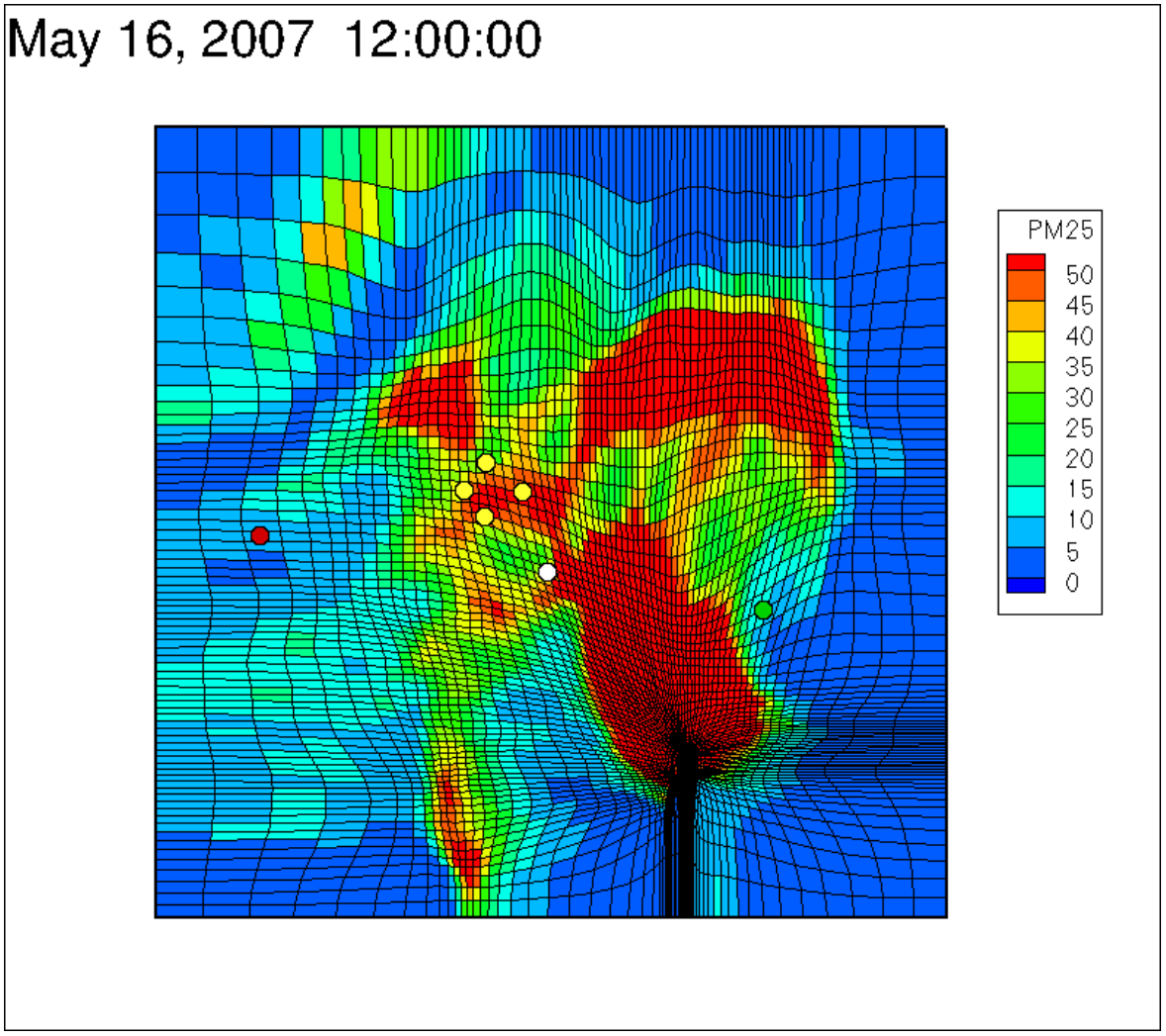
AG-CMAQ: Savannah, GA



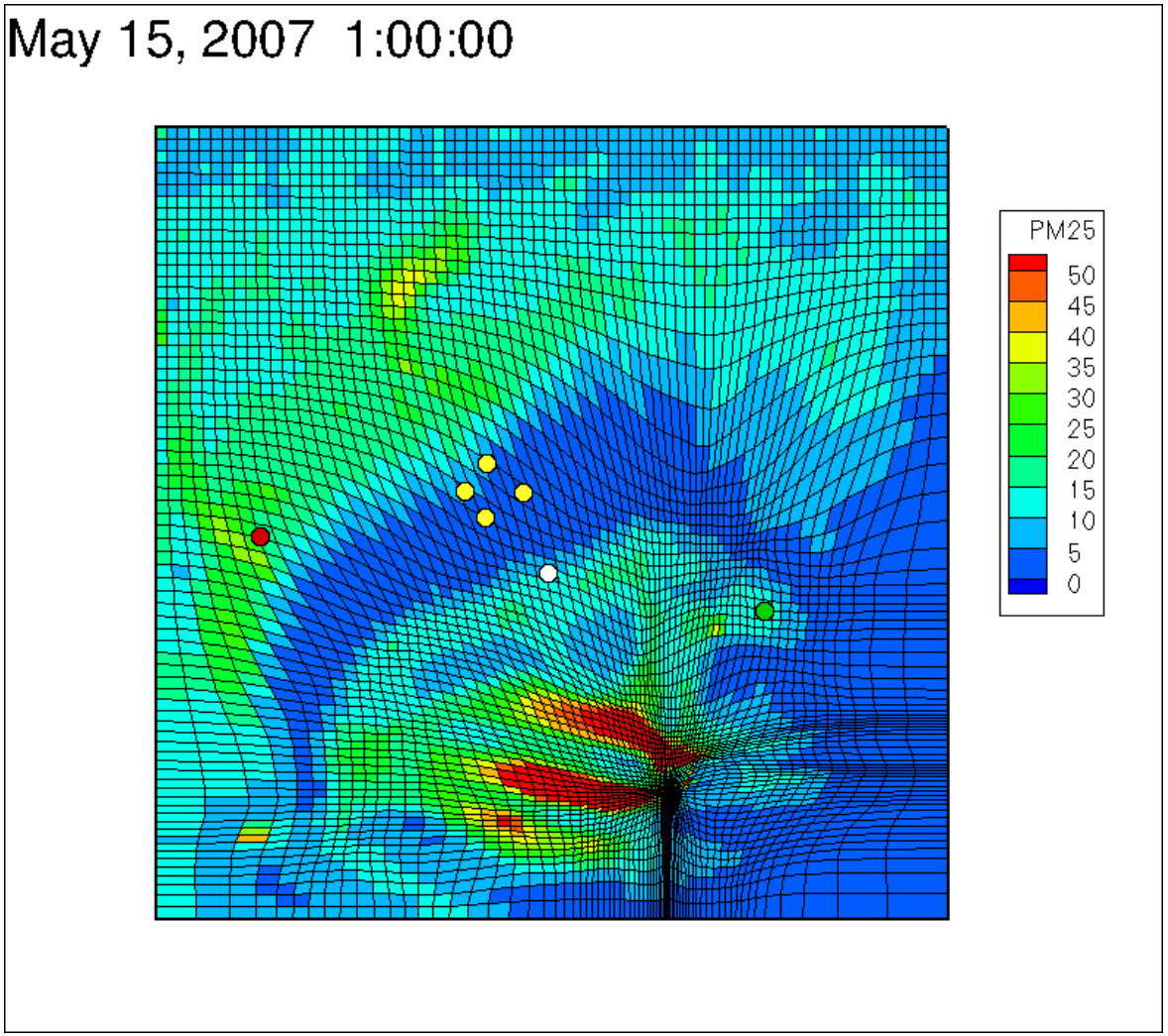
AG-CMAQ: Savannah, GA



AG-CMAQ: Atlanta, GA



AG-CMAQ: Atlanta, GA



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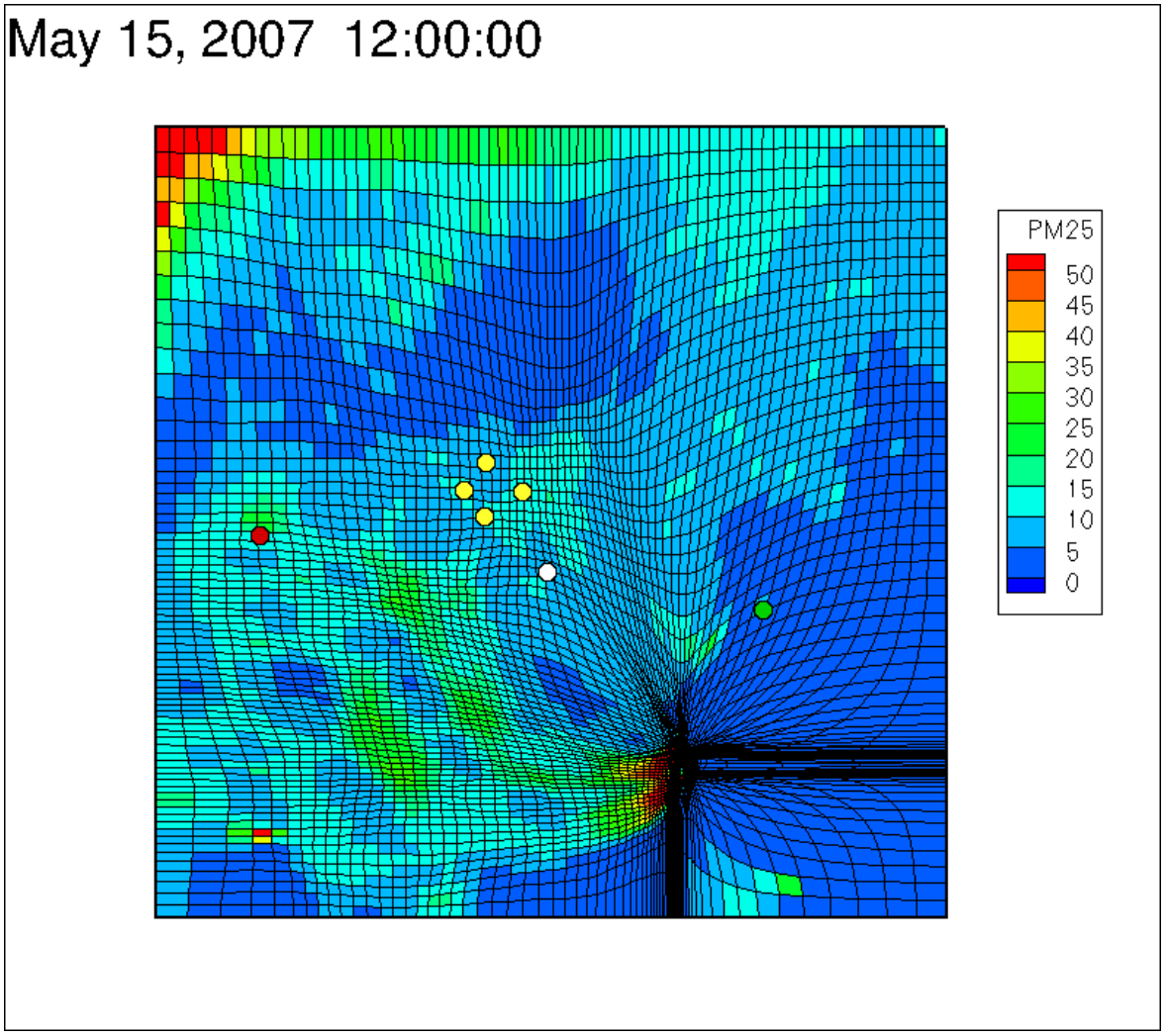

Conclusions

- CMAQ did not perform effectively as a AQ forecasting tool
  - Model severely underpredicted $PM_{2.5}$ impacts
- Simulations do provide useful insight into results and model performance
  - Pollutant transport trajectories agree with observed concentration peaks at monitoring sites
- Significant sensitivity of modeled concentrations at downwind receptors to grid resolution
- AG-CMAQ parameters must be modified to successfully model complex episodes with multiple sources and prolonged emissions

Conclusions

- Modeling needs towards successful CMAQ simulations of the air quality impacts from wildfires:
  - Improved wildfire emissions estimates
  - Plume rise and vertical fire emissions distribution
  - Realistic estimate of secondary organic aerosol formation
  - Accurate meteorological inputs
  - Grid resolution dependent parameterizations

THANK YOU!

Questions?

Strategic Environmental Research and Development Program

Joint Fire Science Program

Georgia Department of Natural Resources, Environmental Protection Division

US Forest Service, Southern Research Station