Evaluation of Grid-Based Ozone and PM Modeling for a 1999 Summer Episode

Air & Waste Magagement Association
95th Annual Conference and Exhibition
June 23-27, 2002
Baltimore, MD

by

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EOHSI is a Joint Project of
UMDNJ-RWJ Medical School & Rutgers The State University

OUTLINE

- Project objectives
- MM5 simulations
- Comparison of observations with MM5 models
- Air quality simulations
- Comparison observations with air uality model predictions
- Conclusions
- Ongoing efforts

Project Objectives

- Modeling Project Objectives : Accomplished & Ongoing
  - A comparative evaluation of prognostic mesoscale meteorological models with ground and upper air data from the North East Oxidant and Particle Study (NE-OPS) research program in 1999 over Philadelphia. The two meteorological models considered are the Fifth Generation Pennsylvania State University/ National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5) and the Regional Atmospheric Modeling System (RAMS) Version 4.3.
  - A comparative evaluation of mechanistic (emision based) photochemical gas/aerosol air quality models with ground and upper air data from EPA's AIRS database and the NE-OPS research program in 1999 over Philadelphia. The photochemical models considered are the US EPA's Community Multiscale Air Quality (CMAQ) model, MCNC's Multiscale Air Quality Simulation Platform (MAQSIP) and CAMx.
  - A comparative assessment of population exposures to ozone and particulate matter (PM) in Philadelphia during the NE-OPS field study.

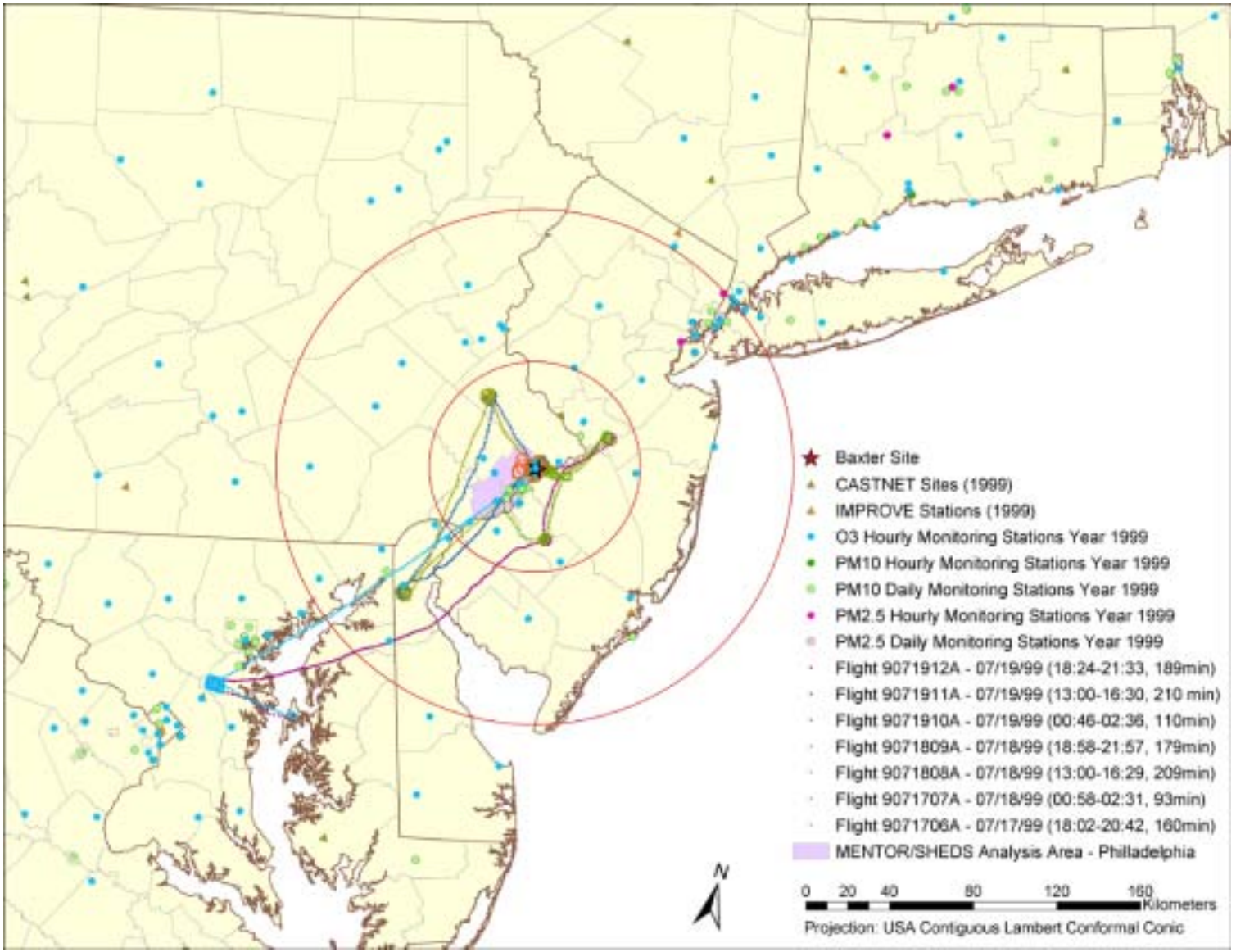
Brief Summary of NARSTO-NE-OPS Efforts

- North American Research Strategy for Tropospheric Ozone - Northeast - Oxidant and Particle Study (NARSTO-NE-OPS) set up to improve current understanding of underlying causes for occurence of high ozone and increased levels of fine particles in NE USA.
  - Location : Baxter Water Treatment Plant, Philadelphia, PA
  - 1998 Pilot Study
  - 1999 Main campaign (28 June 1999-19 August 1999)
  - 2001 Additional campaign
- Seven pollution episodes occured during the above campaign in 1999 3-5 July, 8-10 July, 16-21 July, 23-24 July, 27 July-1 Aug, 11-13 Aug, 15-17 Aug
- Aircraft (particulate matter,chemical species, meteorology) - University of Maryland, Brookhaven National Laboratory
- Radar wind profiler/RASS (profiles of wind velocity components & virtual temperature) - Philadelphia Air Management, PNNL, ANL
- Lidar (profiles of ozone,temperature,water vapor & extinction) - Penn State

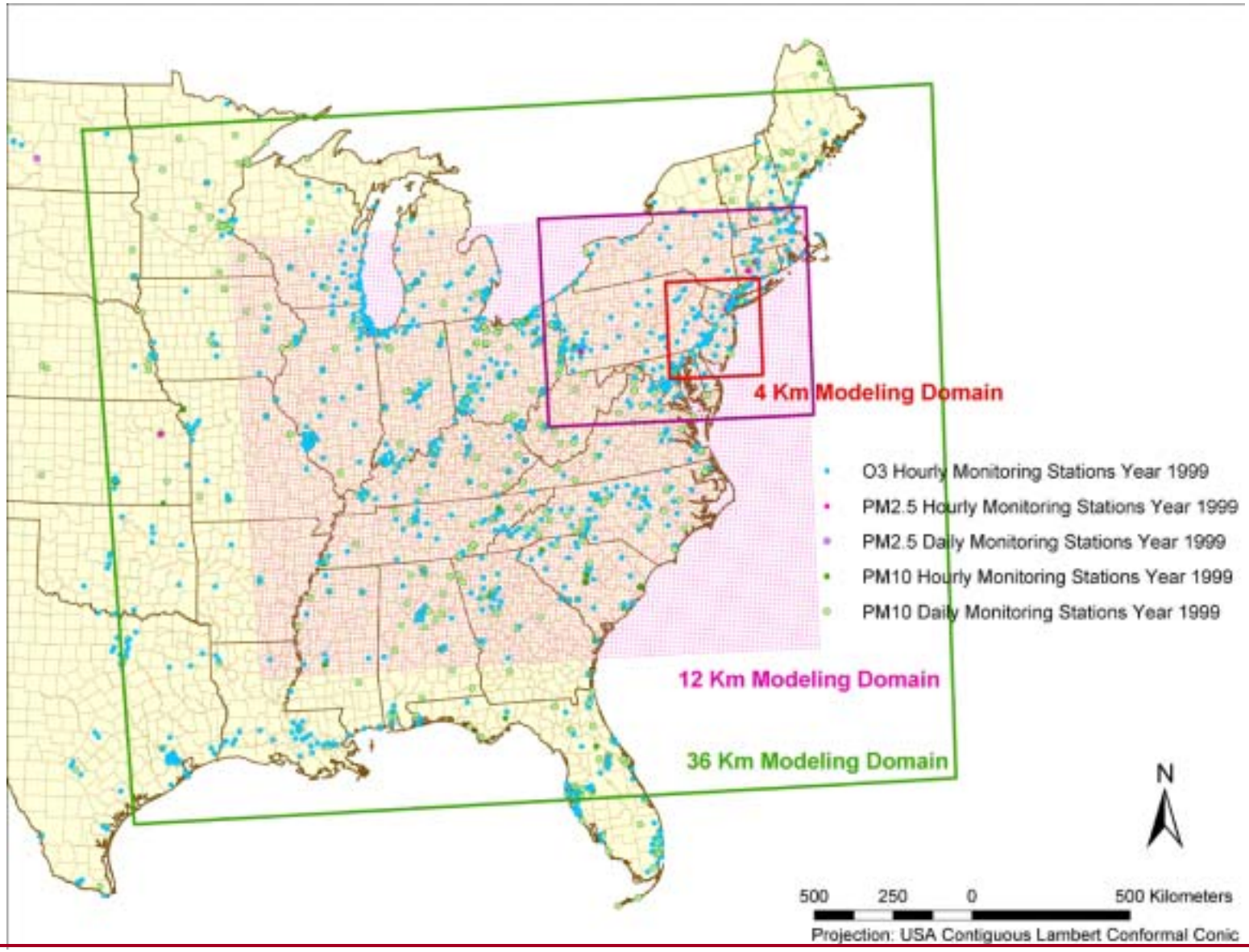
Brief Summary of NARSTO-NE-OPS Efforts (continued)

- Tether (profiles of fine particles, ozone & meteorology) - Millersville University
- Ozonesondes, rawinsondes (profiles of ozone, temperature, water vapor) - PNNL, ANL
- Ground based measurements (analysis of particle/chemical samples) - Harvard University School of Public Health, Drexel University, Bringham Young University

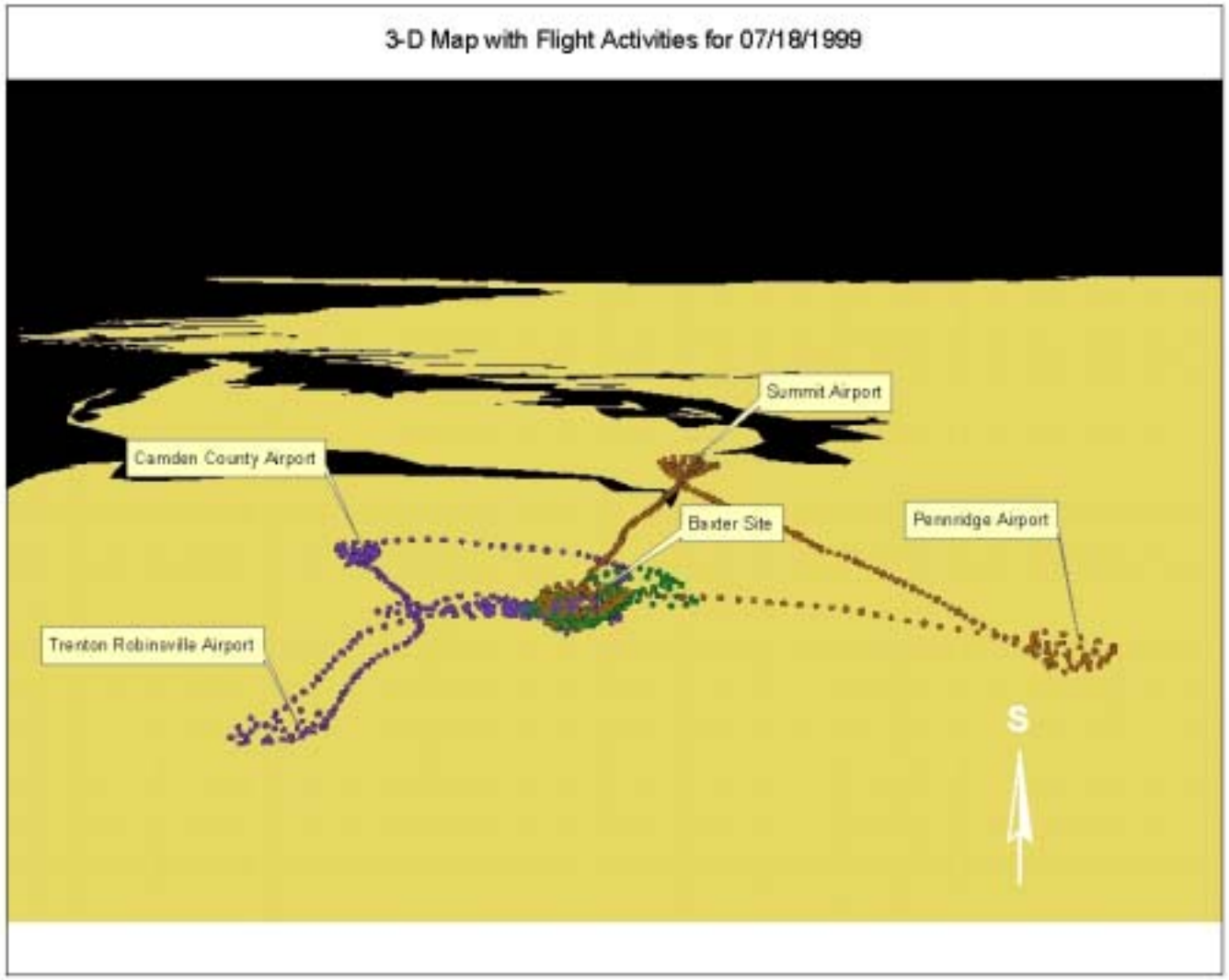
Monitor Stations and Flight Tracks in the NE-OPS Domain



AIRS Monitoring Stations in the OTAG Domain



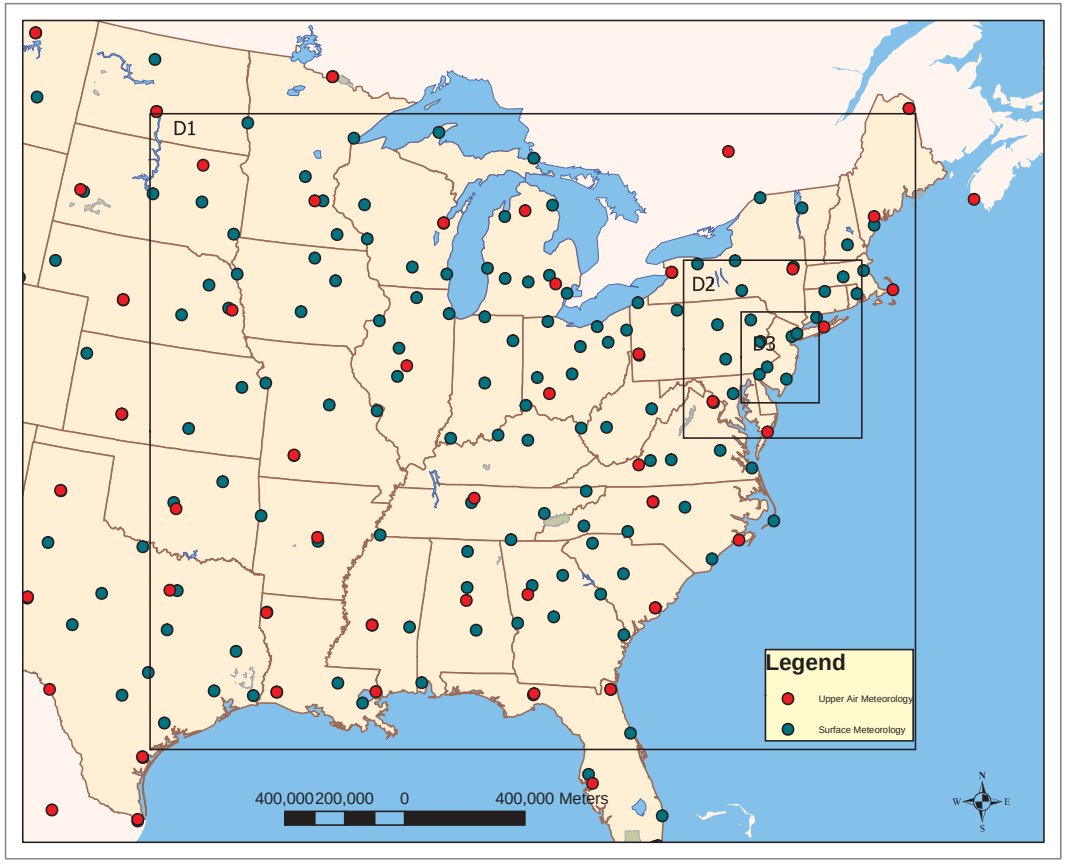
3D Flight Tracks



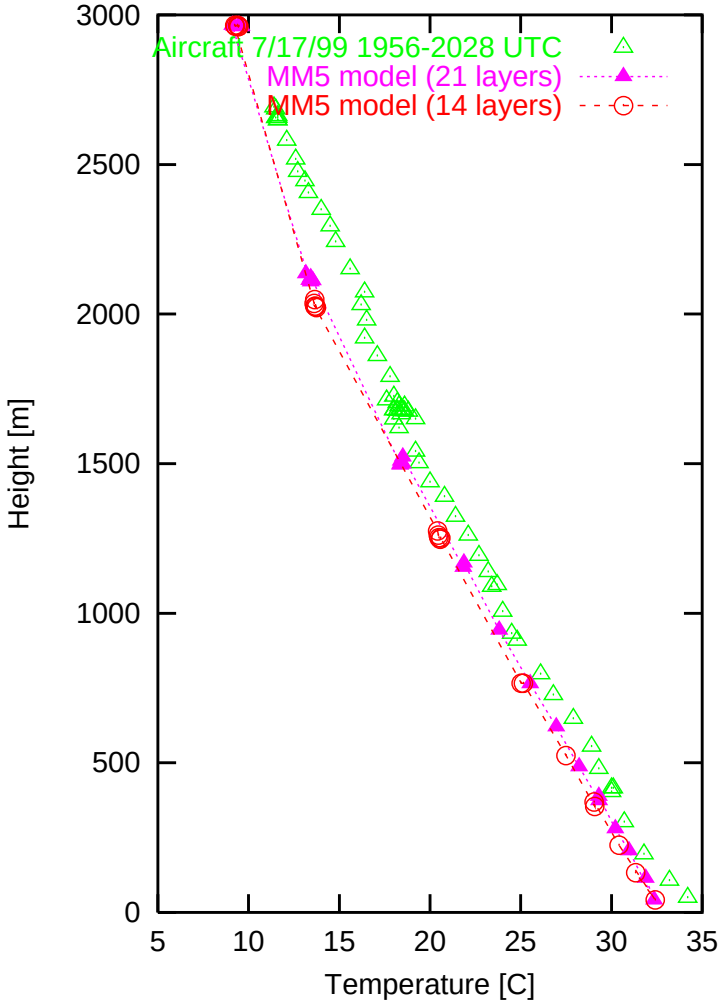
MM5 Simulations for NE-OPS 99

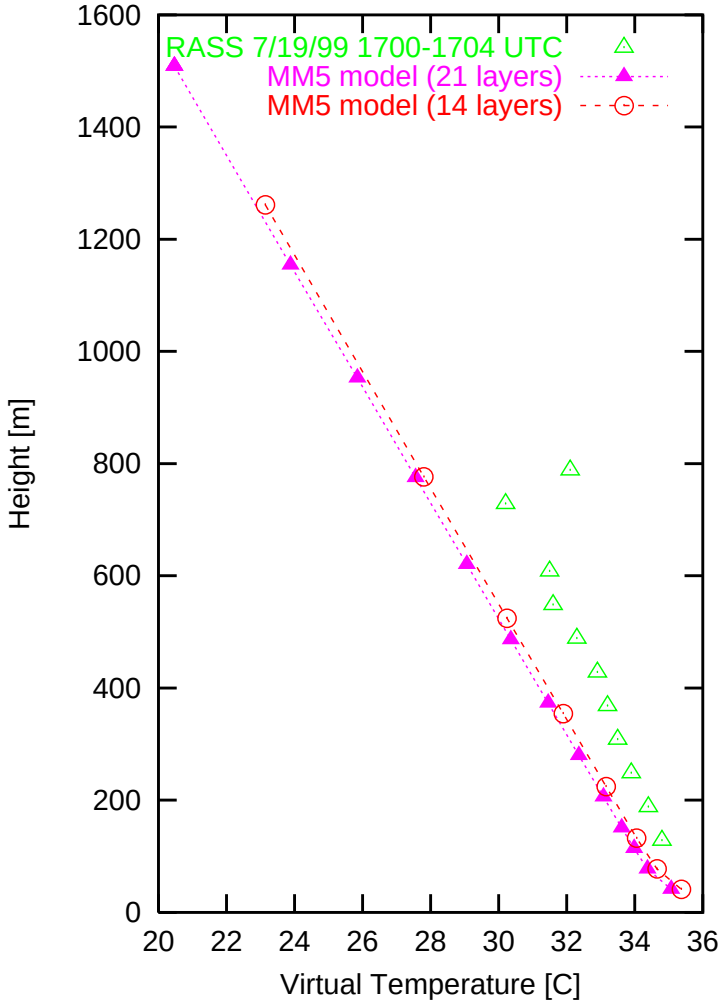
- **Study Utilized the following in MM5 simulations**
  - High Resolution Blackadar Scheme for PBL
  - Grell scheme for cumulus parameterization
  - Mixed Phase (Reisner scheme for explicit moisture)
  - Cloud radiation scheme
  - Force restore (Blackadar) scheme for ground temperature
  - Three levels of nested grid (36, 12 & 4 km resolutions)
  - One way nesting approach with 4DDA. The global analysis data, the upper air data and the surface data were used in 4DDA. The 36 Km domain encompassed about 40 upper air rawinsonde stations and about a thousand surface stations.
  - ECMWF Global analysis data at 2.5 degree resolution
  - Rawinsonde and surface data from standard NWS stations
- 14 layers in the vertical : Grid dimensions 75x69, 52x52 and 67x76
- 14 layers in the vertical : MM5 simulation 11 July 99 00 UTC- 25 July 99 11 UTC

MM5 modeling domain with meteorological upper air and surface stations

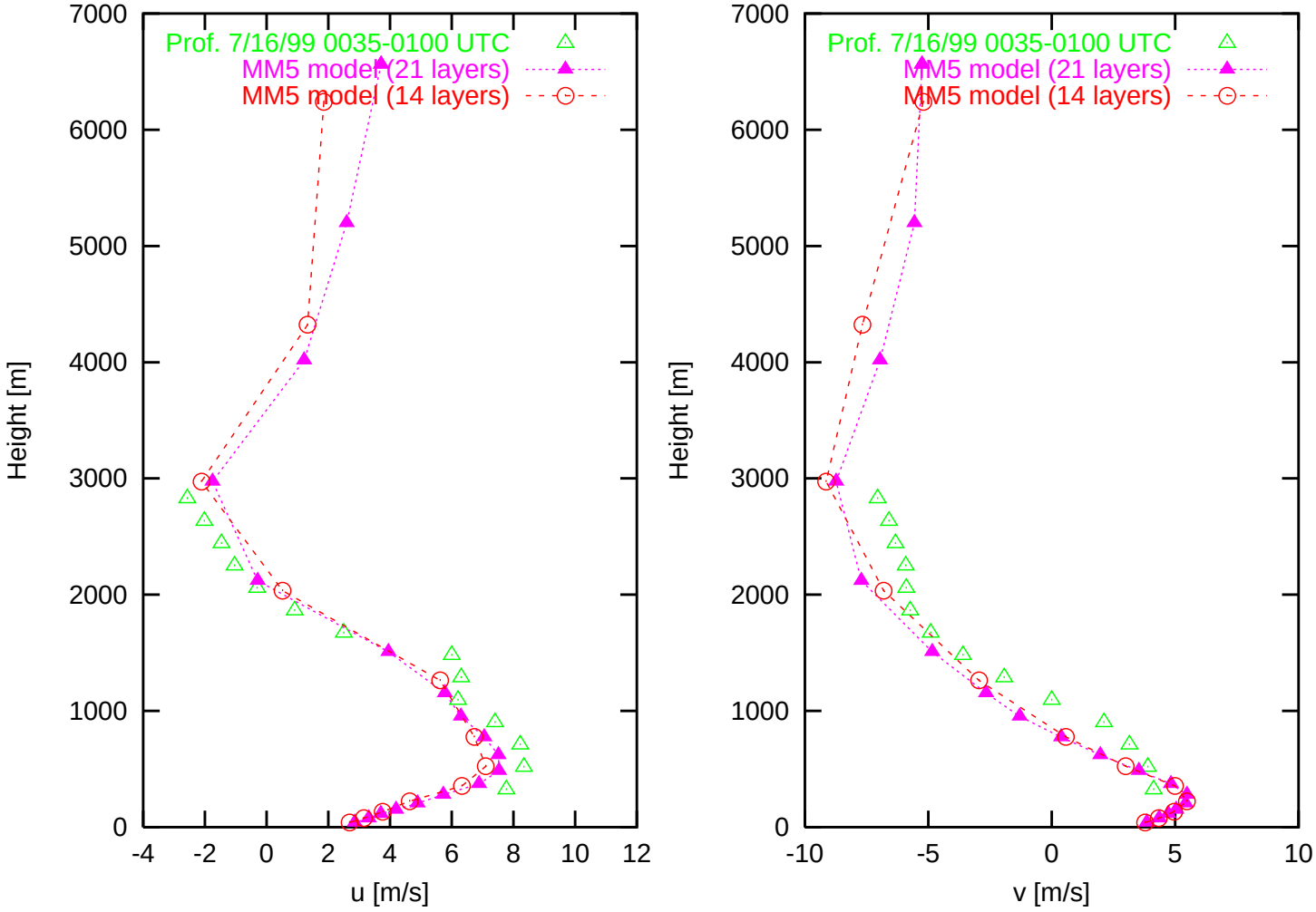


NE-OPS aircraft and RASS data comparison with 4km MM5 model





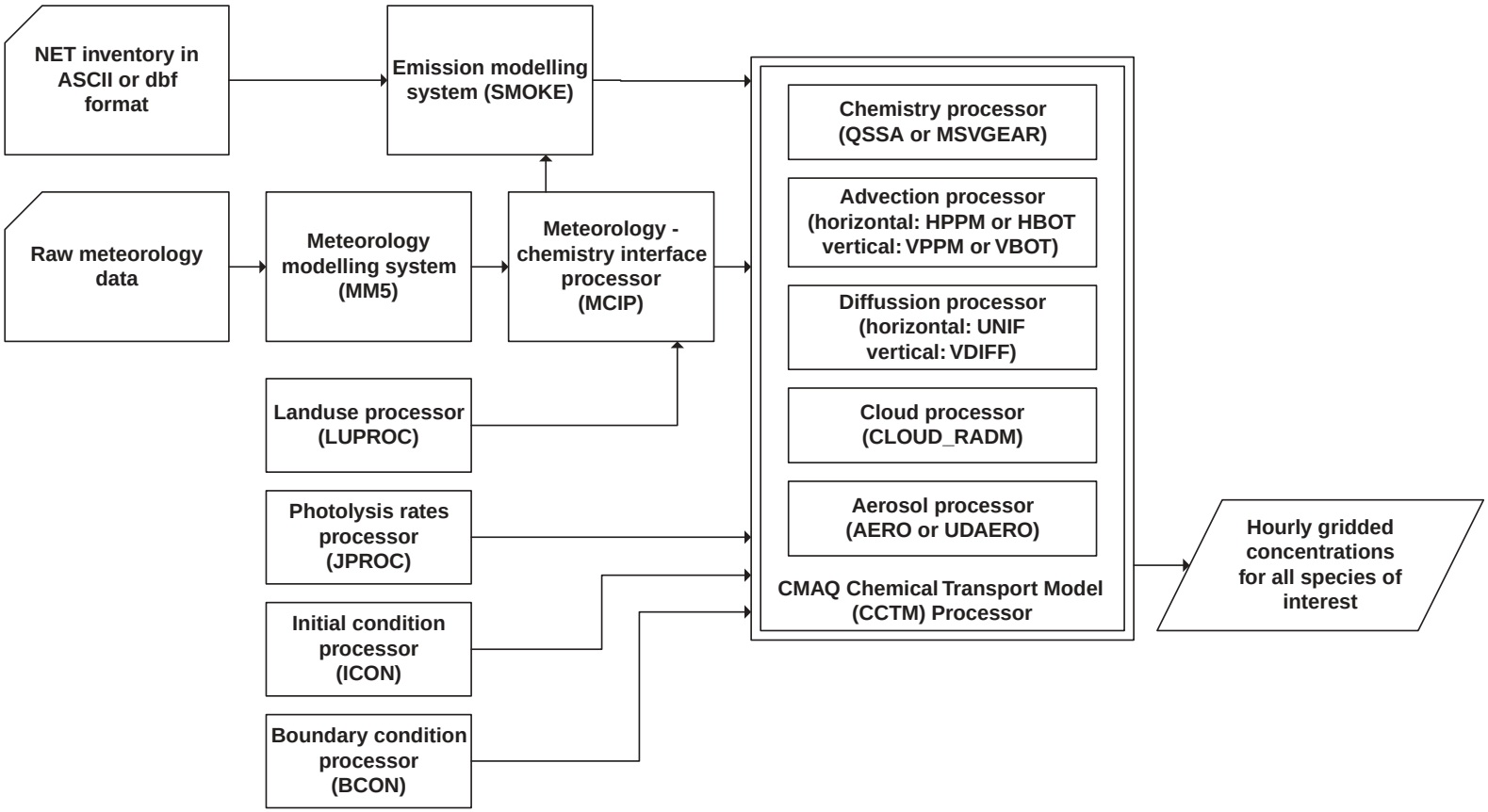
NE-OPS PROFILER data comparison with 4km MM5 model 07/19/99 17 UTC



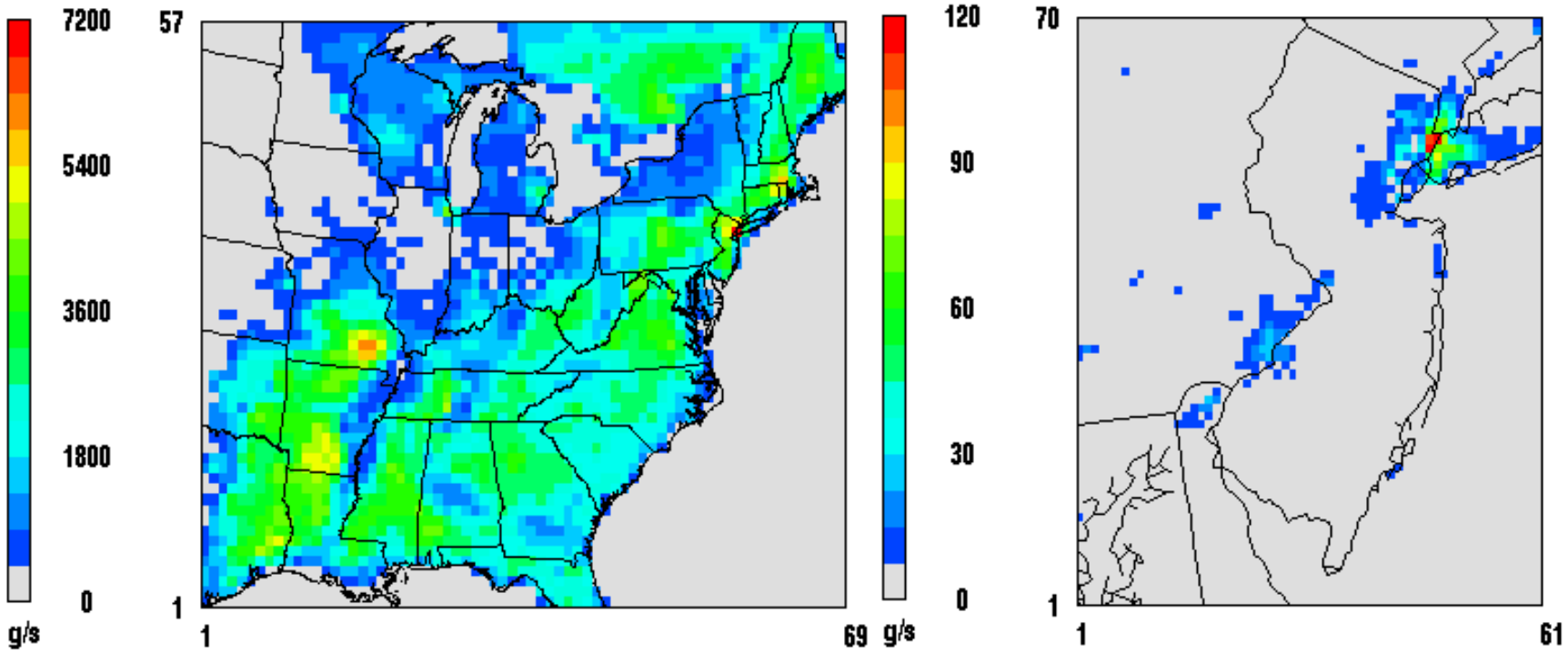
CMAQ Simulations for NE-OPS 99

- Emissions input obtained from U.S. EPA's 1998 National Emissions Trends (NET) processed using Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system
- Meteorology input obtained from MM5 simulations
- Processes modeled in CMAQ:
  - Advection and dispersion
  - Emissions and dry/wet depositions
  - RADM2 gas phase chemistry mechanism with 59 model species and 158 reactions
  - Aerosol dynamics for coagulation, particle growth and particle formation
  - Cloud chemistry and dynamics
- 14 layers in the vertical : Grid dimensions 69x57, 46x46 and 61x70
- Simulation time period: 11 July 99 00 UTC- 25 July 99 11 UTC

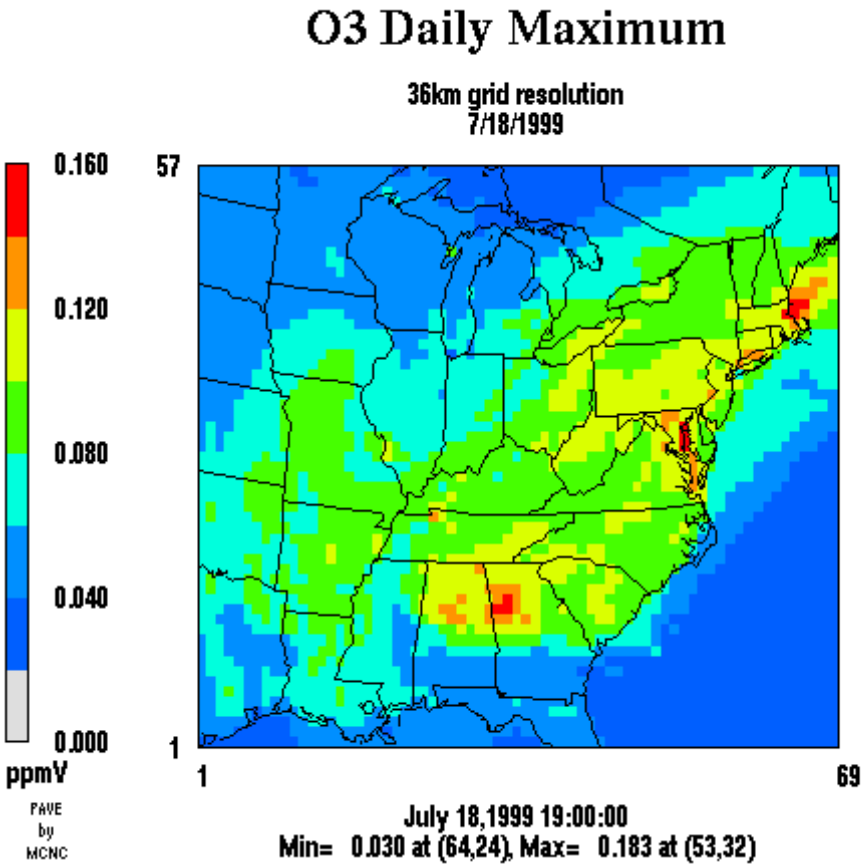
CMAQ Flowchart

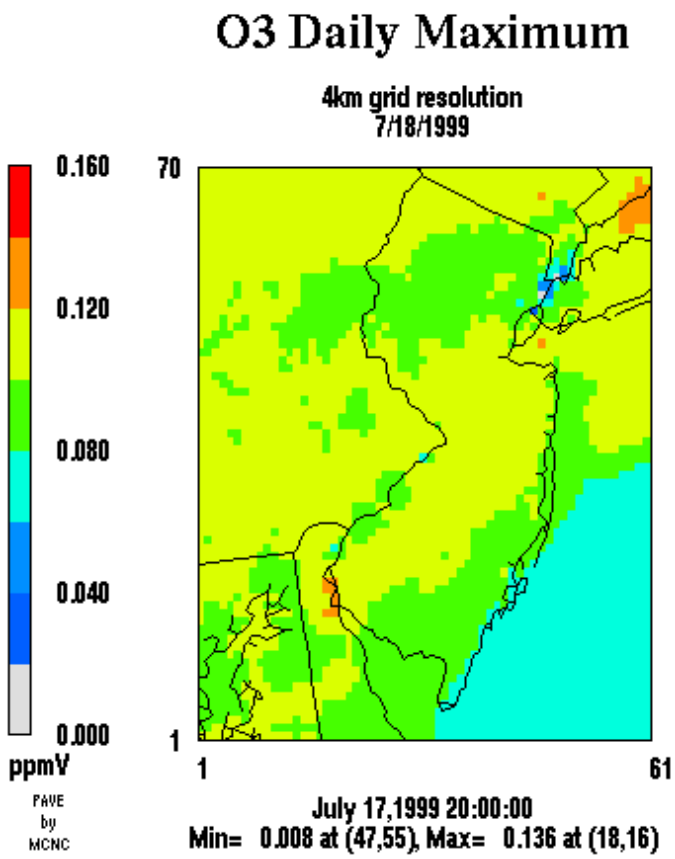


VOC and $PM_{2.5}$ emissions at 14:00 EDT 7/17/1999 for the 36km and 4km resolution domains

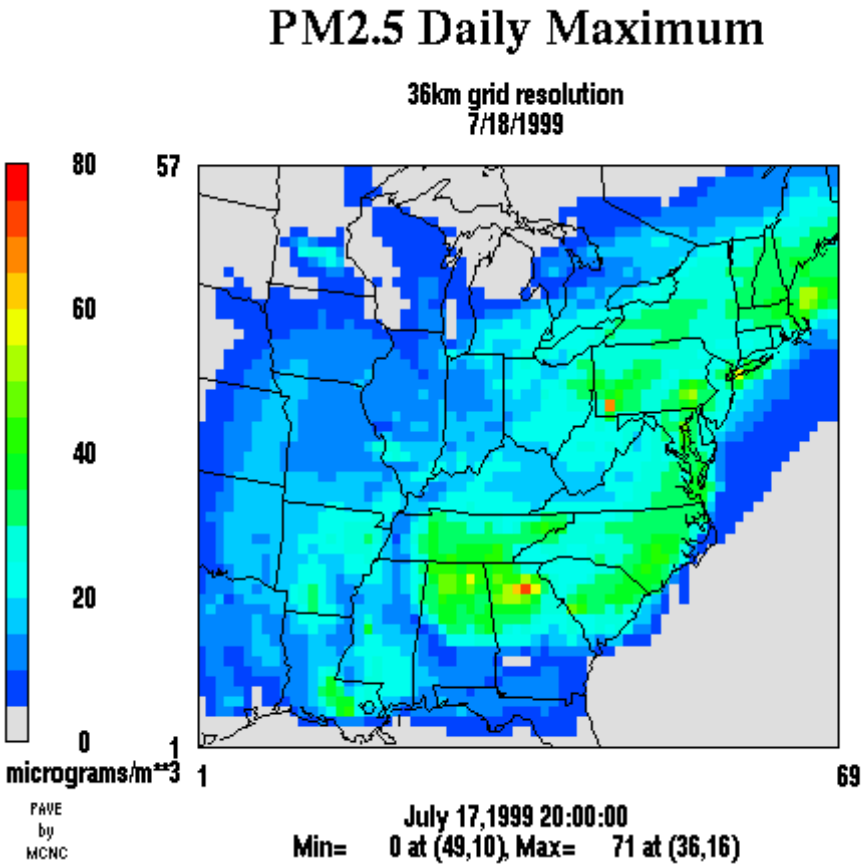


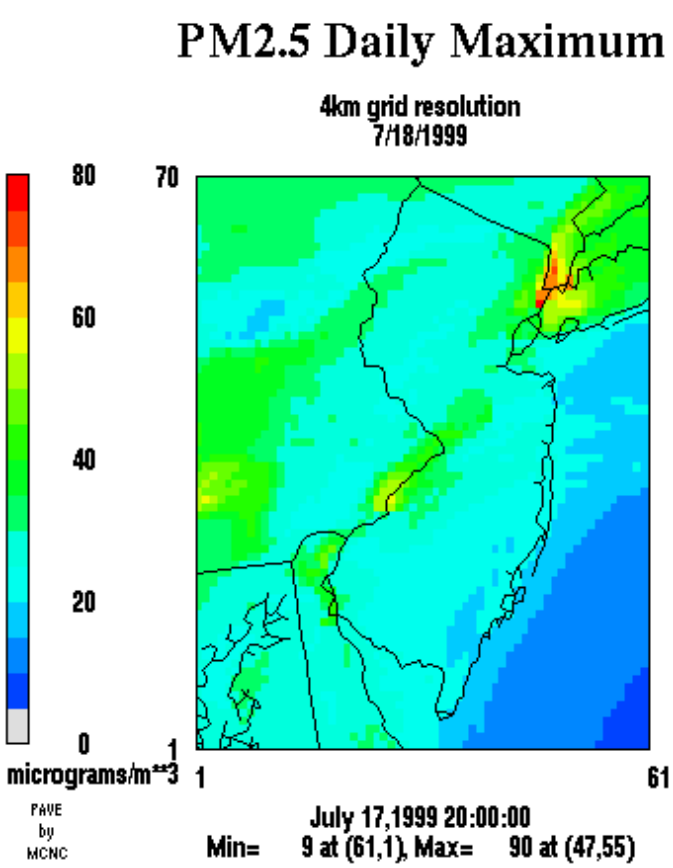
CMAQ predicted daily maximum for Ozone



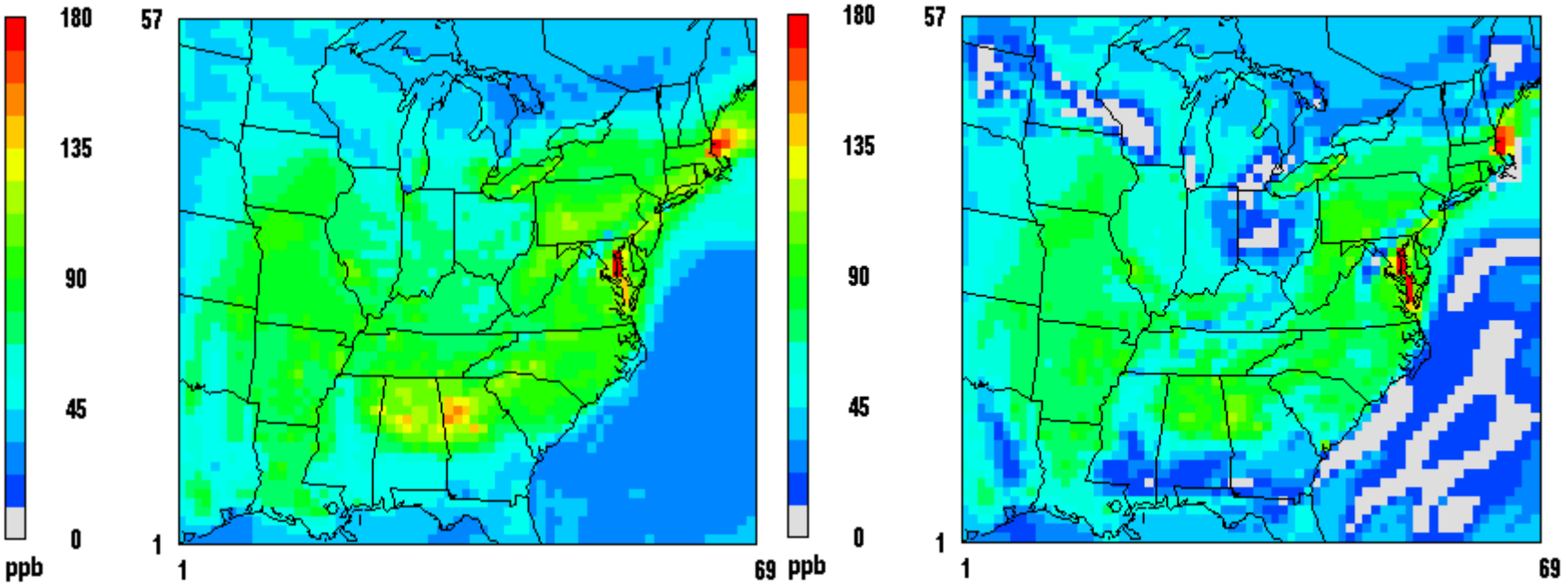


CMAQ predicted daily maximum for $PM_{2.5}$

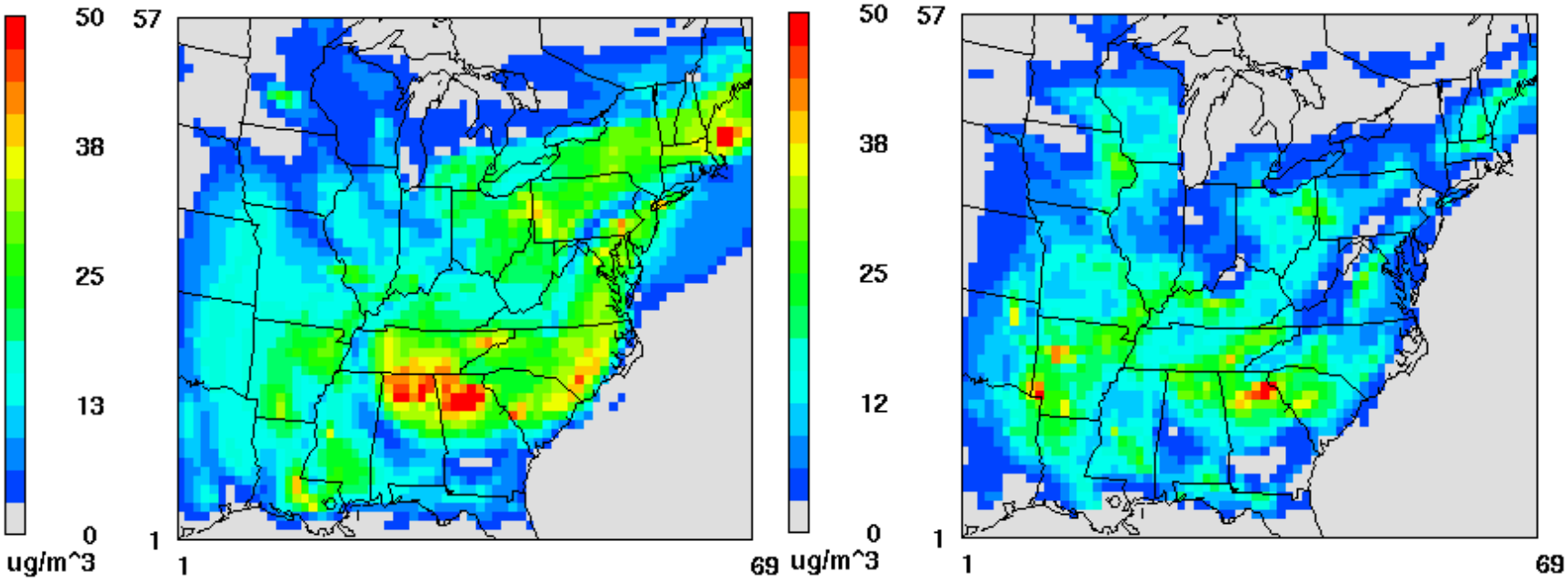




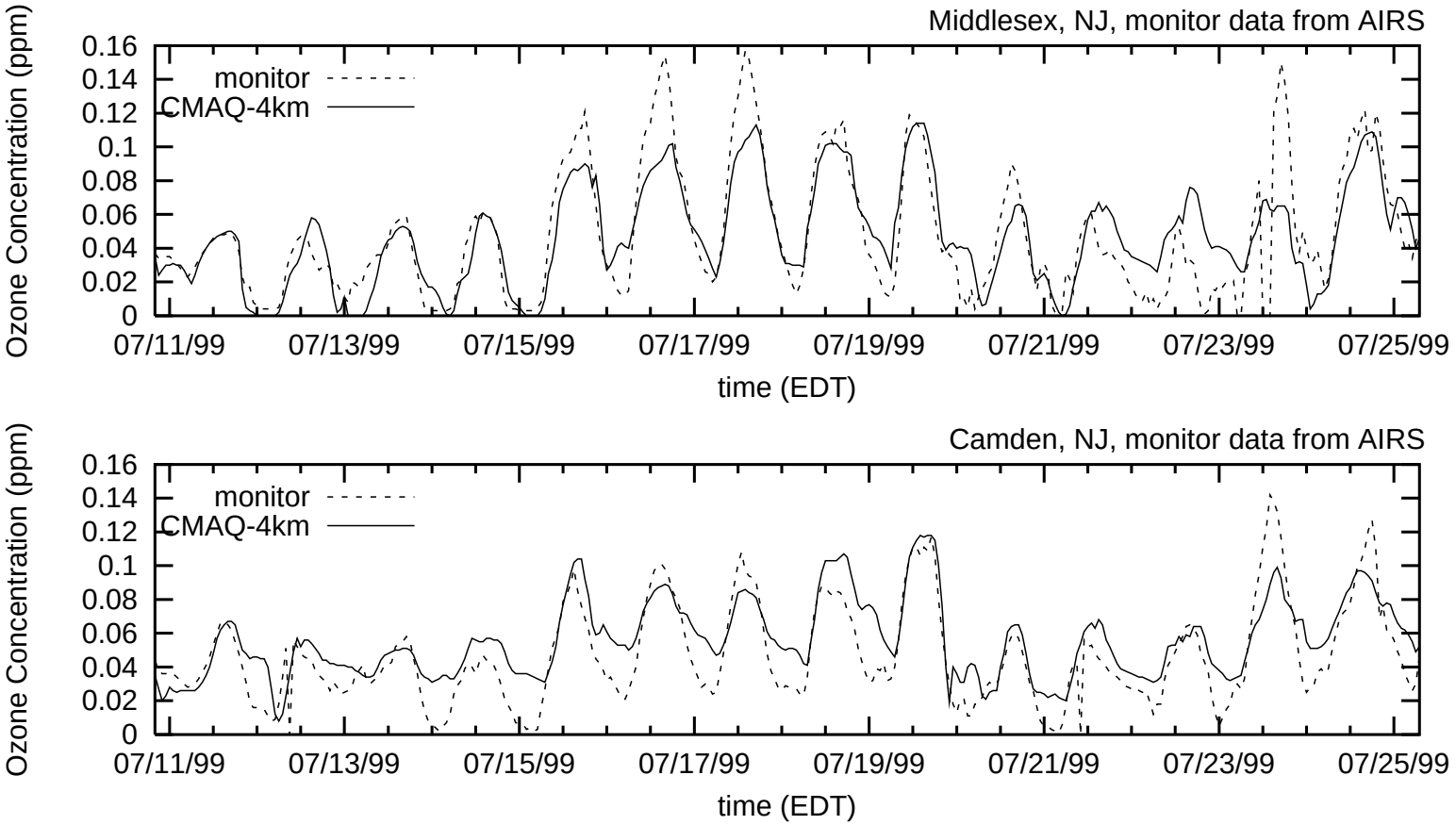
Ground level O_3 predicted by CMAQ (left) and MAQSIP (right) at 22:00 UTC 7/18/99



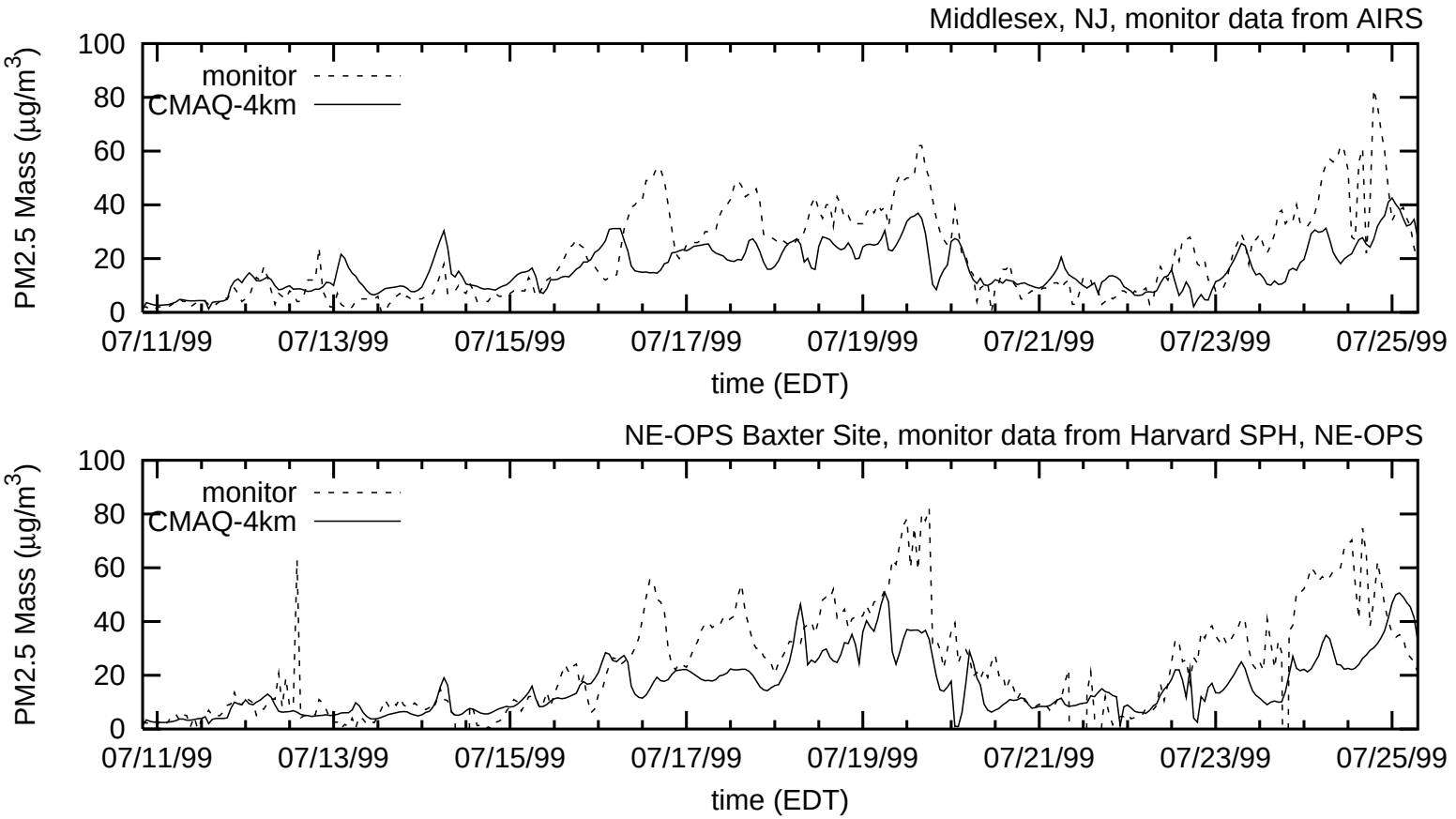
Ground level $PM_{2.5}$ predicted by CMAQ (left) and MAQSIP (right) at 11:00 UTC 7/18/99



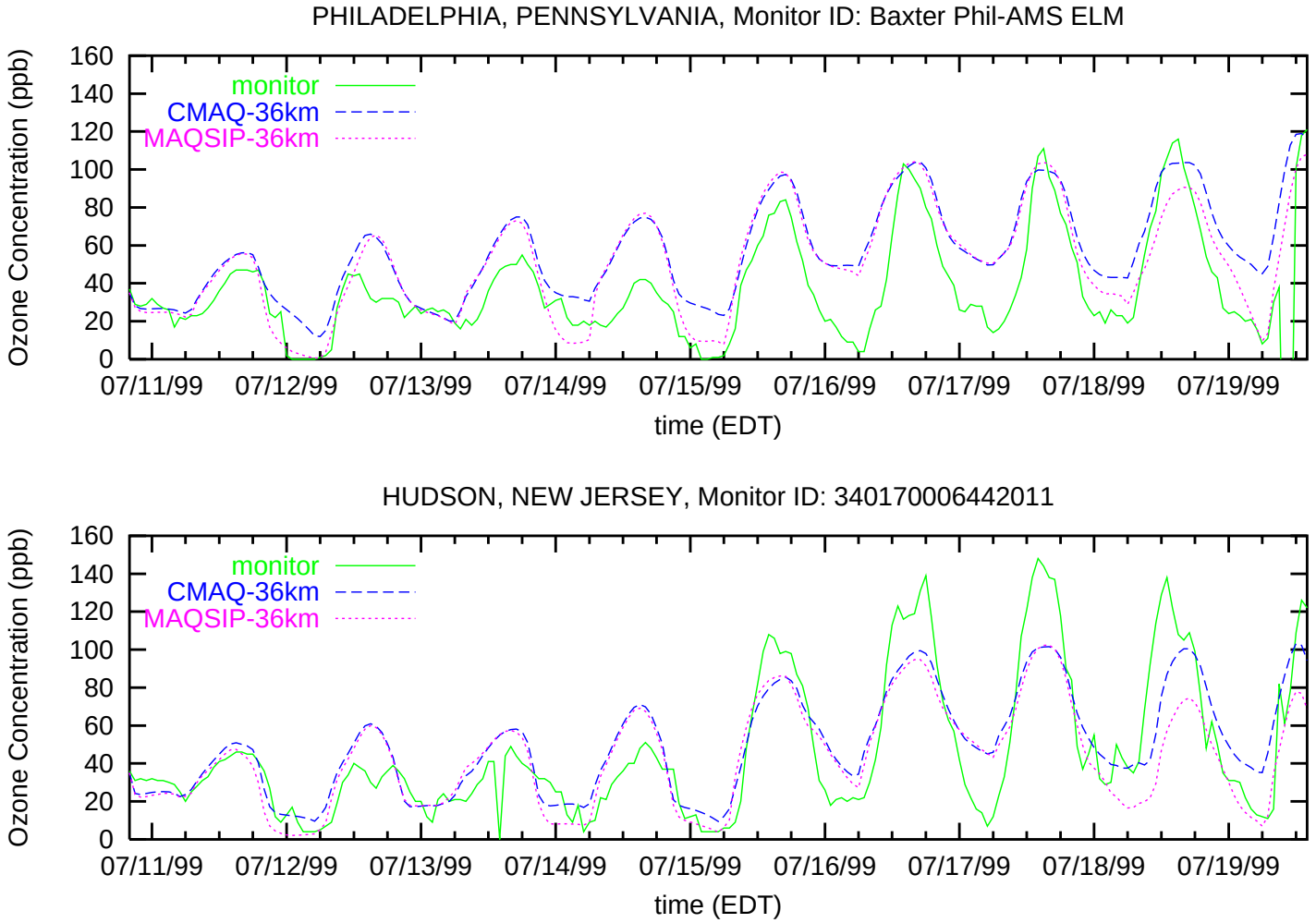
Time Series Comparison for Ozone between CMAQ prediction and observation



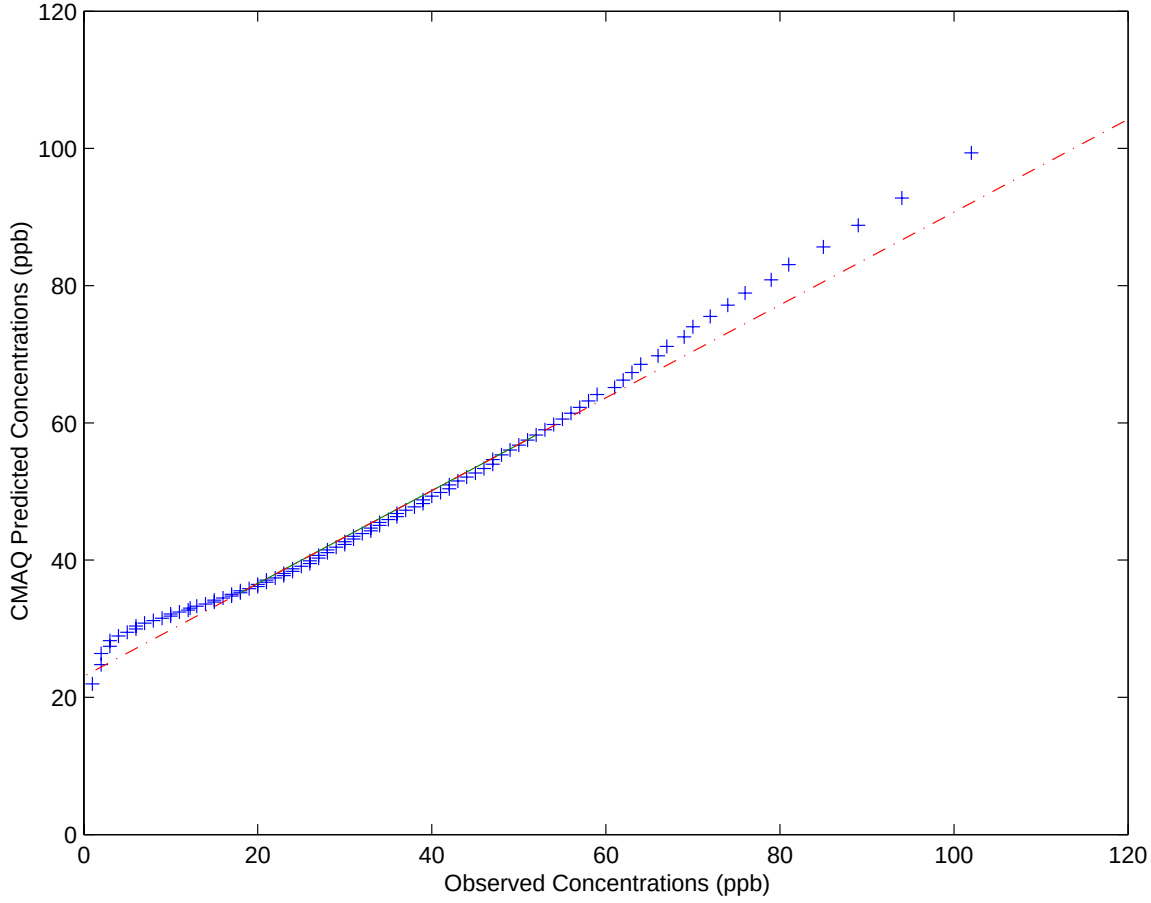
Time Series Comparison for $PM_{2.5}$ between CMAQ prediction and observation



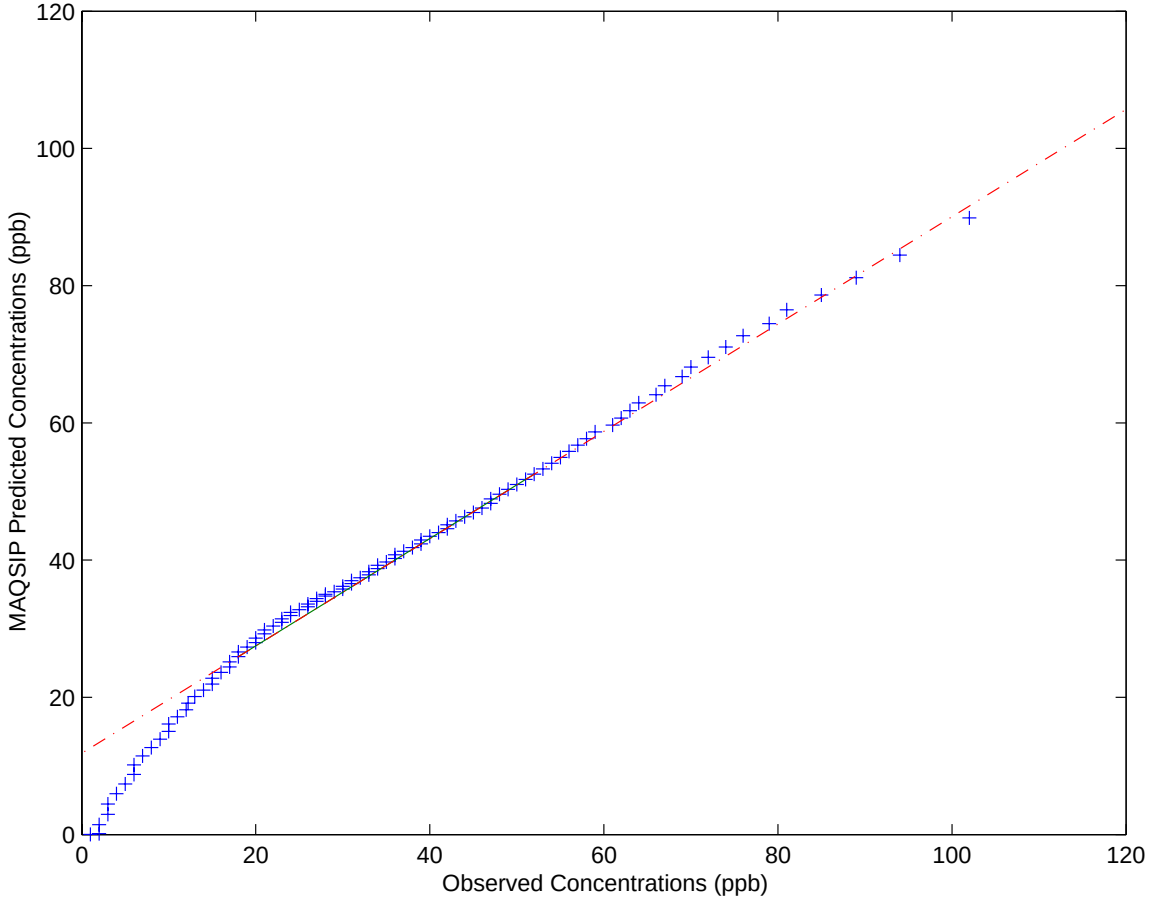
Time Series Comparison for O_3 between model predictions and observation



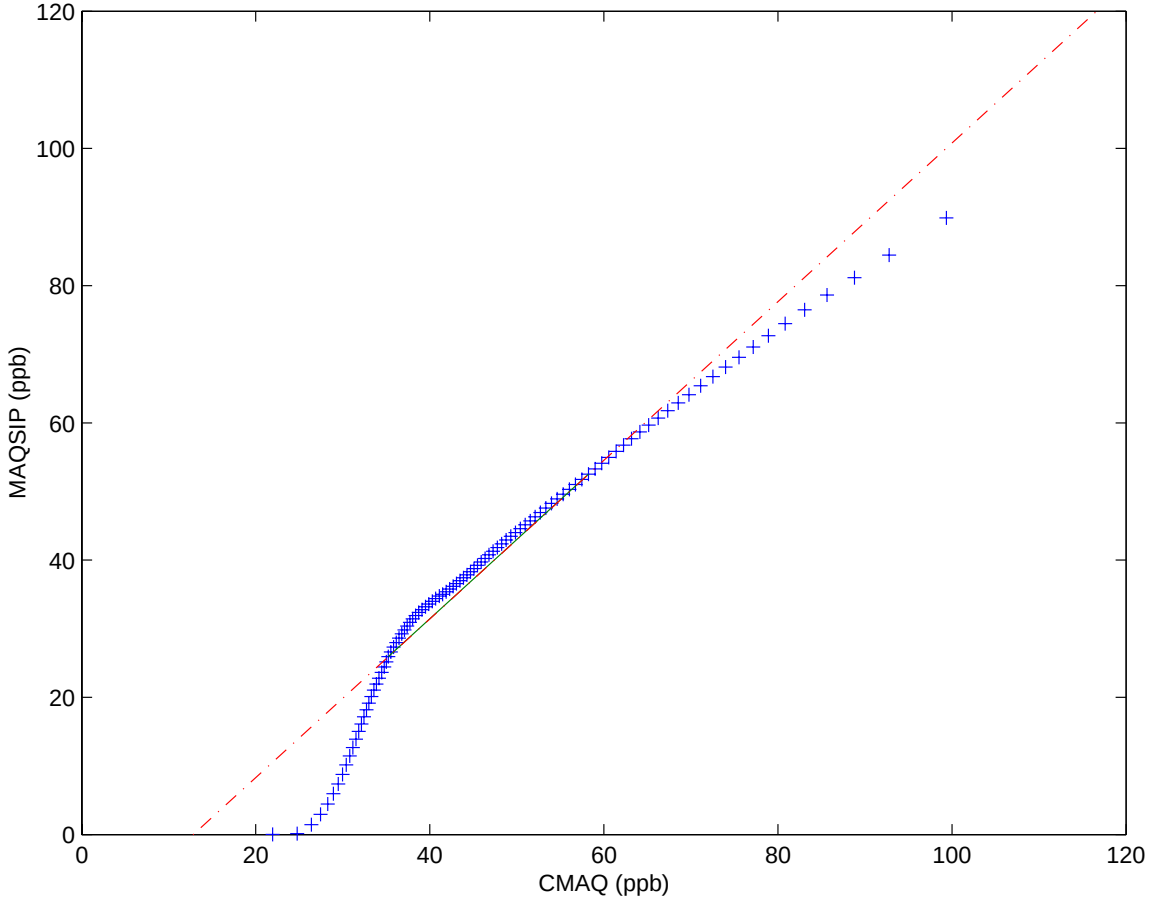
Q-Q Plot of Observed and CMAQ Predicted O_3 Concentrations



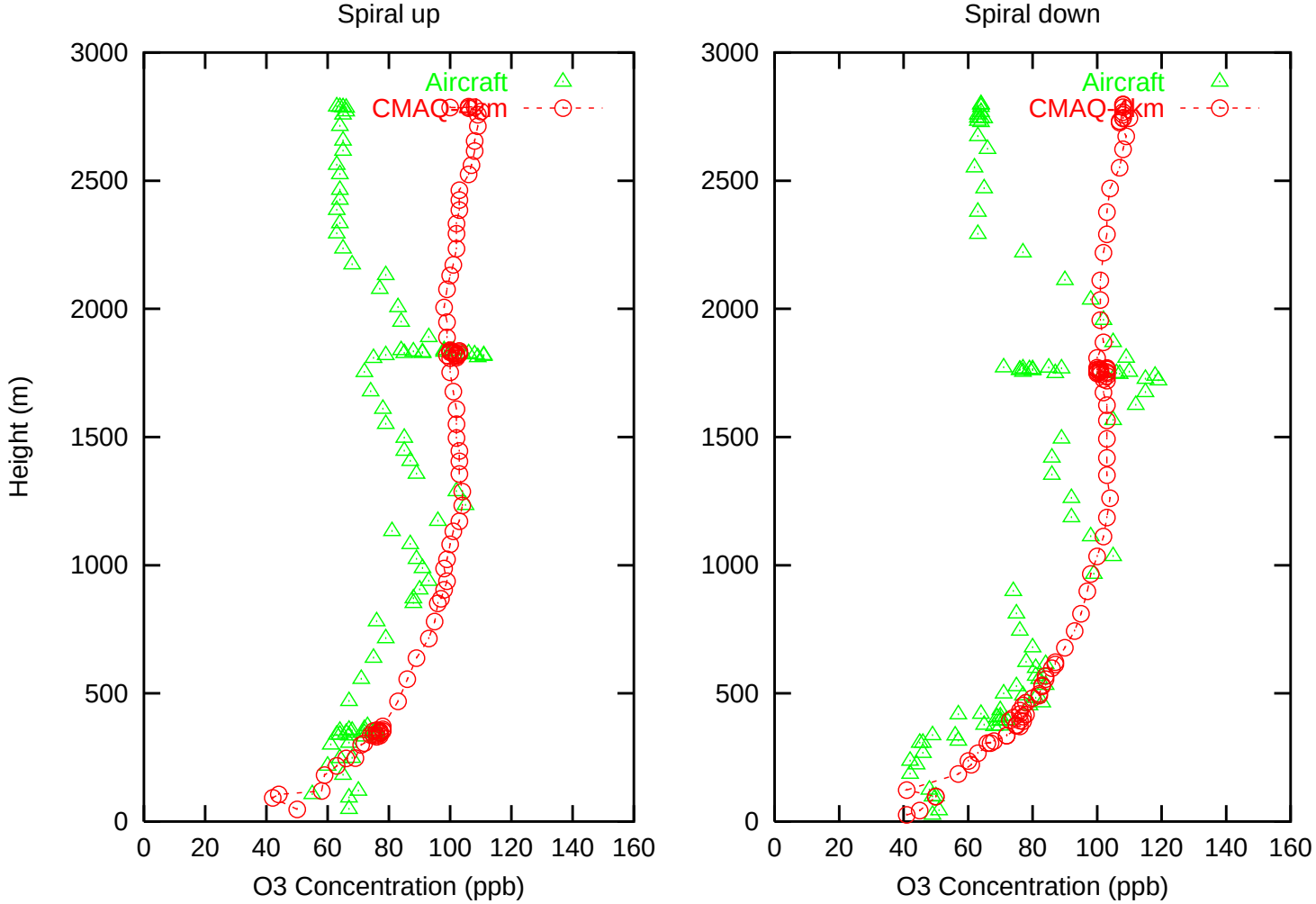
Q-Q Plot of Observed and MAQSIP Predicted O_3 Concentrations



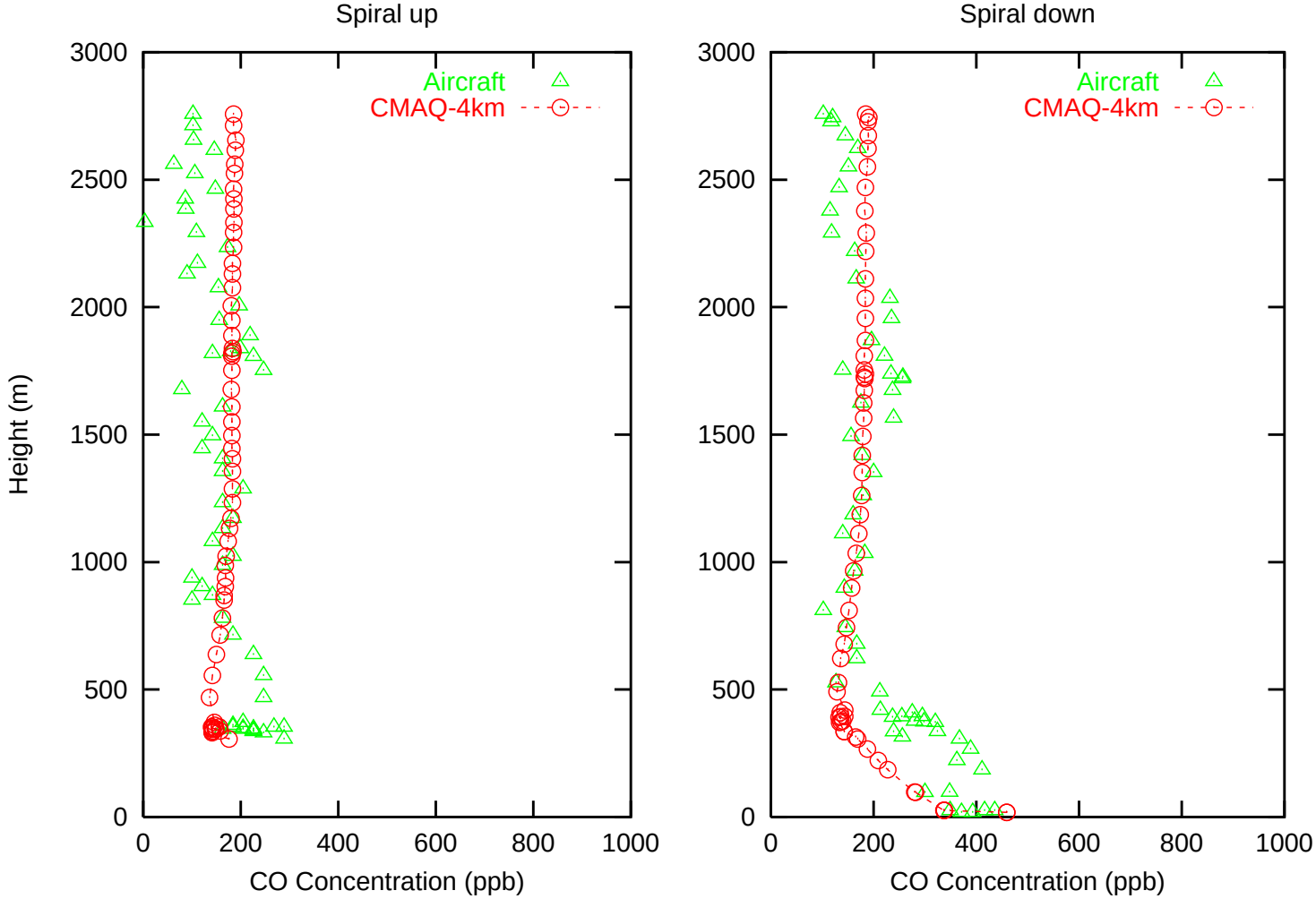
Q-Q Plot of Ground Level O_3 Predicted by CMAQ and MAQSIP



Comparison of CMAQ 4km grid O_3 with NE-OPS flight measurements on 7/17/1999 20:58-22:31 EDT



Comparison of CMAQ 4km grid CO with NE-OPS flight measurements on 7/17/1999 20:58-22:31 EDT



Conclusions

- MM5 successfully reproduced the temperature and virtual temperature values.
- CMAQ simulations can capture the general trends of pollutant concentrations at both surface and upper air.
- Agreements for O_3 are generally better than those for $PM_{2.5}$

Ongoing efforts

- MAQSIP and CAMx simulations and comparison with NE-OPS data.
- Further exploring the effects of different model settings (such as number of layers in the vertical direction in the CMAQ simulations) on the performance of the models.
- Comprehensive comparative exposure assessments of populations to ozone and particulate matter using tools of MENTOR.

Acknowledgements

- NorthEast Oxidant and Particle Study (NE-OPS) University Consortium funded by U.S. EPA
- Center for Exposure and Risk Modeling (CERM) at EOHSI funded by U.S. EPA
- Ozone Research Center (ORC) at EOHSI funded by the State of New Jersey Department of Environmental Protection (NJDEP)